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GREENLAND WHITE-FRONTED GOOSE STUDY

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Report of the 1979 Expedition to Eqalungmiut Nunât, West Greenland

GREENLAND WHITE-FRONTED GOOSE STUDY 1979

REPORT OF THE 1979 GREENLAND WHITE-FRONTED GOOSE STUDY EXPEDITION TO EQALUNGMIUT NUNÂT, WEST GREENLAND

Editors

A.D. Fox and D.A. Stroud

Greenland White-fronted Goose Study

Aberystwyth 1981

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BRITISH LIBRARY CATALOGUING IN PUBLICATION DATA

Greenland White-fronted Goose Study
Report of the 1979 Greenland White-fronted Goose
Study expedition to Eqalungmiut Nunât, west
Greenland.
1. White-fronted Goose
2. Birds - Greenland
I. Title II. Fox, A.D. III. Stroud, D.A.
598.4'1 QL696.A5

ISBN 0-9507667-0-4

Printed by Nimsfeilde Press Ltd. for the National Library of Wales, Aberystwyth.

DEDICATION

This report is dedicated to the memory of Dr. J.G. Harrison O.B.E., F.Z.S., M.B.O.U. who gave us much moral support when the project was in its infancy and helped us to establish not only the feasibility of the expedition but also our credibility as a group. Tragically, he died in the early stages of our preparation, but we hope that he would have gained satisfaction from the successful completion of both the expedition and our final report.

Greenland White-fronted Goose Study

Patron: Sir Peter Scott CBE, D.Sc.

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Phil J. Belman

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David A. Stroud

James T. Higgs

Research Advisers: H. Boyd

Dr. M. Owen

Sponsors: Wildfowl Trust

British Association for
Shooting and Conservation

PATRON'S FOREWORD

In the 1930's and 40's the taxonomy of Palearctic White-fronted Geese was very confused, especially on those birds breeding in Greenland, whose wintering grounds were then unknown. I had received live hand-raised Whitefronts from West Greenland which had predominantly yellow bills and rather dark plumage. I had also noticed a description in a book by no less an authority than Payne-Galway, a normally reliable source, that the Whitefronts in Ireland had yellow bills. A visit to Ireland confirmed that the Whitefronts there were also dark coloured. The 2nd World War intervened but, in 1948, C.T. Dalgety and I had gathered enough evidence to propose a new race of Whitefront, quite distinct from the Russian geese, breeding west of the Greenland icecap and wintering in the British Isles, chiefly in Ireland. Since this time I have always had a special concern for the welfare of the Greenland Whitefronted Goose.

Our race was readily accepted by the ornithological world and in later years, through extensive ringing, its migration through Iceland into western Scotland, Ireland and central Wales became better known. Though there were a few isolated studies, on general breeding biology and on winter food, the habits of the subspecies, especially during the breeding season, are still very little understood. The 1979 expedition represented the first major attempt at such studies since the work of Salomonsen and Fencker in the 1950's.

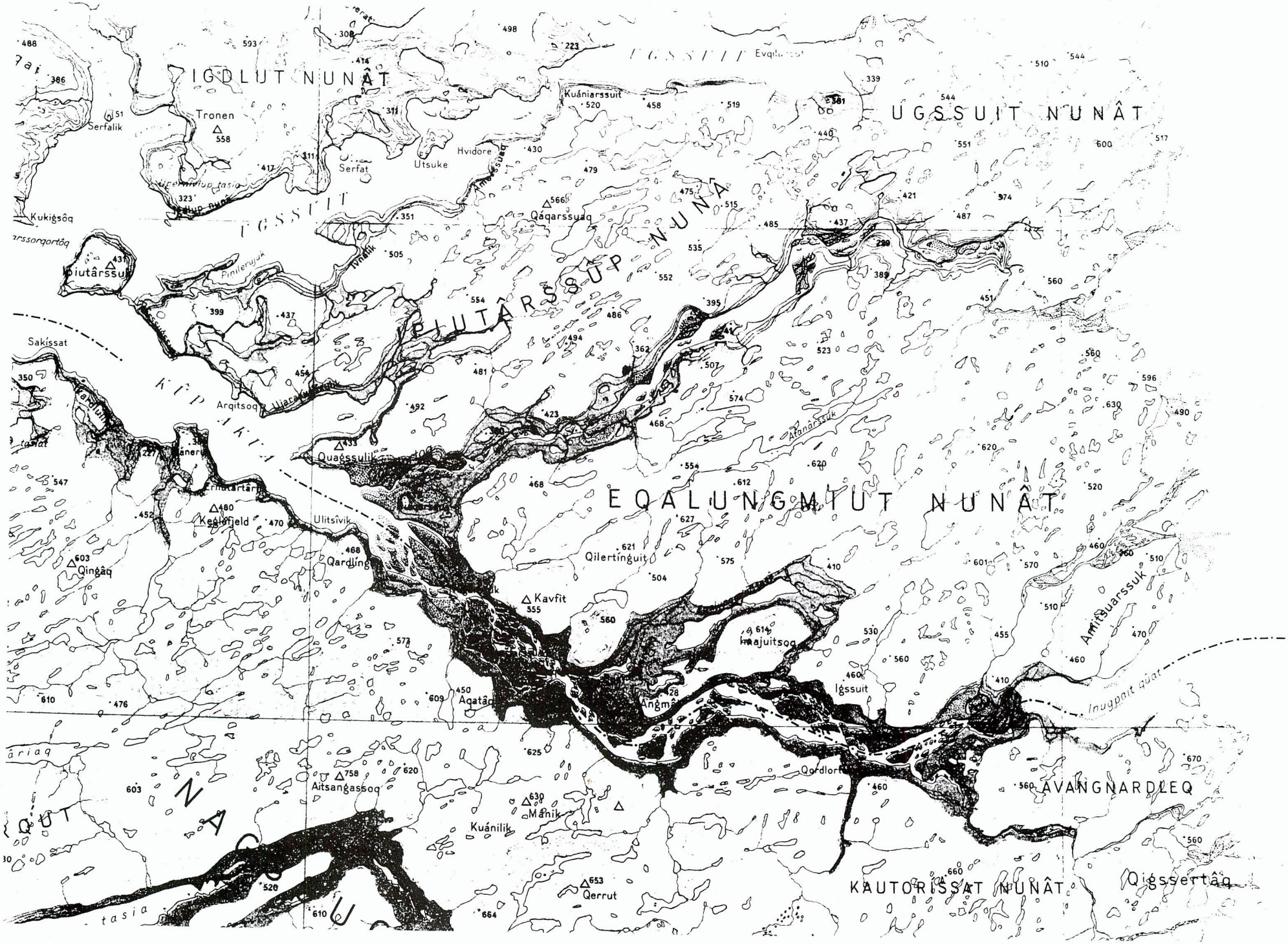
The aims of the expedition were extremely ambitious, as befits a university project, but progress has been made on all aspects of the work - providing a good platform for future studies. As the report describes, the group made important contributions to our knowledge of the flora and fauna of this part of west Greenland as well as of the geese. The pilot colour-ringing programme was especially useful in demonstrating the value of such work in understanding goose movements and distribution. The exceptional sighting rate of the marked geese - over half of those marked seen in the winter range - is particularly encouraging. This performance says much for the enthusiasm and diligence of the expedition members in following up their Greenland work.

In recent years scientists at the Wildfowl Trust and elsewhere have become increasingly concerned at the low productivity of the Greenland Whitefront and the continuing small size of its population. Through the Wildlife and the Countryside Bill we have succeeded in giving the subspecies legal protection in Scotland. We hope that this lead will be followed in Northern Ireland and in Eire. The main object is to give the population a breathing space so that numbers can increase to a healthier level. It is vital that during this early period of protection we make all possible efforts to understand more fully the factors which influence the life of Greenland Whitefronts so that in future we can know with more certainty what actions to take in their struggle for survival.

The Greenland White-fronted Goose Study Group, through their expedition reported on here, have done much to increase knowledge and, equally important, interest and concern about the subspecies. Their work on the wintering grounds and future planned expeditions to Greenland will build on this encouraging foundation.

If our work of forty years ago marked the beginning of this book, this report certainly opens a new chapter in the story of the Greenland Whitefront. A story which we hope will continue for many years to come.

Peter Scott.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PIUTÂRSSÛP NUNÂ
EQALUNGMIUT NUNÂT
AVANGNARDLEQ
KAUTORISSAT NUNÂT
Tronen
Serfalik
Serfat
Utsuke
Hvidore
Kuániarssuit
Qáqarssuaq
Kukigsôq
Ipiutârssuk
Sakissat
Arqitsoq
Quagssulik
Keglafjeld
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Qarding
Kavfit
Qilertinguit
Imajuitsoq
Igssuit
Aqatâq
Aitsangassoq
Kuánilik
Qerrut
Qigssertâq
Inugpait qûat
Amitsuarssuk
Atanârssuk
Pinilerujuk

GREENLAND WHITE-FRONTED GOOSE STUDY FINAL REPORT CONTENTS

A	INTRODUCTION	
A1	Introduction	1
A2	The Greenland White-fronted Goose *(Anser albifrons flavirostris)*	1
A3	Scientific Nomenclature and Authorities	5
A4	Glossary of Place-names and Explanation of Maps	5
B	DESCRIPTION OF EQALUNGMIUT NUNÂT	
B1	Eqalungmiut Nunât	12
B2	A general description of Eqalungmiut Nunât	12
B3	An account of the topography and habitats found near Base Camp	17
B4	Observer coverage of Eqalungmiut Nunât	22
C	THE EXPEDITION: A NARRATIVE OF EVENTS AND OBSERVATIONS	
C1	Leaders introduction to the expedition	24
C2	The Beginning (2-5 May)	26
C3	Arrival in Eqalungmiut Nunât and establishing Base Camp (5-8 May)	27
C4	Life in Base Camp (May-August)	28
C5	Kuk Marshes - first trek (7-13 May)	30
C6	The First Glacier Attempt (11-12 May)	30
C7	First Half - Base Camp and Goose-observation (19 May - 20 June)	31
C8	An attempt to reach Inugpait qûat - second glacier attempt (12-17 June)	33
C9	Midsummers Night at 627 m (21 June)	33
C10	Arrival of the Ringing Party (25 June - 10 July)	34
C11	The walk to North Valley (27 June)	34
C12	Third attempt to reach the ice-cap - success! (27-30 June)	35
C13	The trek to Niaqorssua - the western fringe of Eqalungmiut Nunât (2-4 July)	36
C14	Llyn Anne and Rimwater Marsh (25 June - 8 August)	37
C15	Ringing: the early days (27 June - 10 July)	37
C16	Camp David and Teilhard Tarn (11-18 July)	38
C17	Eagle Camp and Atanârssuk (24-30 July)	39
C18	The North Lakes Goose Survey (27 July)	41
C19	Niaqorssua again (1-4 August)	42
C20	The Greenlanders in Eqalungmiut Nunât (August)	43
C21	The edge of the ice sheet (11-16 August)	44
C22	Inugpait qûat revisited - third Glacier attempt (12-15 August)	45
C23	Packing up Base Camp (16-20 August)	45
C24	Coastal Cruise to Sisimiut (20-26 August)	46
C25	A visit to Aûsiat (21-25 August)	48
C26	Ringers camp in Søndre Strømfjord Air Base (26 August - 2 Semptember)	48
C27	The End (27 August - 2 September)	49
D	THE GREENLAND WHITE-FRONTED GOOSE *(Anser albifrons flavirostris)*	
D1	Distribution and abundance in Eqalungmiut Nunât	51
D2	Pre-nesting Behavioural Studies of the Geese	63
D3	Predation and Predators	71
D4	Nests and Nest-site Selection	74
D5	Breeding Biology	78
D6	Breeding Behaviour	82
D7	Behavioural Response to predators	103
D8	Food and Feeding	108
D9	Post-breeding and Family Behaviour	116
D10	Goose Ringing and Ringing Recoveries	123
D11	Parasites	139
D12	Plumage variation	139
D13	Miscellaneous Notes	145
D14	Status in East Greenland	146
D15	The Life History and Ecology of the Greenland White-fronted Goose	148
E	SYSTEMATIC ORNITHOLOGICAL REPORTS	
E1	Ornithological Records	156
E2	Red-throated Diver *(Gavia stellata)*	158
E3	Great Northern Diver *(Gavia immer)*	160
E4	Cormorant *(Phalacrocorax carbo)*	161
E5	Teal *(Anas crecca)*	161
E6	Mallard *(Anas platyrhynchos)*	162
E7	Eider *(Somateria mollissima)*	165
E8	Long-tailed Duck *(Clangula hyamalis)*	165
E9	Red-breasted Merganser *(Mergus serrator)*	168
E10	White tailed Eagle *(Haliaeetus albicilla)*	169
E11	Gyr Falcon *(Falco rusticolus)*	169
E12	Peregrine *(Falco peregrinus)*	171
E13	Ptarmigan *(Lagopus mutus)*	172
E14	Ringed Plover *(Charadrius hiaticula)*	173
E15	Purple Sandpiper *(Calidris maritima)*	174
E16	Snipe *(Gallinago gallinago)*	174
E17	Red-necked Phalarope *(Phalaropus lobatus)*	175
E18	Grey Phalarope *(Phalaropus fulicarius)*	176
E19	Common Gull *(Larus canus)*	177

E20	Lesser Black-backed Gull *(Larus fuscus)*	177
E21	Iceland Gull *(Larus glaucoides)*	177
E22	Glaucous Gull *(Larus hyperboreus)*	177
E23	Greater Black-backed Gull *(Larus marinus)*	178
E24	Black Guillemot *(Cephus grylle)*	178
E25	Snowy Owl *(Nyctea scandanavica)*	178
E26	Short-eared Owl *(Asio flammea)*	178
E27	Wheatear *(Oenathe oenanthe)*	179
E28	Raven *(Corvus corax)*	179
E29	Redpoll *(Carduelis flammea)*	180
E30	Arctic Redpoll *(Carduelis hornemanni)*	183
E31	Lapland Bunting *(Calcarius lapponicus)*	183
E32	Snow Bunting *(Plectrophenax nivalis)*	187
E33	Ringing Report	189
E34	Breeding Bird Census	192
F	SYSTEMATIC MAMMAL REPORTS	
F1	Caribou *(Rangifer tarandus groenlandicus)*	197
F2	Arctic Hare *(Lepus timidus groenlandicus)*	201
F3	Arctic Fox *(Alopex lagopus)*	202
F4	Midden Remains at Manx Lake	204
F5	Morphology and growth of Caribou atlas vertebrae	206
F6	Non-metrical variation of the Caribou atlas vertebrae	218
G	FRESHWATER INVESTIGATIONS	
G1	Three-spined Stickleback *(Gasterosteus aculeatus)*	219
G2	Dispersal of Stickleback to North-east Greenland	222
G3	Arctic Char *(Salvelinus alpinus)*	222
H	INVERTEBRATE STUDIES	
H1	Seasonal activity and abundance of some land invertebrates	222
H2	An annotated list of invertebrates collected from Eqalungmiut Nunât	227
I	BOTANICAL DESCRIPTIONS	
I1	The Flora of Eqalungmiut Nunât	230
I2	Annotated list of the plants of Eqalungmiut Nunat	241
I3	Observations on *Dryas integrifolia*	245
I4	List of Bryophytes	245
I5	List of Lichens	245
I6	List of Fungi	246
J	METEOROLOGY	
J1	Meteorology	247
J2	Thaw of Seasonal Ice	252
K	OBSERVATIONS ON THE FAUNA OF SITES EN ROUTE TO AND FROM EQALUNGMIUT NUNAT	
K1	Brief notes on the birds of the west Greenland coast Kangerdlugssuaq and Sisimiut	253
K2	The demography of an arctic population of *Littorina rudis* from Sisimiut	258
K3	Littoral and sub-littoral Ostracoda from Sisimiut	269
L	TECHNICAL REPORTS	
L1	Freight and Travel	285
L2	Provisions	286
L3	Medical Report	289
L4	Radio Report	293
L5	Equipment Report	293
L6	Scientific Equipment	296
L7	Hide Construction and Design	297
L8	Canoe construction and design	297
L9	Time-lapse photography	298
L10	Financial Report	301
M	ACKNOWLEDGEMENTS	303
N	BIBLIOGRAPHY OF THE GREENLAND WHITE-FRONTED GOOSE WITH COMPLETE REFERENCE LIST FOR THE REPORT	305



SECTION A INTRODUCTION

A 1 INTRODUCTION

A. D. Fox & D. A. Stroud

The Greenland White-fronted Goose Study was founded in 1978 to investigate the breeding biology of the Greenland White-fronted Goose (*Anser albifrons flavirostris*). The project grew out of the desire of one person to return to the arctic and, as is often the case, the object was determined after the decision had been made to mount an expedition to Greenland. The need for studies of the Greenland White-front on its breeding grounds was pressing indeed as will become evident from the report.

This report is an account of 1082 man-days field work carried out between 5 May and 20 August 1979 in Eqalungmiut Nunat (67°30'N 50°30'W), west Greenland studying the geese, with peripheral observations from our travels to and from the study area and follow-up results of ringing work.

The project gave an unique opportunity to twelve amateur naturalists to study an area unaffected by man and virtually unexplored by Europeans. This was privilege indeed, but we would particularly draw two points from our experience. The first is that working intensively on scientific objectives need not be incompatible with enjoying oneself. Indeed, many of the more satisfying and rewarding moments came during the more arduous and tedious activities, such as the continuous watch of the incubating pair or rounding-up flightless geese which would not have been undertaken were it not our common aim to study these birds. Secondly, we would draw attention to the fact that such a project is within the grasp of anybody. Initially, none of us had qualifications which would particularly enable us to study geese in the arctic. In the event, it became our aim to study the geese in Greenland and with a lot of hard work from many people, particularly Will Higgs, we achieved our objectives. A similar venture lies within the grasp of anyone with sufficient energy and dedication to follow the project to its ultimate success. However, we could never have achieved what we did without the help of the many financial sponsors, advisers, helpers and friends who have assisted us at every stage. To all these groups and individuals, we offer this document as a gesture of our sincere thanks.

We owe a tremendous debt of gratitude to our sponsors for their confidence and support; in particular, we must mention our main financial supporters: the Department of Fisheries and Forestry, Dublin, the NATO Eco-Sciences Panel, the Wildfowlers Association of Great Britain and Ireland (BASC) and the World Wildlife Fund, Denmark. The Royal Air Force, by the most generous transportation to and from Greenland on regular training flights, freed us from the problem of freight transportation and enabled the group to concentrate its resources on helicopter transport to the best area for study. Racal-Tacticom Ltd. loaned us high quality radio equipment enabling us to work more efficiently in the field. To these and everybody else who supported us in many and varied ways, we extend our grateful thanks.

A further debt is owed to the 1974 Joint Biological Expedition to North East Greenland whose report (Green and Greenwood 1978) was published in the latter stages of our planning, so influencing many projects, with the various members giving us valuable advice and encouragement. Any similarity in layout and presentation with that report should be regarded not as plagiarism but rather as emulation!

Several members felt that two reports should be published, one containing the narrative and various non-scientific accounts, the other comprising solely scientific papers. The majority felt the present layout was more satisfactory; the split between science and non-science is not a real one. The narrative section conveys much of the magic of Eqalungmiut Nunât, a beautiful but often unusual and alien environment, so that as well as describing the sequence of events, it hopefully paints a broad backdrop against which the reader can picture our work.

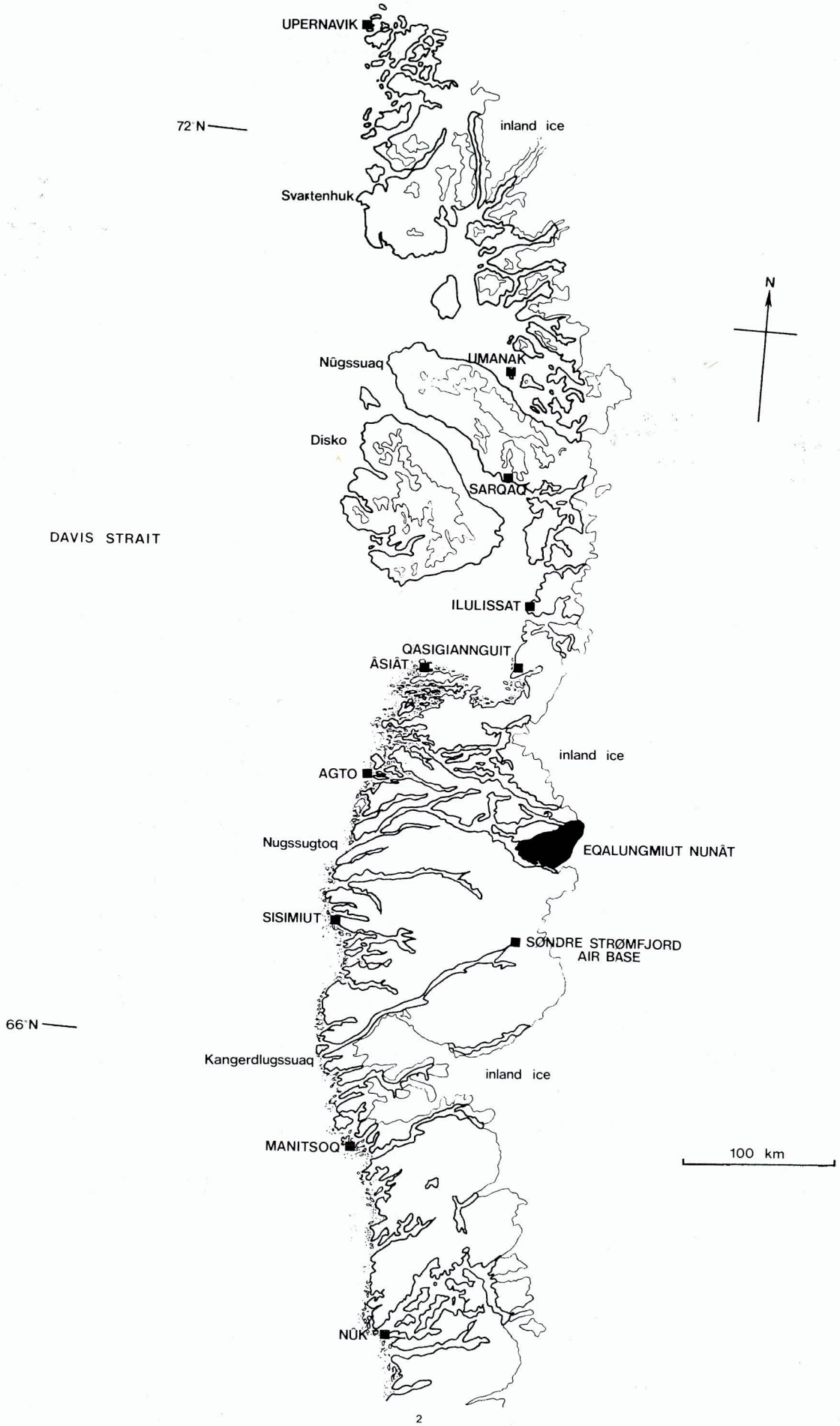
Whilst our efforts may lack the polish of a more professional approach, we hope our achievement in reaching Eqalungmiut Nunât will stand as encouragement to those, who, in a period of economic stringency, might otherwise feel such endeavours to be beyond the scope of groups outside larger scientific institutions. We merely hope that something of the challenge and refreshing experience of working in one of the last remaining wildernesses of this planet is felt by the reader.

The Greenland White-fronted Goose Study continues to act as a focus for current and future research concerning the Greenland White-fronted Goose. The Study organises small-scale expeditions to the wintering areas of the sub-species in the British Isles to locate and identify ringed birds. There is also a detailed study of the feeding ecology of the geese centred on Islay in the Inner Hebrides being undertaken and it is proposed that another expedition be mounted to west Greenland in the summer of 1983 to carry out further investigations on the breeding geese.

A 2 THE GREENLAND WHITE-FRONTED GOOSE

In 1947, Christopher Dalgety and Peter Scott proved that the White-fronted Geese wintering in Ireland, Scotland and Wales were a distinct race separable from the European White-fronted Goose *Anser albifrons albifrons* which wintered in England. They named the new race the Greenland White-fronted Goose *Anser albifrons flavirostris* (Dalgety and Scott 1948), one of the rarest sub-species of geese, breeding in west Greenland between 64° and 73°N (Figure A2.1) and wintering exclusively in the British Isles (Figure A2.2).

The world population of *flavirostris* numbers between 14 300 and 16 600 birds (Ruttledge and Ogilvie 1979), compared with an estimated 17 500-23 000 in the 1950s, the decline occurring mainly in Ireland (43% in this period from 12 700-17 300) whilst the British numbers have risen by about 47% to 6 500-7 300. The most important reason for this decline has been recent habitat loss, particularly reclamation of traditional bog sites in Ireland. Shooting and disturbance have also had adverse effects, but the trend for population recruitment to fall below mortality rates in some seasons cannot always be attributed to effects in the British Isles. The goose is a quarry species in Greenland, Iceland (where birds pass through in spring and particularly autumn) and throughout its' wintering ground, with the exception of a voluntary ban on the Dyfi Estuary. The greatest shooting mortality is encountered during the winter with only localised shooting on the breeding areas outside the nesting season; the Greenlanders are no longer permitted to catch and fatten the goslings as in former years. As this report goes to press, protection for the White-fronted Goose in Scotland (i.e. Greenland White-fronts) is secured in the United Kingdom Wildlife and Countryside Bill currently before Parliament and the recommendation of Owen (1978) and Ruttledge and Ogilvie (1979) was that the bird should be similarly protected in Ireland.


UPERNAVIK
72° N
inland ice
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inland ice
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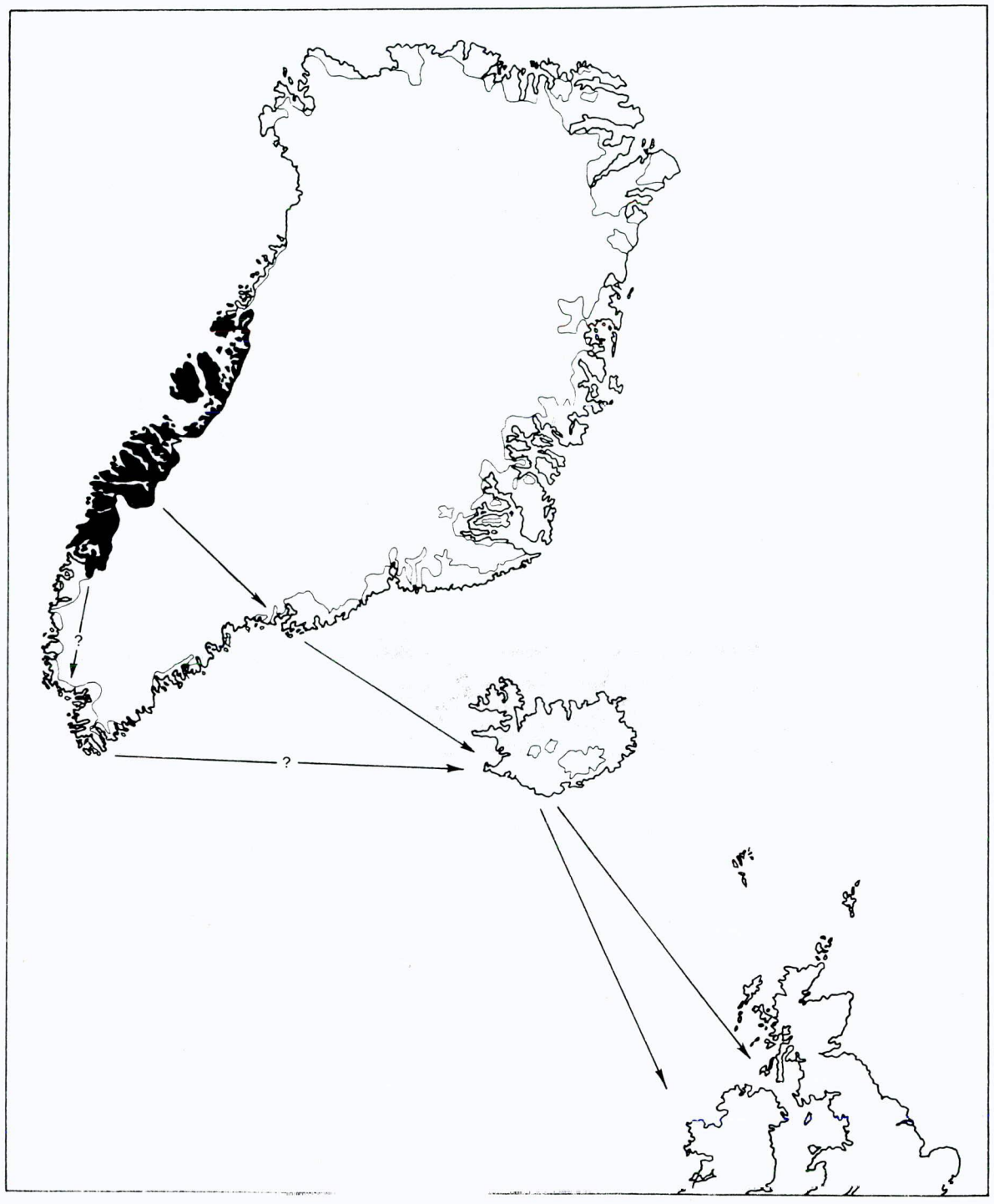


Figure A2.2. The world distribution of the Greenland White-fronted Goose (*Anser albifrons flavirostris*). Shaded area in west Greenland indicates the breeding range, whilst the arrows indicate the autumn migration route through south-west Iceland. The population winters exclusively in Ireland, west and north Scotland and Wales, although there are regular sightings from the eastern seaboard of America.

Figure A2.1. ← The west coast of Greenland showing the location of the major places referred to in the text. The study area of Eqalungmiut Nunât is shaded and is more or less centrally placed in the breeding range of the Greenland White-fronted Geese (*Anser albifrons flavirostris*) which extends from Nûk to Upernavik.

The impetus of the expedition was the decline in numbers of Greenland White-fronted Geese in Mid-Wales at two main sites: Cors Tregaron (Tregaron Bog) and the Dyfi Estuary. In January 1947, it was shown that the flock of White-fronts on Cors Tregaron were at least partially of Greenlandic origin with the recovery of a bird ringed in west Greenland in 1946. With the subsequent determination of reliable field characters, it was recognised that the Tregaron birds were all Greenland geese. The geese arrived in mid-October building to a peak of 500 - 600 in the New Year, remaining until late April unless forced out by severe weather conditions, as in the 1962-3 winter when the bog vegetation froze. Some 500 birds arrived in 1962, but with the onset of the freeze, they scattered and were picked up dead and dying all over mid-Wales; only 200 returned with the thaw. After that, numbers decreased and the geese had ceased to winter regularly at the site by 1968.

There has been a flock of White-fronted Geese on the Dyfi for as long as anyone can remember, and Arthur Cadman showed that some birds in mid-winter were Russian birds, although the presence of birds in early autumn through to April indicated that during the 1950s Greenland White-fronts occurred at least on passage, if not throughout the winter. The group numbered 200 - 300 with maximum counts of up to 600 geese and showed behaviour similar to Greenland birds, feeding on local bogs, including the adjacent Cors Fochno (Borth Bog). By the late 1960s, the European White-front only sporadically appeared on the Dyfi, the main group of birds being of the Greenland race. It will never be known whether the Tregaron flock was exterminated, whether they moved to one or more of the other wintering sites (e.g. Wexford Slobs) or whether the flock merely shifted north to the Dyfi Estuary. What also of the old Dyfi flock? These could always have been Greenland birds or Russian geese replaced by Greenlandic birds during the last decade. Alas, it seems the problem will never be resolved.

The numbers of Greenland White-fronts on the Dyfi have slowly declined throughout the 1970s (Figure A2.3). For reasons outlined above, it is probably not justified in considering counts from the 1960s as these may have been from counts of mixed races, but during the 1970s, the decline in Greenland White-fronts, together with a consistently low recruitment rate made it probable that this flock is a discrete breeding unit.

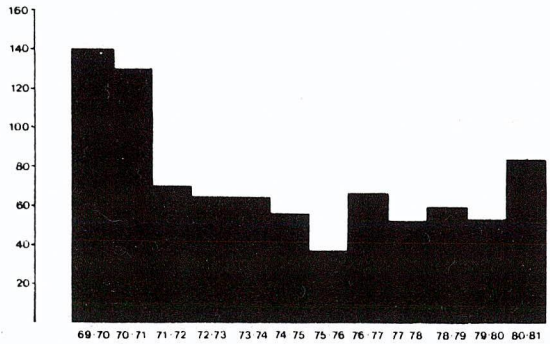


Figure A2.3. Maximum counts of Greenland White-fronted Geese (*Anser albifrons flavirostris*) on the Dyfi Estuary, Dyfed, Wales. (P.E. Davis, pers. comm.).

The decline concerned local wildfowlers who initiated a voluntary shooting ban in August 1971 and persuaded the RAF to ban low flying over the estuary during the winter which had previously caused considerable disturbance to the geese. Whilst the shooting ban is still in force, the low flying has been increasing. The shooting ban failed to halt the decline, but was undoubtedly beneficial as the flock may have otherwise completely disappeared. It would thus appear that the reasons for the decline and low productivity of this flock lie outside the wintering grounds.

A search of the literature revealed that next to nothing was known of the summer ecology of the geese, the only studies being those of Fencker (1950) and Salomonsen (1950a, 1967a). With our interest in the Dyfi flock it seemed opportune to find out more about the summer breeding biology and ecology of the White-fronted Goose in Greenland. This, at its simplest, was the aim of the study.

It is pleasing to report that after several years of low numbers of geese on the Dyfi, there has been a recovery since the inception of the project. Last winter (1980/1), 84 geese returned bringing a larger number of families than usual - we can only hope that this increase will continue.



A 3 SCIENTIFIC NOMENCLATURE AND AUTHORITIES

For convenience, throughout the report, all fish, birds and mammals are referred to using popular or trivial names in common usage. The names of birds follow those of Voous (1973, 1977a, 1977b), while fish and mammals are listed below. The higher plants follow Bocher *et al.* (1968) for nomenclature and authorities; while one might disagree with the taxonomy of this work, it is the standard flora for Greenland, and hence is used throughout. Bryophytes follow Smith (1978) and lichens Dahl and Krog (1973).

FISH

Arctic Char	*Salvelinus alpinus* L.
Three-spined Stickleback	*Gasterosteus aculeatus* (L.)

MAMMALS

Arctic Hare	*Lepus timidus* L.
Brown Hare	*Lepus capensis* L.
Grey Squirrel	*Neosciurus carolinensis* (Gmelin)
Collared Lemming	*Dicrostonyx groenlandicus*
Arctic Fox	*Alopex lagopus* (L.)
Red Fox	*Vulpes vulpes* (L.)
Polar Bear	*Thalassarctos maritimus* (Phipps)
Common or Harbour Seal	*Phoca vitulina* L.
Ringed Seal	*Pusa hispida* (Schreber)
Harp Seal	*Pagophilus groenlandicus* (Erxleben)
Bearded Seal	*Erignathus barbatus* (Erxleben)
Caribou	*Rangifer tarandus* L.
Wolf	*Canis lupis* L.

A 4 GLOSSARY OF PLACE NAMES AND EXPLANATION OF MAPS

The population of west Greenland is concentrated along the coastal area (see Figure A2.1), with no permanent habitation in the central interior region away from the Søndre Strømfjord Air Base. Greenlanders traditionally hunt in the interior regions (see Section C20), but generally few features in Eqalungmiut Nunât are named. Consequently, both in the field and throughout this report we have unavoidably had to use a large number of unofficial 'expedition' names. On all maps of Eqalungmiut Nunât produced here, those official names that appear on the 1:250 000 map of the area (sheet 67V2 produced by the Danish Geodaetisk Institut) have been placed in block capitals, all other names are unofficial. We are aware of the accepted practice of placing all unofficial names in inverted commas, however with virtually every place name being unofficial we feel that in places this would lead to an unnecessarily cumbersome style. Thus in the text of the report all names are treated the same and the reader is referred to the maps for the status of place-names.

In naming many of the small lakes, we used the phonetic alphabet, identified on the map by a letter corresponding to the following names used in the text:-

A Alpha	E Echo	I India	M Mike	Q Quebec	V Victor
B Bravo	F Foxtrot	J Juliet	N November	R Romeo	W Whisky
C Charlie	G Golf	K Kilo	O Oscar	S Sierra	X X-Ray
D Delta	H Hotel	L Lima	P Papa	T Tango	Y Yankee
				U Uniform	Z Zulu

Other lakes in areas infrequently visited were numbered sequentially.

The maps reproduced here (Figures A4.3 - A4.6) were based on the 1:250 000 series, but have been enlarged to a scale of approximately 1:75 000. Many of the more obvious errors on the original maps have been corrected and many of the smaller pools, tarns and streams not shown have been added. It should be noted that on the original maps, as well as those produced here, the contour lines are at best approximate and often highly inaccurate.

The translations of the Greenlandic names in Eqalungmiut Nunât are as follows:-

Eqalungmiut Nunât	-	Land of the Fisherfolk (from eqaluk = Char/Salmon; Nunât or Nunâ = land or place of)
Eqalungmiut tasia	-	Fisherman's Lake
Eqalungmiut nûat	-	Fisherman's Mountain
Kûp Akua	-	"Where the waters meet or mix"
Qilertínguit	-	Greenlandic topknot
Ímajuitsoq	-	"There is no water here"
Kûk	-	Dunes
Niaqorssua	-	Big head
Kuan	-	*Angelica archangelica*
Uggsuit	-	The testicles
Inugpait qûat	-	"Many peoples urine"
Manik	-	Egg
Angmat	-	"Open place with a good view"

We were unable to obtain translations of Atanârssuk and Amitsuarssuk.

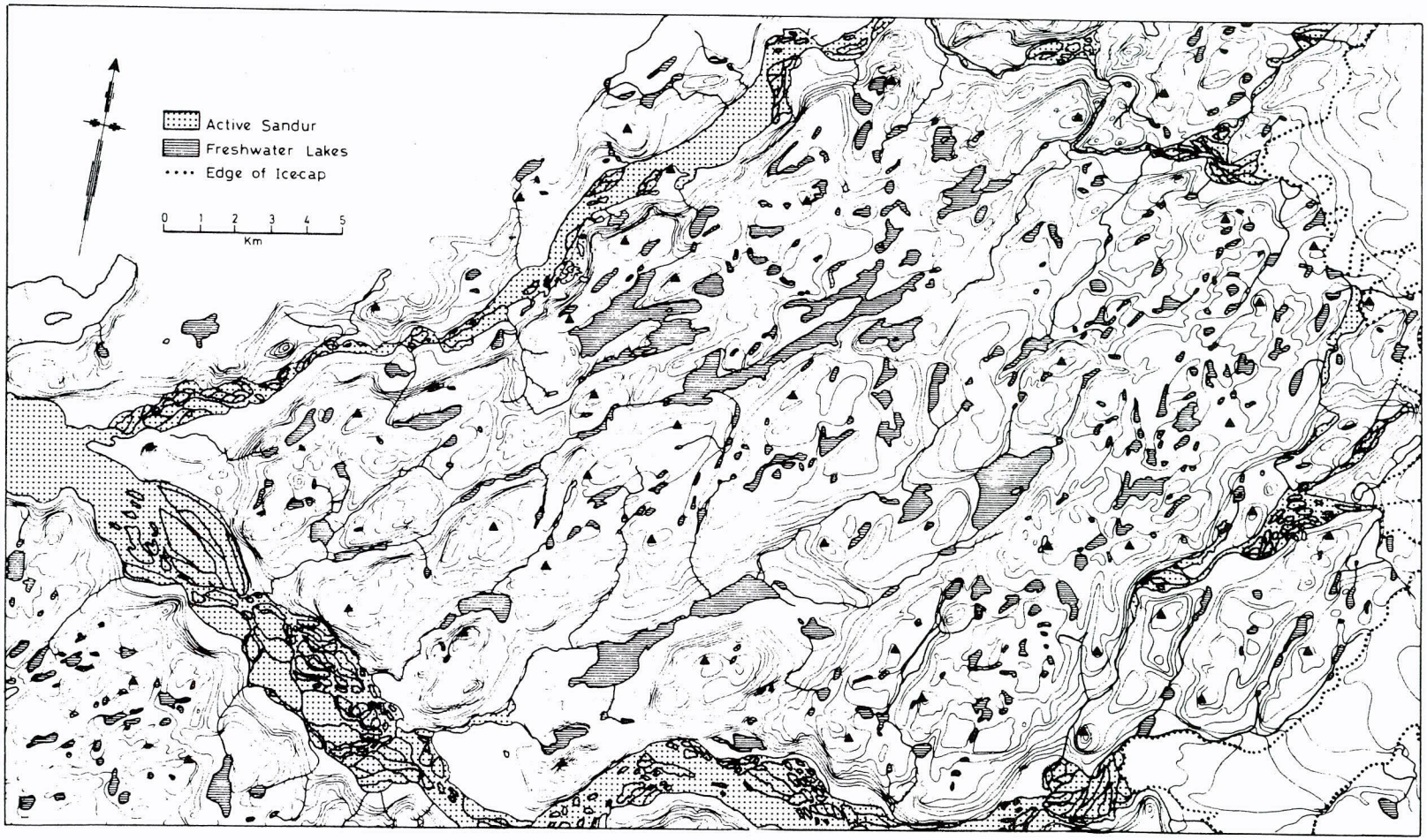


Figure A4.1. Eqalungmiut Nunât, west Greenland; redrawn from Geodaetisk Institute Map 67 V2.

Most towns in Greenland are familiarly known by their Danish name in common usage. However, with the independence of Greenland granted in 1979, all names have reverted to the original Greenlandic. Wherever possible alternatives are given on maps and in the text, but the following lists equivalents for the most commonly used place names :-

Thule	-	Qânâq
Jakobshavn	-	Ilulissat
Egedesminde	-	Âusiât
Christianshaab	-	Qasigiannguit
Holsteinsborg	-	Sisimiut
Sukkertoppen	-	Manîtsoq
Godthab	-	Nûk
Julianehaab	-	Qaqortoq
Angmagssalik	-	Tasiusaq
Søndre Strømfjord	-	Kangerdlugssuaq
Nordre Strømfjord	-	Nagssugtôq

Although the official name of Greenland is now Kalâllit Nunât, the more familiar Greenland has been retained throughout.

Unless otherwise stated, all times given in the report are in local time, three hours in advance of Greenwich Mean Time.

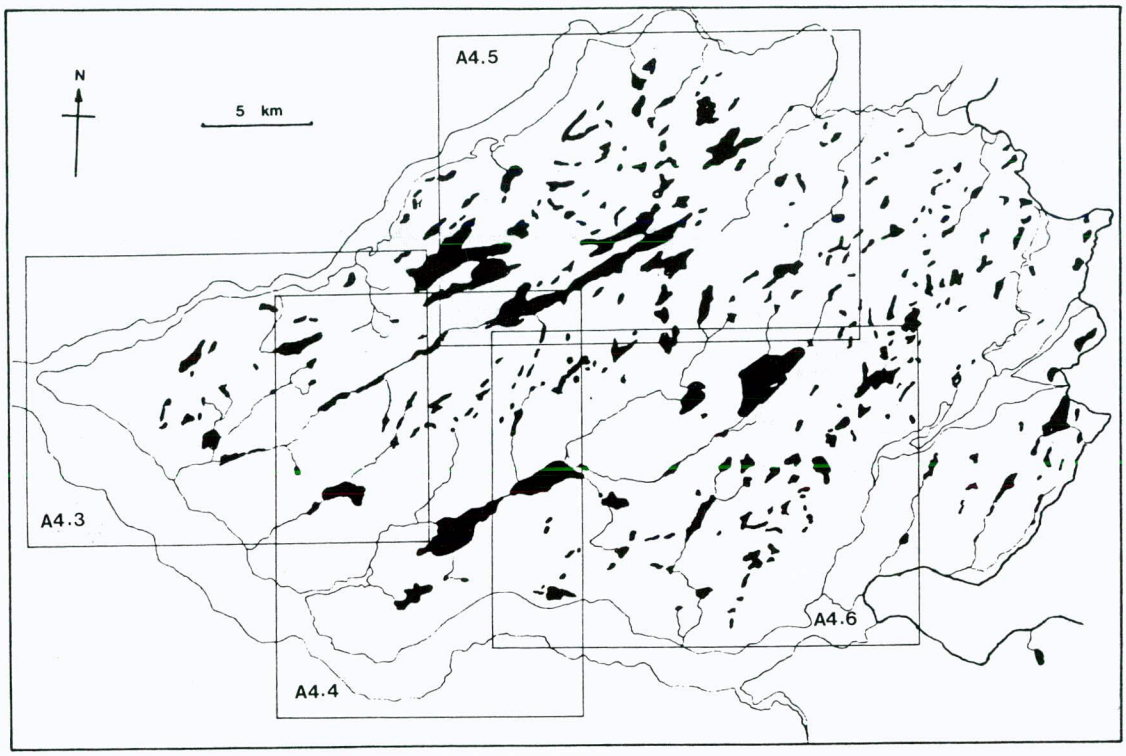


Figure A4.2. Eqalungmiut Nunât, showing the location of 1:75 000 maps (Figures A4.3 to A4.6 inclusive).

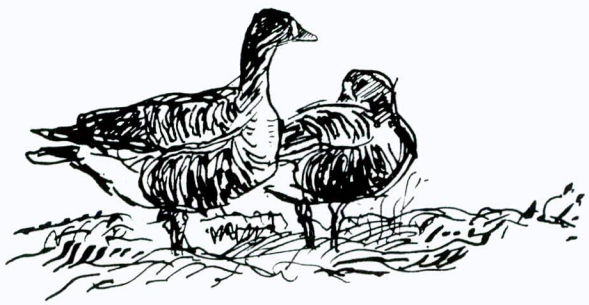




Figure A1.3. The western end of Eqalungmiut Nunât; scale approximately 1:75 000. Shading indicates sandur valley which at Kûp Akua is tidal. Official names appearing on Geodaetisk Institut sheet 67 V2 are shown in bold type, whereas all other names are unofficial.

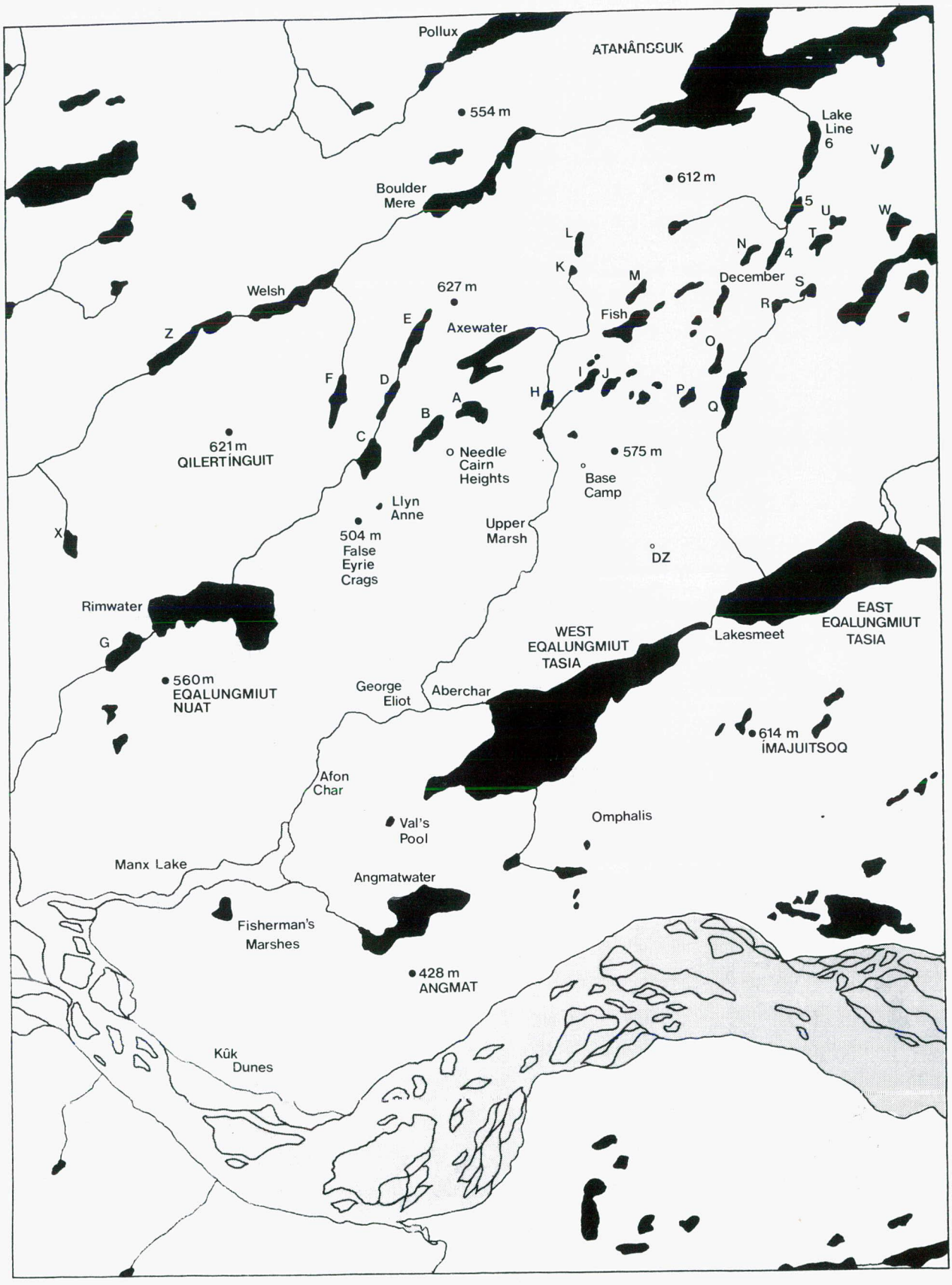


Figure A4.4. Southern Eqalungmiut Nunât, conventions as in Figure A4.3.

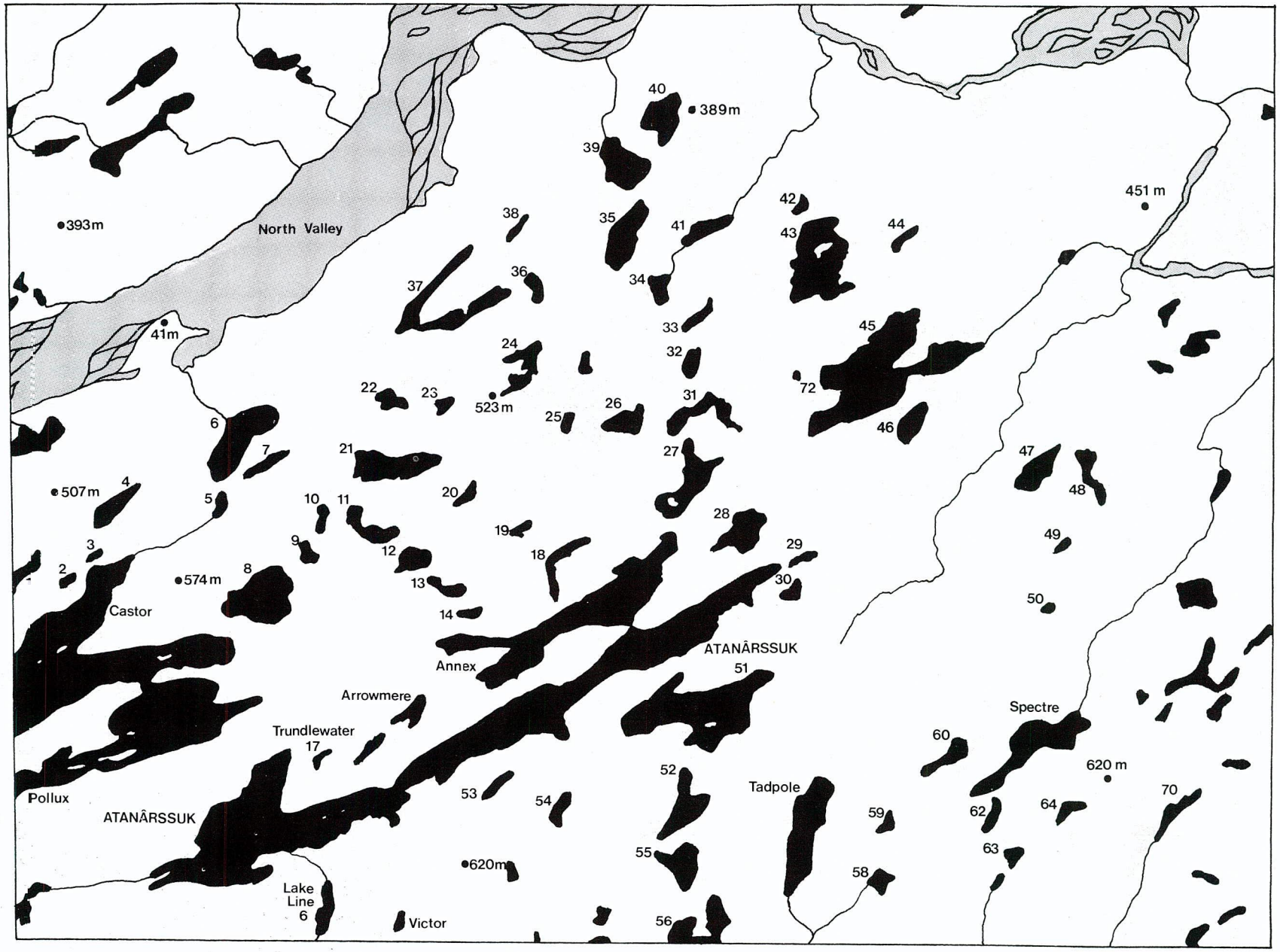


Figure A4.5. Northern Eqalungmiut Nunât, conventions as in Figure A4.3.

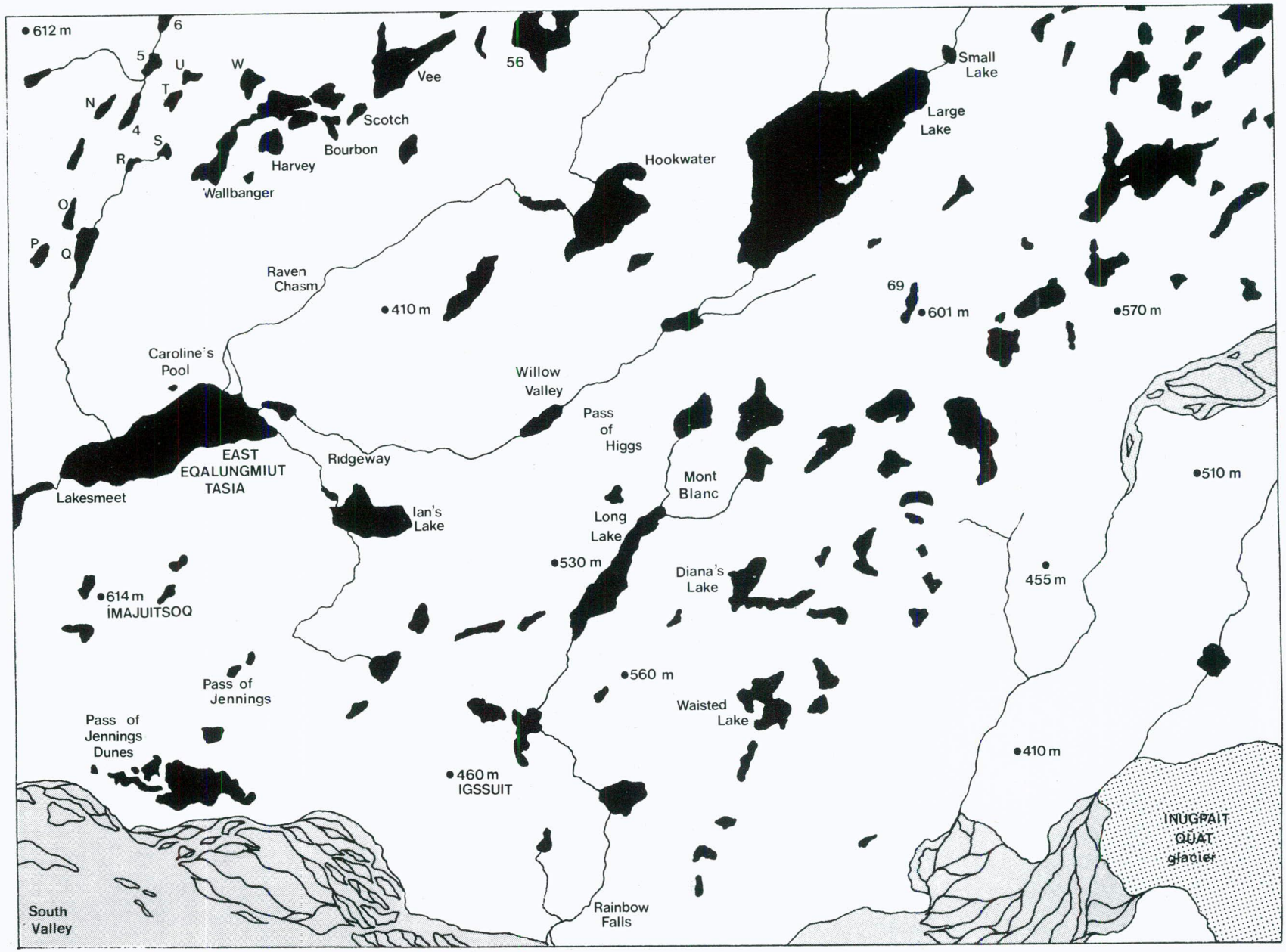


Figure A4.6. South-eastern Eqalungmiut Nunât, conventions as in Figure A4.3.

SECTION B EQALUNGMIUT NUNÂT; STUDY AREA DESCRIPTION

B 1 EQALUNGMIUT NUNÂT

J. Floyd

Eqalungmiut Nunât is an area of upland tundra at the western edge of the Greenland Ice Sheet, 120 km north of the Arctic Circle. It is bounded by two large melt rivers that join to form the southern branch of Nagssugtôq (Nordre Strømfjord) which continues westwards for 120 km to the Davis Strait. Great tracts of similar land stretch away to the north, south and west with little to distinguish Eqalungmiut Nunât from the rest of the wide undulating plateau. The land is spectacular and fairly uniform, with skylines subdued by recent glaciations and poor soils supporting arctic heaths and grasslands, but it has a completeness and subtlety no longer found in western Europe: the incomparable beauty of an isolated land left to function in its own way remains. Distant hills looked sharp and bright through incredibly clear air, the pre-spring silence was startling and the freedom of an 'empty' land revitalising.

From the air Eqalungmiut Nunât looks almost bare; the bands and fractures of its bedrock dominate the surface and vegetation seems insignificant. Even at ground level, the land appeared almost dead when we arrived in May; a dry brown litter covered the hard frozen soil. As the summer progressed migrant birds arrived, fresh grass appeared above the dead mat and the hillsides developed a green sheen, but in comparision with more temperate regions life is neither profuse nor varied. Considering the richness and beauty of Eqalungmiut Nunât, it is tragic that so little equally unspoilt land exists in our own countries.

Most of the region is plateau, a stony terrain of whaleback ridges, low crags, damp gullies and hundreds of lakes. The windswept hilltops, up to 600 m high, are ice-smoothed, lichen-encrusted outcrops of bedrock strewn with glacial erratics and inhabited by white hares. The plateau never seemed austere; below the rock-beaded skylines the slopes were thinly mantled with coarse frost-heaved soils which allow a scant and brief bloom of arctic flowers; boulders and crags are alive with Snow Buntings and Wheatears; the lakes are dark but never dull. The views from the plateau strengthen the sense of space and isolation, row after row of similar ridges in every direction scarcely faded by the great distances. To the east the land is engulfed by the long white dome of ice towering smoothly above it, but otherwise the view is clear, the only break in the uniformity being the coastal mountains near Sisimiut (Holsteinsborg) 100 km distant. In the spring, shaded snow banks give the impression of extensive snowcover to the south contrasting with the bold bare slopes in other directions. While the lake ice remained intact its brilliant white was set off by the brown land; the largest lakes were white plains stretching between hills, tranquil and remote. As the thaw progressed the ice became water-logged and fragmented, drifting slowly from the shore in dwindling rafts of chiming fragments.

In a few places the plateau hides deep and narrow gorges, the dramatic haunts of falcons. Most are nearly dry, littered with fallen slabs, but one concealed a large river and powerful waterfall.

Not all Eqalungmiut Nunât is plateau; there are also broad lowland valleys particularly in the south, with long, even, grassy slopes and stretches of low willow scrub and many small streams. They are more sheltered than the plateau and noticeably warmer; on sunny days an intense heat-haze developed and the landscape shimmered. The soils are deeper and bare ground is relatively scarce, with Caribou scattered across the slopes and high densities of Lapland Buntings and Redpolls reflecting the high productivity. The lowland terrain includes small marshes, patches of early green where Phalaropes nest and the White-fronts feed in May and June. Magnificent Great Northern Divers and Arctic Char inhabit the broad lakes that cover the floors of lowland basins. To the south, the valleys end, steep escarpments and cliffs rise abruptly and the plateau begins again; the damp slopes are streaked where water darkens lichen-covered rock or seeps through bright mossy vegetation.

The two deepest valleys are the glacial troughs bounding the region; milky meltwater flows copiously down them in braided channels meandering over wide silt flats. These valleys are dry with tracts of dunes on sedimentary terraces alongside the active flats and dust storms are frequent during föhn gales from the ice sheet. Downstream the flats become tidal and grey water creeps over them twice a day bringing reflected light and the strange high-pitched cries of white gulls from the blue fjord.

B 2 A GENERAL DESCRIPTION OF EQALUNGMIUT NUNÂT

J. Floyd

GEOLOGY

Origins

The rocks underlying Eqalungmiut Nunât determine many features of its landscape, and their structure is best understood through their history. The region is part of the Nagssugtoqidian mobile belt, a 300 km band crossing central Greenland which extends on the west coast from Kangerdlugssuaq to Disko Bay. The belt was part of a larger continental plate formed between 3 800 and 3 000 million years ago. It underwent major metamorphism between c.2 700 and 1 700 million years b.p. when the rocks were reheated and the whole region was subject to ductile shearing so that the variously orientated formations were attenuated and aligned to the ENE. The movement also caused limited thrust faulting with the same orientation; North Valley is associated with such a fault. In Eqalungmiut Nunât alignment is pronounced and narrow bands of rock dominate the region. In the main they are steeply tilted, folds formed before the shearing have been steepened and their axes conform to the general orientation.

Rocks

The rocks have been classified according to their grade of metamorphism as granulite facies gneiss and amphibolite facies gneiss, with the exception of two minor formations of distinctive rocks (Figure B2.1). This is a great simplification since the major categories include rocks with a wide range of composition. Most rocks show gneissic foliation as well as banding on an intermediate scale and frequently exhibit flow-style folding.

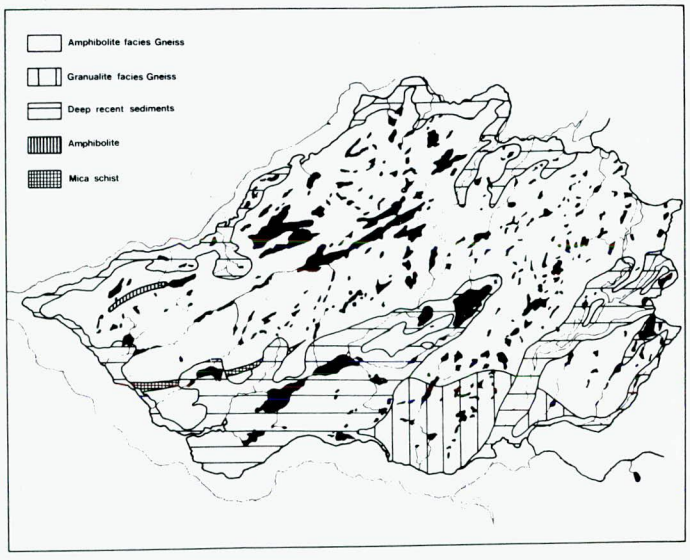


Figure B2.1. The major rock-types of Eqalungmiut Nunât, west Greenland.

We came across a formation resembling marble not published on maps and other equally distinctive formations may well remain uncharted.

Faults and Folds

Changes in the geological structure since 1 700 m.y.b.p. have been relatively minor but are significant for the present landscape. No younger rocks have been preserved, but the existing rocks have been deformed and fractured by Tertiary and Mesozoic earth movements. The region is crossed by many faults, most of which are orientated between north and north-east (Figure B2.2). Displaced bands of resistant rock now form crags and the impressive spurs thrust out from the southern slopes of North Valley, showing that in many cases, land to the east has moved north relative to that on the west. Fault scarps such as the series of three from 627 m through Foxtrot to X-ray Pass indicate that the eastern land has also risen, perhaps as much as 200 m along some faults. The southern slopes of the Eqalungmiut tasê lowland complex and the Atanârssuk valley may be a series of scarps produced by a large fault aligned with the rocks to the ENE, but glacial erosion and sedimentation obscure the geological structure at these sites. Folding since the last metamorphism has been limited, but there is a large synclinal curve in the north face of Îmajuitsoq which is at odds with the general orientation and other similar folds may have been overlooked.

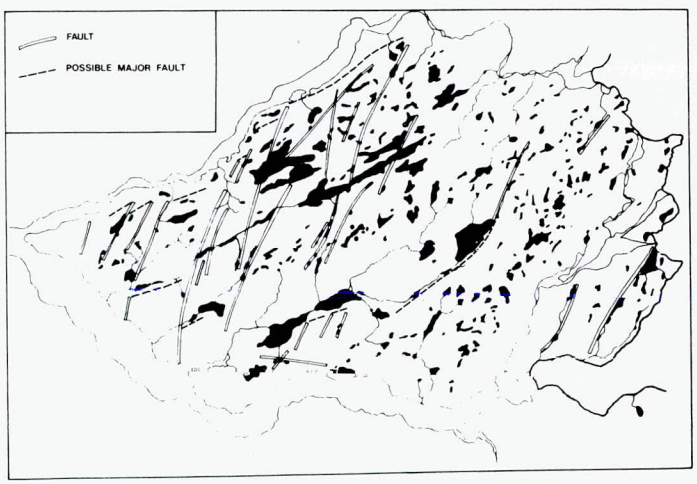


Figure B2.2. Prominent fault-lines identified in Eqalungmiut Nunât, west Greenland.

Positioning

The region's rocks were metamorphised deep within the earth's crust and reached their present position following the series of plate movements that culminated in the opening of the North Atlantic about 80 m.y.b.p.. Through these aeons the overlying rocks were slowly removed by erosion. High plateau remnants around 2 000 m above sea level in the Manîtsoq (Sukkertoppen) and Qaqortoq (Julianehâb) districts mark a late Tertiary sea level, but all of this plain has been removed in Eqalungmiut Nunât. The undulating plateau is suggestive of a poorly preserved, later erosional surface that has been uplifted and forms the basis of the present landscape.

Isostatic Uplift

During the last glaciation the region was depressed by the ice sheet, now it is rising again. Raised marine sediments beside Afon Char upstream from Manx Lake, between 25 and 40 m a.s.l. mark the shoreline at an early stage of deglaciation. They contain shells of the bivalves *Mya truncata* (L.), *Chlamys islandica* (Müller) along with a barnacle, possibly *Balanus balanus* (L.). Weidick (pers. comm.) has dated shells from the terrace 12 m a.s.l. at Pass of Jennings Dunes as 5630 ± 110 years b.p.. Similar deposits have been found to the north of the region which indicate isostatic uplift of up to 100 m. Terraces of relic sandar in the North and South Valleys were deposited near sea level later and are now about 10 m a.s.l.. The uplift may have involved some tilting; the large lake Gemini appears to have discharged through a well preserved melt-water channel to its south until relatively recently, but now drains north over a ridge (at almost the same altitude) which shows little fluvial erosion.

BEDROCK TOPOGRAPHY

Glacial Erosion

The present landscape has been sculpted by the processes of weathering and erosion, of which the repeated abrasive and plucking action of glacial ice has been by far the most important. Over most of the region, the ice probably advanced on a broad front, scouring the plateau from east to west, erasing details of the pre-glacial topography and eroding the surface to an extent dependent on the underlying rock. Resistant formations are now whaleback ridges, with smooth bare summits scratched by the ice, and craggy lee slopes where large blocks have been plucked away. Weaker rocks form depressions that are frequently overdeepened and now contain lakes. The resulting relief reflects the geological structure, a furrowed surface of parallel ridges and basins, crossed by grooves along faults that have been etched out by the ice. Fault scarps aside, the plateau relief is relatively slight, in the order of 150 m, but in some places, glacial erosion has been more intense. The North and South Valleys have been straightened and deepened to below sea level by streams of rapidly flowing ice. Both have steep sides, particularly to their south, and their upper reaches are occupied by short outlet glaciers from the ice cap. North Valley deepens steeply from 200 m to near sea level 6 km from the ice where the true glacial trough begins, a common but poorly understood feature of valleys of this type. At Niaqorssua, the valleys merge to form the southern branch of Nagssugtôq which runs 120 km to the coast. It has been suggested that the positions of the west Greenland fjord valleys were determined by major faults; this is true of the western 30 km of North Valley which runs ENE along a straight line which continues as a smaller trough into Ugssuit Nunât where the main valley veers east.

Some valleys are difficult to fit into the simple scheme of glacial features: the Atanârssuk valley is long and up to 300 m deep, but lacks the regularity of a glacial trough and follows the ENE trend; it seems to result from a line of weak rock, perhaps a fault which produced the steep southern slopes as a fault scarp. The Eqalungmiut tasê lowlands, along with their extensions around Hookwater, Large Lake and Rimwater are a major feature, up to 450 m deep and extending for 20 km; they are difficult to explain. It is tempting to identify their lower reaches with a glacial trough, but their relationship with the shallower surrounding valleys suggest that the ice took advantage of part of a preglacial valley system or a complex of weak rocks associated with the unidentified geological formation suggested by the possible fault scarps mentioned above.

Fluvioglacial Erosion

Other types of erosion are too slow to greatly change topography since deglaciation. Running water has eroded bedrock on a smaller scale than ice and its action is localised, although in some places it has cut impressive features. As the volume of precipitation runoff is small and its erosive power slight, all substantial fluvial erosion is due to the debris-laden meltwater that flows copiously from the ice cap. While the region was glaciated, grooves were cut by water flowing beneath the ice under hydrostatic pressure. In the main, they are shallow ravines that follow faults on the plateau for short distances, but in a few cases, large subglacial meltrivers have cut deep gorges such as those north of Foxtrot and Hookwater, both of which follow faults. Gorges were cut where ice-dammed lakes overflowed (Gemini has two of these, Mirrormere has one) and anywhere that a major meltwater channel has dropped rapidly or crossed over weaker rocks, as at the Atanârssuk outflow, Bean outflow and Barrier River Gorge. The latter is still active with a high and powerful waterfall.

Minor Form of Erosion

The most important type of contemporary bedrock erosion is mass wasting that slowly removes debris downhill. In a few places, whole hillsides appear mantled in shattered rock, but the effects have been slight, a gradual rounding off of topography, progressing little since deglaciation.

The only other type of bedrock erosion noted was local and minor; an outcrop of soft granular rock with intricately curved hollows and arches probably formed by wind.

Resultant Topography

The bedrock topography is complex, but uniform on a large scale due to the relatively few factors acting on it. Most of Eqalungmiut Nunat is an undulating plateau strewn with elongated lakes, low crags and smooth ridges, crossed by steep-sided furrows. In some areas, these features are large enough to divide the plateau into blocks or disrupt the landscape of alternating ridges and valleys. The plateau surface has been influenced by faults, the attenuated geological structure and the passage of glacial ice; all these have specific orientations, readily apparent in the landscape. The plateau ends abruptly at North and South Valleys and more gently about the Eqalungmiut tase lowlands. In these valleys, the slopes are covered by sediments and the bedrock irregularities and floors are dominated by sediments, lakes and meltrivers that are discussed below

HYDROLOGY

A relatively thin layer of materialweatheredand eroded from the bedrock covers the land to tens of metres depth in places, but on the plateau up to 20% of the surface is bare. The over-burden is intimately associated with water and it is useful to consider the movements and transformations of water in the region.

Inland Ice Sheet

The ice cap rises smoothly, reaching 1 000 m in 6 km, its edge dark with rock debris and heavily crevassed, but further out isolated grids of crevasses show as tight arrays of pinnacles. Further still, the crevasses peter out and turquoise lakes and meandering rivers sparsely pattern the bright snowfields.

Meltwater

Meltwater is already channelled on leaving the ice cap, with streams flowing down the surface of the ice or appearing within it and large rivers emerge from cavernous tunnels and extensive subglacial drainage systems. Marginal and submarginal channels follow the ice edge, often through lakes before reaching valleys leading away form it. There are three routes: the North and South Valleys contain large braided meltwater channels and between them a system of meltrivers drains south-west, remaining within 5 km of the ice, and joins South Valley near the snout of Inugpait qûat, isolating Amitsuarssuk from Eqalungmiut Nunât.

The flow of meltwater varies throughout the year; it is minimal or non-existent in winter, increasing through summer to reach a peak in August when temperatures begin to fall again. Meltwater was already flowing when we visited South Valley on 8 May, although the cycle is sometimes interrupted by surges caused by the sudden drainage of reservoirs within the ice or lakes along its margin. Barrier River flows over a bed of rounded boulders that are much too large for its normal volume, including rocks over 1.5 m in diameter, which could not have been moved in its normal condition. One marginal lake marked on our maps was empty of standing water, a sparsely vegetated zone around another showed its level had fallen by about 15 m in recent years and as we flew from Kangerdlugssuaq over a similar region we saw bare ground and stranded blocks of ice where a marginal lake had very recently emptied.

Runoff

Permafrost restricts free water to the active layer which is easily saturated, so surface water is common once the thaw has begun. Fluvial erosion has been slight so rivers have irregular profiles, lakes are numerous and the drainage pattern has been determined by glacial and fluvioglacial action. Much of the drainage system was previously occupied by meltwater and many streams are overshadowed by their course, almost hidden beneath rocks deposited earlier.

Tidal Water

All runoff and meltwater that does not evaporate eventually flows via North and South Valleys into Kûp Akua, the southern branch of Nagssugtôq. The fjord is tidal and saline, freezing for a relatively short period, being ice-free throughout our stay. The meltwater and seawater mix in broad swirls and the upper surface is streaked when the tide covers the South Valley flats twice a day up to 10 km from permanent seawater at Niaqorssua.

Non-glacial Ice

The annual cycle of runoff is controlled by the winter freeze which immobilises all rivers. Many forms of ice occur. Snow falls throughout the year, accumulating in wind compacted drifts only in winter and cover then may not always be complete. Permafrost seemed continuous although in many places the active layer reached the bedrock and was probably over a metre deep. We were seldom able to observe the permafrost structure, but an isolated horizontal band of ice 2 m thick was exposed in a sandur terrace undergoing rapid erosion by meltwater near Inugpait qûat. Rivers freeze each winter; when ice begins to restrict their flow, the banks are flooded and, as freezing continues, thick plates of layered columnar ice crystals called aufeis accumulate. The North and South Valley sandar are covered by aufeis in winter and we found an accumulation 2 m thick where the Atanârssuk outlet emerged from its gorge. Aufeis is visible there and at a similar site on the Mirrormere outlet in aerial photographs taken in 1948; perhaps these large lakes release water during the freeze so that aufeis builds up to an unusual depth. When rivers thaw, they normally flow beneath their ice first, undercutting it until it collapses into often massive slabs, although the river at Raven Chasm hurtled over thick ice in a deep channel. Aufeis sometimes flattens the stones beneath, making a pavement as noted at the Atanârssuk site.

All lakes freeze over in winter; when temperatures fall further, contraction fractures form and freeze over, so on warming the ice expands and pushes against the shores, often raising a small embankment or "ice-rampart": the best example of this being Rimwater.

SEDIMENTS

Glacial Deposits

Most sedimentary material has resulted from the glacial ice, so the history of present day deposits begin with deglaciation. Ten thousand years ago, the whole region was under ice, and moraines 10-15 km west of the ice cap show its position between 9 500 and 7 500 y.b.p.. Deglaciation has occurred in a series of fluctuations and it is likely that more land than now was exposed at the climatic optimum 1 500 y.b.p.. Away from the glacier snouts, little change has been noted during the historical period, but Inugpait qûat has retreated 400 m since 1920. This "trim-zone" of lichen-free rock that varies in width up to 10 m indicates a recent exposure at several points along the margin.

The ice has left a margin of till covering most areas to varying depths. Glacial erratics are dotted over the whole region; ranging in size up to monumental blocks over 5 m high. Many have been split cleanly into two or more pieces, a phenomenon supposedly caused by decompression after release from the ice.

There are many more ordered moraines, but they lack clear orientation and it was difficult to classify or interpret them. The largest runs along the neck of Niaqorssua and is a medial moraine forming where the North and South Valley glaciers merged. Long, sharp-crested marginal moraines follow much of the ice margin and elsewhere heaps of broken rocks have a complex relationship with the ice; they cover a band several hundred metres across at the glacier snouts. Many fresh moraines are ice-cored and the ice margin is not always distinct, collapsing if deglaciation continues.

Fluvioglacial and Fluvial Deposits

Meltwater has a high sediment load, making fluvioglacial deposits extensive. The North and South Valleys contain sandar stretching from Nagssugtôq to the ice and sandar fill smaller basins near the ice. Meltwater flows over the unvegetated flats in wandering braided channels, but vegetation covers inactive sandar. Relic sandar dating from earlier, higher sea levels form a discontinuous terrace up to 1 km wide and 15 m high alongside the North and South Valley sandar which is still being actively eroded where meltwater flows against it. On relic sandar, particularly on the North Valley terrace, kettle-hole lakes are common, the result of buried fragments of glacial ice leaving hollows after melting. High level dunes on the plateau were probably the remains of old marginal fluvioglacial deposits. Considering the number of recent deposits by the present ice margin, they were surprisingly uncommon, perhaps because of their vulnerability to erosion in their exposed positions.

The limited sediment load of precipitation runoff forms only small lake deltas, the most striking of which are at east Eqalungmiut tasia, Spidermere and Yankee, but elsewhere fluvial deposits are insignificant.

Wind Deposits

The active sandar provides a large source of fine particles and during the föhn gales 400 m high clouds of sand and dust were visible drifting down South Valley. Wind-borne sediments are of two grades, fine 'rock-flour' and sand.

Sand transport is limited to the immediate surroundings of the sandar where there are large tracts of dune systems. Much of the area under sand is mobile and very sparsely vegetated with 'hedgehog dunes' stabilised internally by *Salix glauca* bushes, but elsewhere, e.g. Pass of Jennings Dunes, they are densely vegetated. The dunes are continually modified by wind; in some areas the vegetation is fragmented, erosion predominates and flat areas of bare sand identify totally decayed systems. Fluvioglacial terraces provide platforms on which dunes grow protected from the action of meltwater, but in places, as at Kûk Dunes, the upper reaches of North Valley and elsewhere, dunes spread onto active flats displacing meltwater. Dune systems are concentrated on the northern shores of both major sandar since most gales are south-easterly. There are also dunes alongside smaller sandar up to the ice-cap.

Slope Deposits

Hillside sediments from any source migrate downslope in several ways and are best treated separately. Movements can affect whole hillsides, filling irregularities and producing regular slopes. Gelifluction is common on the steeper slopes; the vegetation is ruptured and the saturated active layer flows downhill in long narrow lobes terminating in piles of soil and moss exposing the underlying soils, indicating rapid movement. On gentler slopes, gelifluction is slower and evidence for it is scarce; broad gravel lobes topped by thin strips of vegetation were found at two sites. On the broad even-sloping edges to the Eqalungmiut tasê lowlands there are numerous sub-parallel streams which over a long period affect most of the hill-sides. Early in summer, ground ice immobilises soils and streams flow below the surface; later, as the ice supporting the banks and passages thaws, slumping is common and much sediment is carried downhill. It is difficult to assess the importance of other types of mass wasting. Falls of ice-shattered rock and loose soil were evident on the steepest slopes; at the base of cliffs there were piles of talus (mostly vegetated) and sometimes large blocks; most gorges were floored with great fallen slabs. Surface washing is most apparent around late snow patches which provide a steady supply of runoff, inhibiting vegetation cover and sometimes excavating nivation hollows.

Slope deposits can be classified into two types depending on their gradients. Steep slopes are dominated by gelifluction, usually saturated and with a loose mossy flora. On gentler gradients, deposits are generally deeper, drier and dominated by small streams. Their flora is grassy with *Salix glauca* along the streams and they are amongst the most productive habitats with high densities of passerines. To develop fully, they require long slopes which were relatively rare, but there were extensive examples in the Eqalungmiut tasê lowlands, around Marble Gorge and Rimwater as well as in two valleys in the north of the region.

Patterned Ground

Sediments are sorted in situ in periglacial environments in ways that are poorly understood, producing patterned ground in some circumstances. In the coarse plateau soils sorted circles and stripes are common although generally indistinct. The 1-2 m diameter circles are rings of large particles and stones, elevated and about 50 cm wide, enclosing a low sparsely vegetated circle of finer sediments. Sometimes these gravel circles occur without a raised border. On slopes, circles are distorted by frost creep to form stripes. Turf-covered hummocks, about 30 cm broad and high are also common on the plateau and occur in large numbers on the damper and finer soils. Ice wedge polygons are widespread but scarce in damp valley bottoms at low altitudes. They are several metres across, marked by straight grooves 20 cm deep and 40 cm across which overlie ice-filled fissures beneath. The narrow contraction fractures which initiate polygons are visible at a few sites. Segregated ground ice also formed a single mound in a marshy stream gully on the slopes north of east Eqalungmiut tasia. It was roughly circular, 7 m in diameter and 1 m high with a clear ice core, covered by thin mossy vegetation, that was freshly fractured indicating recent uplift. Many types of ice-cored mounds have been described but their classification is confused and their causes uncertain, and it does not seem possible to identify this one on the basis of our observations.

Soils

The chemical and biological processes involved in soil formation are slow in the arctic and ice-induced sorting interferes with vertical stratification, but nevertheless soils have formed, even near the ice cap where they are coarse and barren. On the higher, better-drained ground there are coarse mineral soils with little humus or stratification. They are usually thinly vegetated because of the exposure factor and perhaps because of the leaching effect. Where drainage is poorer, soils have a darker peaty layer covering paler mineral material. Organic matter accumulates despite low annual production because of slow breakdown. The litter of previous years was still largely intact and clearly visible in August.

CLIMATE

Temperature

Eqalungmiut Nunât is 120 km north of the Arctic Circle and the sun is clear of the horizon from 7 June until 13 July, but it is always low in the sky so mean annual temperatures are low. The ice cap exerts a continental influence, with the sea 120 km away beyond the coastal mountains and frozen in winter, resulting in a large temperature range. Winters are very cold but summers relatively mild, with mean temperatures around -20°C in January and 7.5°C in July.

Wind

The thermal properties of the ice do differ from those of the land; it imparts little warmth to the air, so convection is weak and the sky above it is usually cloudless. Deep temperature inversions often develop above it, particularly in winter, and combined with the height of the ice (up to 3 000 m) constitutes a barrier which reduces the frequency and intensity of depressions and associated wind and rainfall. The inversion is disrupted when depressions do pass over, but during the intervals between them cold dry air drains off the ice, veering clockwise by the earth's rotation and warming as it descends. Powerful south-easterly föhn gales develop; we experienced two during our stay, 11-12 June when the wooden hide blew away and winds of 83 km h^{-1} were recorded and 16-17 July, although at other times winds were generally light. Lenticular clouds on standing waves set up by the hills appeared during the föhns and create spectacular skyscapes. South-east is the commonest wind direction with north a close second (see Section J).

Precipitation

Rainfall is low; we recorded 133.4 mm at Base Camp between 8 May and 20 August. This is probably a large proportion of the annual total because during this period when there is no pack-ice on the sea, the ice cap inversion is least stable and the maritime influence greatest. The June and July readings were both just over 50 mm, while snow fell up to the first week of July and was recorded again in mid-August.

Microclimates

Local climatic variations are marked and ecologically important. The sites of late snow-banks show clearly the effect that aspect has on temperature because of the low sun, and the thaw's progress also showed the importance of altitude; lake ice remained over a month longer on the plateau than at sea level. The effect of shelter was less obvious but in crevices and gullies vegetation was luxuriant and some species were confined to sheltered sites so exposure to wind is limiting for some plants.

References

To avoid fragmenting the text, no direct references have been used; the interested reader is referred to Embleton & King (1975a, 1975b), Escher, Sorensen & Zeck (1976), Ives & Barry (1974), Mason (1977), Sugden & John (1976), Washburn (1979), Weidick (1968) and Gordon (1981).

B 3 AN ACCOUNT OF THE TOPOGRAPHY AND HABITATS FOUND NEAR BASE CAMP

A. D. Fox & D. A. Stroud

INTRODUCTION

Base Camp was situated in a gully alongside the Eqalungmiut tasê valley complex 9 km from the fjord to the south. The site was chosen because of the proximity to the Drop Zone (DZ) and its suitability as a centre of activities, giving easy access to the plateau to the north and the low-lying areas to the south and west.

The landscape of Eqalungmiut Nunât is a developing one (Section B2) characterised by thin soils and generally poor nutrient status. Large areas of the uplands are covered by dry 'barren' communities dominated by *Dryas integrifolia, Diapensia lapponica, Vaccinium uliginosum* and *Salix glauca*, the low-arctic heath vegetation typical of the region (see Section I1). Goose Valley (the area comprising the river system draining Upper Marsh through George Eliot to Kûk Marshes) and the surrounding lowlands were strikingly different from the plateau. (Throughout this report, the lowlands will refer to land below 200 m, see Figures B3.1 and B3.2) The main features in this area were Kûk Marshes, Goose Valley, Eqalungmiut tasê and the Ridgeway Marshes. The Imajuitsoq/Angmat complex (610 m and 428 m respectively) form a highland island amidst the lowlands extending south to the glacial melt river draining the Inugpait qûat glacier. A generalised map of the vegetation communities present is shown in Figure B3.3.

LOWLANDS

The vegetative production of the lowlands far exceeded that of the plateau. In dry, flat sunny areas, the dominant community was *Calamagrostis purpurescens* grassland with a ground layer of *Aulocomnium turgidum, Polytrichum spp.* and *Tortula ruralis* with other bryophytes and containing many herbs such as *Stellaria longipes, Campanula gieseckiana, Cerastium alpinum* and *Draba glabella* and scrub of *Salix glauca* and *Betula nana* (Figure B3.3). On arrival in May, all grass slopes were covered with litter from previous seasons, which acquired a green sheen as the sward began to develop in mid-June, although it was not until July that the new grass and herb cover came vigorously through the dead remains. Thus, during the period when the geese were present in the lowlands (Section D1), production in non-aquatic vascular plants had largely to commence.

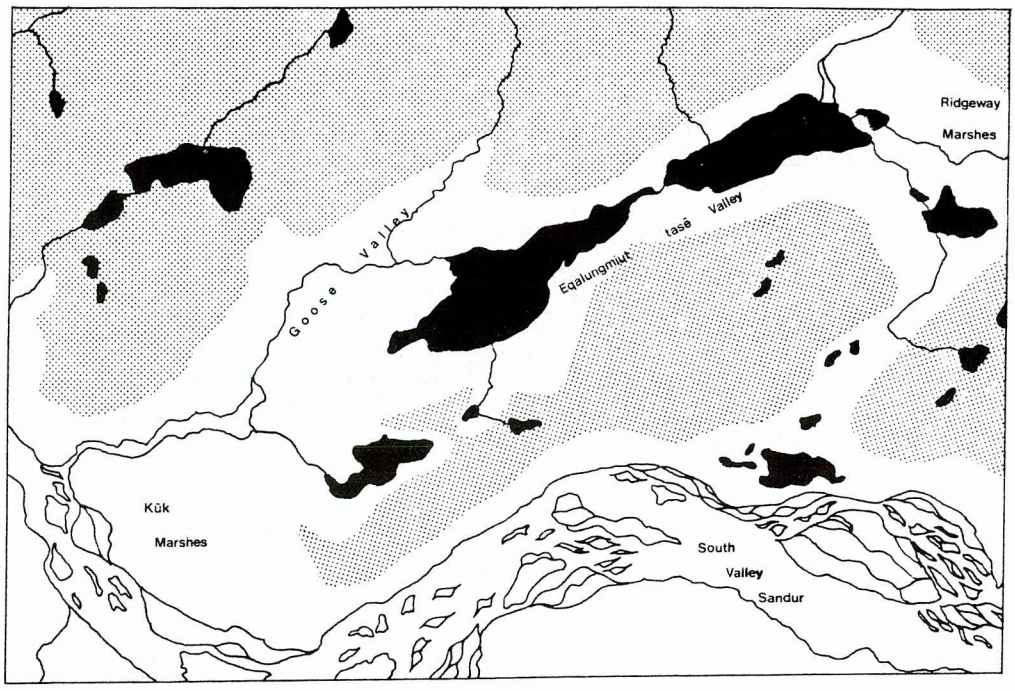


Figure B3.1. Lowland areas around Base Camp in the south of Eqalungmiut Nunât. Shaded area indicates land above 200 m.

The most obvious factors affecting vegetation patterns in the lowlands were aspect and drainage. On the south-facing slopes below DZ and particularly below False Eyrie Crags, there were extensive stands of *Salix glauca* growing up to 2 m height, petering out with the lessening of gradient into the herb-rich grassland below Needle Cairn Heights. This in turn graded into more heath-dominated communities with *Salix herbacea* and *Betula nana* as altitude increased closer to Base Camp where the *Salix glauca* thicket was absent. Small streams running down Needle Cairn slopes were marked with *Salix glauca* scrub which showed up clearly on aerial photographs. On the north-facing slopes below Imajuitsoq and the Angmat ridge, the grassland merged into *Empetrum*-moss mat (Trapnell 1933) with *Aulacomnium turgidum* the predominant ground cover, as well as much *Peltigera aphthosa* and relatively little vascular plant cover, although *Vaccinium vitis-idaea, Ledum palustre* and *Betula nana* were frequently present. This was the typical community associated with all steep northerly slopes and areas of late snow-lie at lower altitudes in Eqalungmiut Nunât.

The inland regions of west Greenland close to the ice-cap experience a continental climate, with dry winds from the ice-cap anticyclone. The rainfall is low since the area lies in the rain-shadow area of the high coastal mountain ranges. Impedance of drainage is an important determinant of local vegetation patterns. Trapnell (1933) discusses the effect of climate and physiographic factors on the west Greenland vegetation, and should be referred to for more detailed information.

Upper Marsh

From Top Tarn, a stream flowed from the plateau down Goose Valley; the flow at all times was slight considering its catchment area and in August became a trickle like so many other streams. Beside Base Camp, it entered Upper Marsh, an area of some 0.5 km^2 extent, probably an old moraine terrace blocked at one end by a moraine ridge forming a marshy area with predominant *Sphagnum*-moss cover. *Eriophorum angustifolium, E. scheuchzeri, Carex bigelowii, C. rariflora* and *Salix arctophila* were also present with *Hippuris vulgaris* in the stretches of ponded water about the periphery. At its western end, the stream flowed through thick *Salix glauca* scrub, underlaid by *Calamagrostis spp.* and frequently dense mats of *Mnium spp.*, the only discontinuity in the grass sward of the well-drained slopes below the Upper Marsh area.

Goose River and George Eliot Marsh

Below Upper Marsh, the stream passed down into a wetland known as George Eliot. This was different to the higher marshland, being generally drier, although, during the main period of the melt, it became difficult to cross, while never completely flooding. The wetland contained several large pools set away from the main area of stream flow below the foot of Needle Cairn slopes. The stream was deeply incised at the top, eastern end of the wetland. The vegetation was wet grassland rather than true marsh, although there were some extensive wet flushes of *Carex, Eriophorum* and *Sphagnum*.

The outflow of west Eqalungmiut tasia drained from Aberchar to join the Goose Valley stream at Riversmeet, a generally flat area with several large meanders in the course of both streams.

George Eliot was separated from the western lake by a ridge, the north side of which was steep and covered in *Empetrum*-moss mat. The south side had exposed rocky outcrops, running parallel to the lakeside above Aberchar, which were frequented by Snow Buntings, Wheatears and Arctic Hares.

Afon Char

Further down the valley, the river, here called Afon Char, ran through the flat valley bottom with *Ledum palustre* and *Betula nana* amongst the grassland communities to the south and the

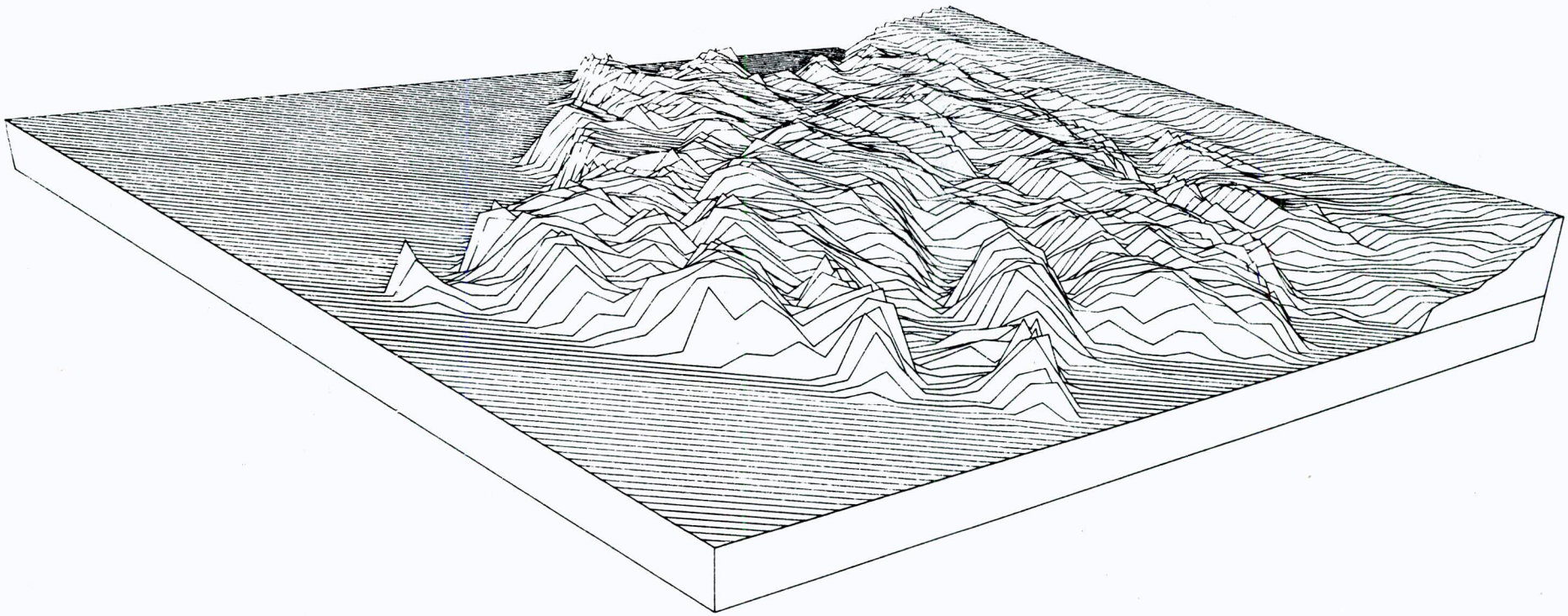


Figure B3.2. Aerial view of Eqalungmiut Nunât from the south-west, produced from the computer graphics of the Computer Unit at the University College of Wales using the SYMVU mapping package. Note that areas to the north and south are omitted.

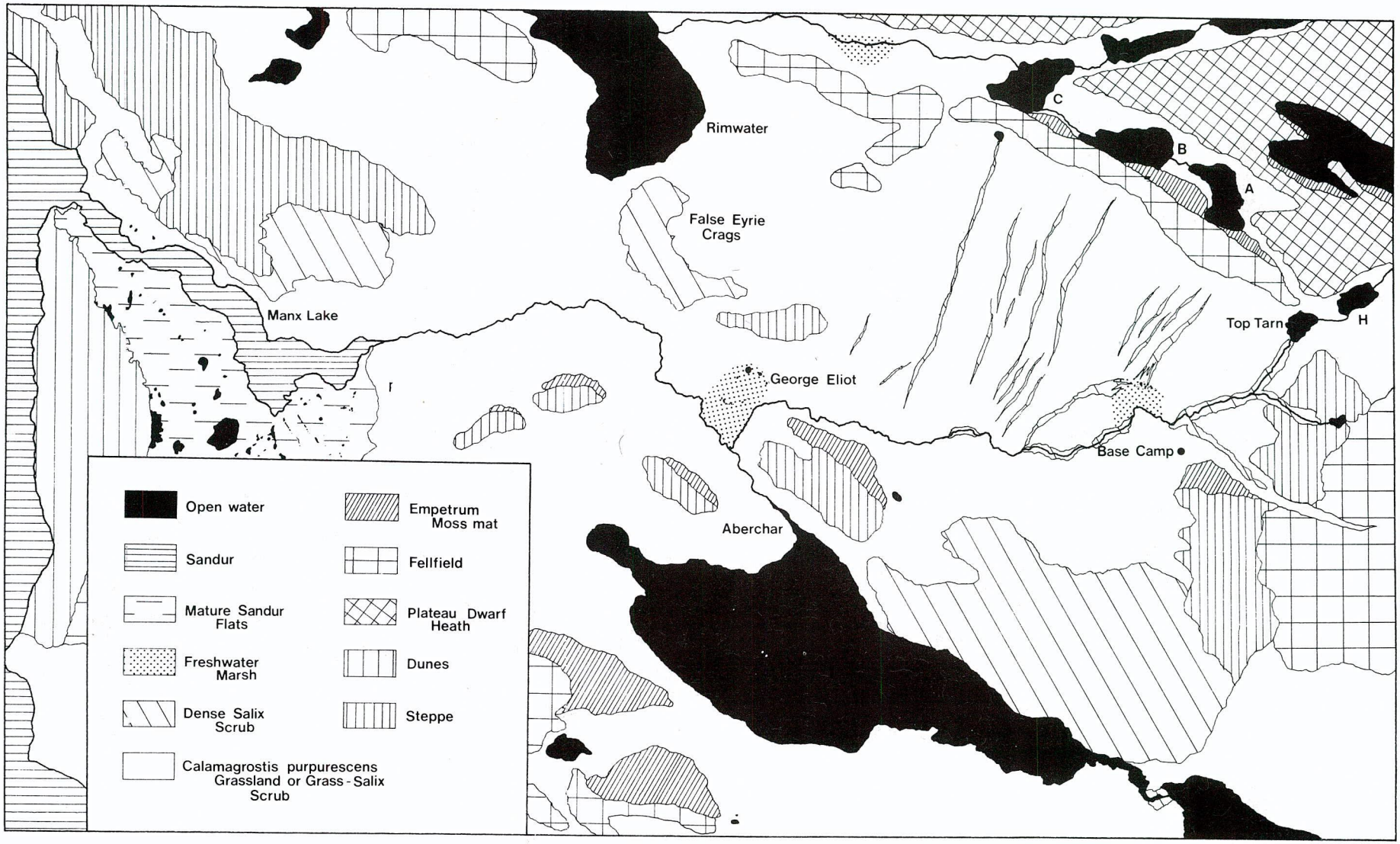


Figure B3.3. Generalised map of habitat types present around Base Camp.

Salix glauca slopes rising to False Eryie Crags to the north. Below Rimwater Saddle Pass, Afon Char dropped rather faster through a series of rapids to enter Manx Lake which was also fed by the Angmatwater outflow (Figure B3.1). Before entering the lake, the river cut through a sedimentary terrace, exposing a 10 m face of sediment to either side. This was the site of considerable instability, the open clay surfaces being colonised by *Puccinellia spp.* with an ecotonal band of *Lomatogonium rotatum* along the base of the faces. In the fine 'rock-flour' sediments were numerous shells of *Mya truncata, Chlamys islandica* and fragments of a large barnacle (*Balanus ?balanus*). These seem to be part of an area of marine sediments raised by isostatic uplift (Weidick 1968). The upper surface of the terrace was some 20 m above the present level of the fjord.

Kûk Marshes

Kûk Marshes consisted of part of the glacial melt river flats isolated from the main sandur flood plain by the Kûk dune system. The resulting wetland has developed into a series of brackish pools and areas of freshwater marsh of some 4 km^2 extent. The drier zones are characterised by grass and heath with much *Vaccinium uliginosum, Salix glauca, Betula nana* and *Calamagrostis spp.*, as well as much *Festuca rubra* rarely encountered elsewhere. There were considerable tracts of bare mud colonised by *Puccinellia spp.* (principally *P. deschampsioides*), *Triglochin palustre* and, on substrates of greater organic content, *Calamagrostis neglecta*. In addition, there were many pools of varying depths, often with sharply defined edges, containing *Hippuris vulgaris* and considerable algal growth.

One of the features of the marshes was a large (400 x 150 m), domed mud flat. Although open at one end to Manx Lake, it had no apparent inflow. The centre was raised some 1 m above the edges and was a favourite roost for the geese on the marshes in early May, lacking cover for Arctic Foxes. Faecal pellets from previous seasons suggest the area is not fully inundated, although the mud's relationship with Manx Lake suggests it was once an arm of the lake.

Kûk Dunes

The dune system of Kûk was 3 km x 1 km, separating Kûk Marshes from the braided glacial river. The dunes were clearly still actively accreting and probably spreading back to engulf the northern edge of Kûk Marshes. That they were still active was demonstrated by the many sandstorms that were seen over the dunes and visible for up to 10 km. These occurred whenever strong winds blew from the south-east, with deposits from the sandur and associated terraces up to 400 m into the air (estimated against surrounding hills). Nowhere did any stable, grey dunes occur, there being a sharp delineation between the unstable yellow dunes and Kûk Marshes, with very little evidence of dune stabilisation. None of the dunes possessed more than 50% plant cover and the species present were all typical of yellow dunes. In particular, *Elymus arenaria, Salix glauca* (forming large hummock formations), *Festuca rubra, Plantago maritima* and *Carex maritima* were all typical along the fjord edge. The damper hollows between dune ridges held *Armeria scabra, Juncus arcticus,* and *Calamagrostis neglecta*. In places, the wetter hollows held water throughout the summer, many supporting a variety of aquatic life; the small snail *Lymnaea vahli* was common in one pool.

The drainage river from Inugpait qûat consisted of heavily braided streams of varying sizes, winding across the sterile flats of mud and silt. These flats are known as sandar (singular: sandur) and are defined as alluvial surfaces formed by meltwaters away from glaciers. The channels of the river change frequently and there were many ox-bow lakes and similar features on the sediment surface. During a canoe trip across the main channel from Kûk, the banks of large meanders were witnessed eroding as was a large terrace along the valley further east. The sediments were of rock-flour, highly thixotropic in places, quicksands being most frequent along the edges of the sandur, possibly where less disturbed by erosion. When trodden upon, an upwelling of water indicated the dynamic tension; further towards the centre, the sediments were stable enough to walk on. In places, differing layers of sediments, probably of different particle size, were revealed in exposed faces, indicating changes in depositional processes in the past.

Although the middle area was safe enough to walk on, the peripheral quicksands were impossible to cross. Sediments covered with water were also safe to walk on, although the water was milky and opaque and the bottom often shelved, with the main channels probably extremely deep and very swift flowing.

The entire sandur south of Eqalungmiut Nunât was only very gently shelving towards the sea, and the semi-diurnal tide covered an area of some 8 km^2, from almost opposite the Gullery to the small island of Qerqertaq in the fjord near Eqalungmiut nûat; although the tide influenced the river levels upstream from this point, the river never covered anything approaching 50% of the valley floor above the outflow of Manx Lake.

Ridgeway Marshes

These constituted the third extensive tract of wetlands in the lowlands with George Eliot and Kûk Marshes. They lie in a large basin with streams entering from the Pass of Jennings, from the west from Ímajuitsoq and from the south-east down Willow Valley, being surrounded on three sides by Ímajuitsoq, Coogans Bluff and 410 m. The areas drained into the eastern Eqalungmiut tasia. The outflow into Eqalungmiut tasê had once been blocked by a series of moraines along the southern shore of the lake. However, the river from the marshes has since flowed through these making a deep cutting. The marshes were partially bisected by the Ridgeway, an area of raised ground running north-west to south-east.

At the north-eastern end of east Eqalungmiut tasia was another marsh with the river descending from Hookwater and Raven Chasm flowing across it, forming the main inflow into Eqalungmiut tasê. An outflow from a small pool formed a complex of streams and marshes here. The whole area around the east end of Eqalungmiut tasê was much used by geese in the latter half of May (Section D1).

Eqalungmiut tasê

Two lakes situated between Ímajuitsoq and the remainder of the Eqalungmiut Nunât plateau dominated the lowlands. They are fed largely from the east, with many small streams entering from the north and southern edges, draining slopes up to the plateau tops and drying up by August. The lakes were separated at Lakesmeet, where the outflow of the east lake dropped some 5 m in 150 m to the 10 m wide channel that eventually widened into the west lake. The braided outflow stream from the east lake passed through a series of boulder-strewn rapids, supporting a dense stand of

Salix glauca up to 3 m high with associated *Angelica archangelica*. (These two species were found in association by fast water courses; we should have named Lakesmeet 'Kuanerssuit' meaning the large or many kuan, the Greenlandic for *Angelica*). Along the edges of Eqalungmiut tasê there were small marshes where streams flowing down the hillsides spread out on to the small flat alluvial plains bordering the south-western end of the lake and on the northern shore of the east lake. This did not happen about the lake in the absence of flat plains of sufficient flow.

Rimwater Marsh

Rimwater Marsh was a flat area not strictly in the lowlands, with the outflow of Charlie Lake braided across it. In several areas near the southern edge, old courses of the stream could be made out by the string of pools. The vegetation was dominated by *Aulacomnium turgidum* but with *Sphagnum squarrosum* and other marsh plants and aquatic vegetation around the water courses and pools. *Eriophorum angustifolium, Carex rariflora* and *Salix arctophila* were found by pools, with *Vaccinium uliginosum, Salix glauca* and other heath plants present on the drier parts. The heaths merged into *Calamagrostis*-grassland on the northern slopes and into *Empetrum*-moss mat on the southern slopes.

B 4 OBSERVER DISTRIBUTION AND BIAS IN EQALUNGMIUT NUNÂT

D. A. Stroud

Our distribution over the summer in Eqalungmiut Nunât produced uneven observational cover. In order that the sightings bias of certain animals (e.g. Caribou and White-fronts) may be appreciated, Figure B4.1 and Table B4.1 show our distribution in detail. These give a rough guide to movements, and it is not attempted to calculate the distributions in fractions of man-days in any area. Thus squares may have been visited briefly and there may be no record of any man-days spent in it - where two observers spent a day equally in two or more squares (as on a walk), then a single man-day has been recorded for each square.

The diurnal bias in our observations was greatest in May when the cold and low light intensities meant most observers slept conventionally. In June, the continuous watch at the goose nest (Section D6) caused people to be about at all hours, while in late June and for the rest of the summer the mosquitoes forced some of those most severely affected by biting insects to adopt nocturnal activity patterns taking advantage of the minor lull in insect activity with lower night temperatures. This and the midnight sun meant that activities went on well into the small hours. Thus while data such as Figures F3.1 and E11.1 etc. are biased by observer activity, this is not as great as might be expected, although it cannot be quantified.

Table B4.1. Table of distribution of man-days spent in different parts of Eqalungmiut Nunât according to areas shown in Figure B4.1.

AREA	May	June	July	August	Total
A1			1	11	12
B1	35	14		12	61
B2			67	13	80
B3		3			3
C1	42	20	1	5	68
C2	136	213	243	183	775
C3		1	9		10
D1	3	8		4	15
D2			8	4	12
D3		1	14		15
E3		4		2	6
E4			1		1
	216	264	372	234	1086

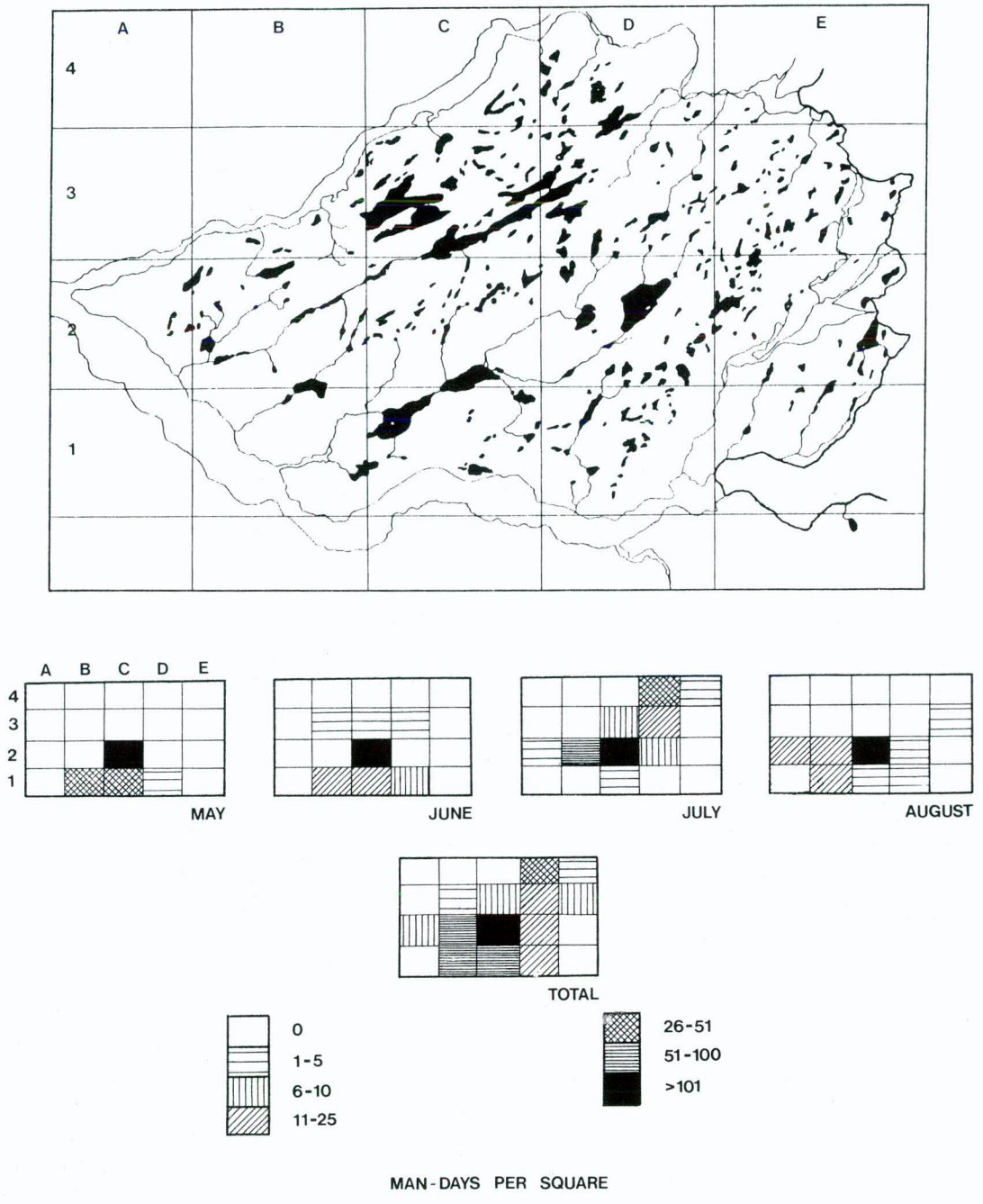
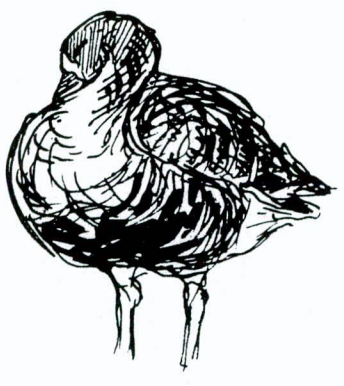


Figure B4.1. Observer cover in different areas of Eqalungmiut Nunât during summer 1979. The area has been divided by a grid, and the number of man-days spent in each square indicated by degree of shading.



C THE EXPEDITION: A NARRATIVE OF EVENTS AND OBSERVATIONS

How does one describe a landscape such as Eqalungmiut Nunât to those who have never seen the place? Any expedition provides experiences which lie beyond the scope of scientific papers, yet in their way are every bit as important as the critical analysis of collected data. An expedition account of bare science is as distorted as a collection of adventures and anecdotes. The group felt it important that some of our experiences be set out to complement the summary of our work and stand many of our observations in the context of their environment. Section C comprises this narrative account of our stay, linking the project through its preparation and execution. The section has been compiled separately by APF to whom the editors are extremely grateful.

C 1 LEADER'S INTRODUCTION TO THE EXPEDITION

A. M. V. Higgs

Few people are lucky enough to have the opportunity to fulfil their wildest dreams, yet this report is the work of twelve people who were able to do just that.

There were countless moments in the months leading up to our departure for Greenland when I doubted, if not our sanity, then at least our wisdom in expending so much enthusiasm and energy on such an impossible venture. In retrospect, I believe that it was our sheer naivety which broke down barriers that the more cautious would have assumed unbreachable.

This introduction tells how the expedition began and developed, shaped by an alarmingly powerful mixture of caprice and intent. It is written for all those who have the temerity to seek adventure, in the hope that I can show that anyone with a fair amount of imagination and determination can achieve all we did.

In September I returned from a short expedition to Iceland convinced that the only thing I wanted to do in life was go on expeditions. Since it was unlikely that anyone running a serious scientific expedition would consider taking me, I would have to start my own - the British Antarctic Survey would not have me (I lacked one vital quality), so I would go one better and go as far *North* as possible and "I'm going to Greenland" became the war-cry. I bought the only map of Greenland in Stamfords and learned the place-names. I wrote away for piles of tourist brochures. I asked everyone I met whether they wanted to go to Greenland, and generally behaved as befits one new to the business and thoroughly wet behind the ears. The fact that I was not deserted by my friends but indulgently supported and encouraged by them testifies more to their loyalty than to their wisdom!

Miraculously, the whole thing began to take shape, and by the end of 1977 two of the final members were recruited - Dave Stroud and William Higgs, both of whom I had met in Iceland, and who were now snowed under by their final examinations. Up to that time my idea had been a two-month scientific expedition, possibly biased towards a botanical study of an area (unspecified), my interest being more in the organisation - putting scientifically competent people on the spot to do the work - than the scientific findings themselves. During that Autumn, however, the entire expedition took, if not a 'U-turn', then a very sharp right angle bend. The cause was little more than a chance remark: "while you are there why not have a look at some White-fronts?" The next day I sought out Dave and Will - "Have you ever heard of something called the Greenland White-fronted Goose?" From that moment the world lay at our feet.

Will, a mad keen wildfowler, and Dave, an enthusiastic ornithologist, took the bit between their teeth and were off. The area we would visit was prescribed by the rather limited number of areas known to be frequented by the geese, and the timing by their breeding cycle. Our intent was now clear. We would go to Greenland to ring White-fronted Geese, and thus we recruited our first ringer, Andy Gosler.

Shortly after Christmas 1977 we had our first proper meeting and I was introduced to Tony Fox and Adie Fowles, both ardent ornithologists and particularly interested in the Greenland White-fronts which wintered almost in their back-yard, on the Dyfi estuary near Aberystwyth. To my anxiety I found that the 'bird-boys' had decided in no uncertain terms that the expedition was scientifically valid only if we extended our brief to a study of the breeding biology in all its details. This meant an extra two months in the field to give an awesome field time of four months, and for the first time I was seriously worried. A scheme for two months seemed hare-brained but feasible, an extra two months I was convinced would make the whole expedition founder. It was too ambitious even for me to swallow - or perhaps my ears were drying out?

However, there was no logical reason to disagree - the major cost of the expedition was transport and obviously this was unaffected by the length of stay. I had reluctantly to report that logistics, while strained, would not break down completely given the restriction that we stayed near the coast, and so the die was cast and the real work could begin.

Jobs were parcelled out to members, and we began the hard graft of planning the scientific campaign, fund raising and logistics. We even opened a building society account and began to receive personal contributions. Finals came and went, as did expedition members. Jobs were reallocated and by October 1978 we were left with a hard core of five people - often separated by hundreds of miles and yet miraculously held together by an almost fanatical purpose.

David had from the start taken on the job of defining the scientific projects and equipment. His library of photocopies became ponderous, and to my alarm he appeared to be dragging high technology into behavioural observation. He would emerge periodically with a new crack-pot idea, circuit diagrams and soldering irons, new theories and unending enthusiasm - in retrospect most of these paid off. Tony Fox took over the cheque-book and kept - and is still keeping as I write - detailed accounts of every transaction. He had the ability to keep the purse-strings tight and I feel it is the greatest compliment to him that every one of us, when we needed money for our project, wondered if we would be able to persuade him that our particular purchase was deserving.

Adie Fowles was more familiar with Chaucer than expedition equipment and yet, when asked took over the whole of the equipment ordering most diligently. He even mastered the delicate art of the sewing machine to put the finishing touches to our tents.

Will Higgs shouldered the thankless task of secretary like a man (unbiased statement) and kept the whole show on the road; he acquired information, permission and money by continuous effort over the best part of a year. Without his energy and drive we could not have achieved so much in so short a time. During this period we acquired our scientific advisers and received the patronage of Sir Peter Scott. We printed notepaper and a prospectus, and visited the Wildfowl Trust, where we were met with less scepticism than I would have expected. Our greatest compliment was "Well, at least you don't want to go *this* summer". We were promised Darvic plastic for rings, and then a great step - WAGBI promised a substantial donation. We had achieved credibility!

The office we had been so generously given by the Botany Department at Aberystwyth hummed with activity, correspondence and an ever rising tide of money as the fund thermometer rose imperceptibly into the "irresponsibility belt", where we didn't have quite enough money, but would go anyway, and cope with the consequences later! Then, after a successful interview at Kensington Gore with the Royal Geographical Society and the Mount Everest Foundation, leading to recognition from both, the money really began to roll in. With a leap we were home and clear, with enough money to send ten people and the thermometer still rising.

Two ringers, Phil Belman and Pauline Eddings, had been introduced to us and Phil took over the ringing arrangements from Andy who was by now facing finals and short of time. But we coveted a doctor. We just couldn't see how we could manage four months in the field without one, and so we placed an advert in the *New Scientist* and the *British Medical Journal*. More than any other statement I think this sums up the incredible optimism of the members at that time:

> "Expedition to Greenland requires medically qualified ornithologist/ ringer for four months end of April. Danish/Mountaineering advantageous."

Superman, as he was immediately christened, materialised in the shape of John Bell - not a medic, but with Antarctic experience, an unnaturally even temper, loads of common sense, and a penchant for heavy rock music and fast motorcycles. With the help of Dr Stroud he immediately took on the task of organising the first-aid and medicine chest. His patent cure for all ills was 'Senakot and Distalgesic'. Mercifully the threat was enough, and he never had to use either.

We began to forge contacts with Denmark and having found that written communication was a rather lengthy business, inserted an advert in the local student newsheet:

> "WANTED altruistic Danish speaker to make exciting phone calls to Greenland and Denmark."

Olaf Jones proved to be just that, and soon calls to those countries became commonplace. This culminated in Will's visit to Copenhagen to meet some of the people professionally concerned with Greenland. He came back with a large donation from the World Wildlife Fund (Denmark) and a Danish Ornithologist, Jesper Madsen, who proved to be an incalculable asset to the expedition as a linguist, a scientist and a friend. Shortly afterwards, the third ringer was recruited, Phil Davies, who started out convinced he was past it, and ended up passing the rest of us! The Irish connection was made by John McCormack, a resident of Wexford, where many of the geese winter. He turned out to be a prodigious stalker and the only man of the expedition to surround a lakeful of geese single-handed!

With a full complement of members spread about the countryside, fast communication became a major problem. It was decided that the regular meetings of those present in Aberystwyth should be joined via the telephone to any member with a problem, progress report, or a desire for the latest news. This gave me at least the impression that we were a unit of people working together.

The RAF, meanwhile, gave us a definite'maybe'to our request for transport on the most expensive leg of the journey, releasing money which could be used to hire a helicopter - which, together with the possibility of an RAF air-drop, meant that we were no longer tied to the coast. At the same time Jesper brought us exciting news from Denmark in the form of air-surveyors' sightings of a 'high density' of flightless geese in an area about 70 km north of Søndre Strømfjord Air Base. Should we change tack and go here or stick to our original intention of studying a coastal region at Sydostbugt, Disko Bay? We had made several friendly contacts in the Sydostbugten area but the reports of geese from there were vague and the terrain promised to be very difficult for walking. On the other hand there was nothing to show that the geese had actually bred in the more southerly region. We took a gamble, amid much discussion, and opted for Eqalungmiut Nunât, the Char-fisherman's Land, at the head of Nagssugtôq. We chose for our base a unique area of valley, lake and plateau in the hope that this terrain would provide a variety of habitats, at least one of which might suit the geese.

Back in Aberystwyth the food was mounting up and packing began - a mammoth packing-weekend and hours of dust-covered labour during the previous weeks had to be faced before this was completed. John Floyd spent the following weeks either up to his eyebrows in powdered milk or wielding an engraving machine making over 700 Darvic rings. Life moved apace! Maps, rings, and aerial photographs came in from Denmark. The hide and canoes were built in Essex and the equipment was slowly brought together from all corners of the country. We were given a radio course by Racal-Tacticom in Reading, and a first aid course in Aberystwyth. Fibre pile suits were cut out of a vast carpet-sized roll of green material and stitched together by no less than a quarter of a mile of cotton thread wielded stoically by my mother who was "on holiday" in Aberystwyth. Bales of mosquito netting dating from a long forgotten eastern expedition were attached by Velcro to the tent doors, in what turned out to be an abortive attempt at mosquito proofing. Finally, everything we would need for our four months of self-sufficiency was packed into tea-chests and piled into a hired van. The journey to RAF Lyneham must have been a nightmare as the van was grossly overloaded and the passenger was in danger of being crushed beneath a pile of mobile crates and huge blocks of cheese every time it slowed down.

The final weeks were spent by various members rushing around in their own whirlwinds on their home territory. Last minute items were rushed in and packed into personal kit while we tried to encompass the idea that we were really going to Greenland. Our final gathering at David's house in Pangbourne was rife with supressed excitement and with our breath held in disbelief we were on the threshold of our dream.

C 2

THE BEGINNING (2-5 MAY)

A. P. Fowles

The curtains were thrown back in the early hours of 2 May and we looked out on a beautiful, crisp English morning. Preparations were over and the expedition had now begun. The male contingent of the advance party had enjoyed the kind hospitality of the Stroud family for a few days prior to departure while the finishing touches were put to our plans. We breakfasted quickly, though lavishly (every taste of "real food" was now to be treasured as a fond memory for the coming months), and packed our personal gear into the convoy of cars gathered on the drive.

We were well on schedule as we headed down the M4 through the bright sunshine to RAF Lyneham, taking in our last glimpses of English countryside. Hercules 206 was still being loaded when we arrived and the flight eventually left an hour late. This gave us one last chance to enjoy the vagaries of British weather as it began to snow on that perfect Spring day. By the time we took off the snow was driving steadily across the runway - a foretaste of the climate we were heading for. However, we were not flying direct to Greenland as the Hercules had first to deliver supplies to the air-base at Goose Bay, Labrador, in Canada and we were to spend the night there.

The air-crew had warned us that facilities on board the Hercules were spartan, but in fact we were all surprised at the relative comfort in the cargo-hold considering that it is essentially a transport plane. Admittedly there was little room to stretch one's legs - but it was the two and a half tons of our own equipment that took up the space. Once airborne we crowded to the windows awe-struck as the industrial scene of South Wales unfolded below us. Pembrokeshire, Skomer Island, and Southern Eire followed before we headed out across the blue Atlantic. During the flight the crew treated each of us to a visit up to the cockpit to marvel at the amazing battery of dials - an unforgettable experience.

Seven hours later the snow-clad mountains of Canada began to peep through the clouds at us, though sadly the cloud cover was too dense to get much of an idea of the landscape below. Goose Bay itself is uninspiring: tall, square, featureless buildings scattered in blocks over the dusty base. The surrounding countryside was no doubt typical of this part of Canada, an endless vista of dark conifer forests, a line of mountains just visible on the horizon. We'd all brushed up on our knowledge of North American birds and had high hopes of seeing such exotics as juncoes, kinglets, and flickers but the truth of the matter was that these vast forests had a very sparse bird-life; in three hours we saw one Raven!

After tea we made use of the remaining daylight hours to explore a little way into the pines and here we had more success, seeing nine species in all. The best of these by far were a pair of Red-tailed Hawks circling over the conifers and calling to each other. I do not doubt that the pine forests generally lack a dense population of birds but the immediate environs of Goose Bay must surely suffer from the indiscriminate tipping of waste; the rivers literally ran red with the 'blood' of rusted oil cans. Evidence of considerable shooting suggests that this pastime contributes significantly to the absence of bird-song.

As the light failed we retreated to the NCO's club - four months without beer was a daunting prospect. For the next four hours we acquainted ourselves with several pints and talked to Capt. Phil Sharman, our pilot. Finally, at 02.00 hours local time, we sauntered back to the insufferable central heating of 481 barracks and went quickly to sleep.

I've no idea what woke me at 05.45 hours; perhaps it was the soldier singing an obscene version of 'Mother Kelly's Doorstep' in the showers. I duly roused John Floyd, Tony and Dave and we set off into the drizzle for a spot of pre-breakfast bird-watching. It was typically unrewarding, although a chorus of drumming Three-toed Woodpeckers in the pines below us made it almost worthwhile. Breakfast, then straight over to the Hercules as it was being loaded, and airborne once more by 10.15 hours.

Today the cloud was very dense so again we were unable to see any land beneath; it's strange to leave a rain-sodden world and enter the permanent sunshine in blue sky above a layer of blinding white. Two hours later we had glimpses of sea with scattered pieces of ice and then suddenly we were told to don life-jackets as we were descending. For five minutes we dropped through the cloud and then this dramatically disappeared to reveal a most incredible, and indescribable, view: ice-mirror lakes glittered in the snow-capped mountains - the jagged, barren beauty of rock - as they fell steeply into the frozen sea. A fairy-tale landscape. The Hercules then headed due east and followed a fjord into Kangerdlugssuaq (Søndre Strømfjord); the snow petered out quickly inland and the mountains rolled more gently.

The next destination was our Drop Zone in Eqalungmiut Nunât and the loadmaster and his team began preparing our gear for the air-drop. The RAF were using the requirements of the expedition as a training run for low-level flying, navigation, and air-drop techniques so for the next two hours we were treated to a sensational flying display as the aircraft manoeuvered in and out of the valleys. At Eqalungmiut Nunât we overflew the area chosen for the drop and began a series of eight runs which circled the Ímajuitsoq massif; at times the huge plane was only 35 m above the ground. The first load to be jettisoned was attached to a pink parachute as a marker and the next seven came down efficiently within a 100 m radius. There was only one hitch to this success: a parachute came off the box containing most of our scientific equipment and it hit the ground with a sickening thud. We feared the worst but there was obviously nothing we could do about it.

I'm told that the whole of this low-level flight was a once in a lifetime event but I'm afraid I suffered greatly from the oscillations of the aircraft and for two hours I felt the need to clutch onto my NATO sick-bag. Although we were told that it was a very smooth ride, six of us succumbed to the twistings of the plane and in fairness I must add that several of the crew did as well. Hence it was a very bedraggled expedition that sat on the runway at Søndre Strømfjord Air Base awaiting transport, though spirits were raised by the sight of five Snow Buntings that flew overhead. Through the kind offices of the Commander, we were able to stay at the plush hotel reserved for the air-crew and to enjoy a couple of days of luxury before we resigned ourselves to the rigours of the tundra.

The air-base is effectively split into two by the runway, the north side composed of the civilian settlement connected with the SAS commercial airlines and the south side reserved for USAF military personnel. It is much smaller than the Goose Bay monster, is flanked on both sides by mountains, and the grey-milk fjord runs down past the hotel. The scenery isn't exactly breath-taking but the ice-cap is visible some thirty kilometres distant and that makes it quite special.

In the evening we made our way over to the bar and chatted with the crew of the Hercules once more. We owe a great deal to them, and their friendliness and interest in the expedition was most encouraging. It was at this time, in the early hours of 4 May, that we learnt of the election of our first female Prime Minister. What kind of Britain awaited our return?

Next day, while the others arranged final details with the authorities, John Floyd and I climbed to the top of the ridge north of the base. It was a beautiful warm day, hardly what we had expected, and the views were magnificent with the ice-cap gleaming prominently to the east. On our descent we disturbed an Arctic Hare which casually moved a little further off and then sat up on its back legs to stare curiously at us.

Back down at the terminal, the SAS flight from Copenhagen had arrived and we gathered to welcome our leader, Alison, who was prevented from travelling with us by RAF policy - No Women Allowed. Then it was over to the runway to wave goodbye to our friendly Hercules on its way to Qanaq and colder climes. The rest of the day was spent relaxing and conserving energy for tomorrow's strenuous task of setting up Base Camp, although we did allow ourselves one last visit to the bar for a final reminder of what we were to miss. Late-night packing and excited chatter meant that we got to bed at 02.45 hours.

Three hours later and the time had come to get the expedition proper underway. We made full use of our last civilised meal and then trudged over, under heavy packs, to the Danish side. Even at this hour of the morning the sun was blistering and the skies crystal clear.



C 3 ARRIVAL IN EQALUNGMIUT NUNÅT AND ESTABLISHING BASE CAMP (5-8 MAY)

A. M. V. Higgs

Of all the possible ways to travel on an expedition, the helicopter gets my vote. For one thing it gives an expedition that aura of authenticity that arriving by SAS jet never could. As we encaged our baggage in the net behind the pilot's seat and settled ourselves into the slung canvas seats of the S58 Sikorsky that was to take us into the field, I was conscious of both a tremendous sense of achievement and of excitement at setting my first foot on unknown territory. The motion of the helicopter was quite unlike that of an aeroplane; it throbbed violently in response to the engine, and yet we lifted and travelled without any sense of movement.

The day was hot and cloudless so that as we flew the distorted shadow of the chopper hopped and glided across the hillocks below. I found it impossible to gauge either our height or the size of the features we passed over until my attention was drawn to some small white specks alleged to be Caribou. I began to appreciate the scale of the terrain and the size of the lakes that littered the landscape. Most stunning of all were the vast muddy valleys. Although I had realised from the maps that they were wide and braided by rivers, I was unprepared for the fact that the breadth of the valley was impassable, covered by what turned out to be fine glacial mud, liquid under a frozen crust, and netted by milky rivers flowing from the ice-cap. Two such valleys separated us from the nearest outpost of humanity, 75 km away - we would be truly isolated in our chosen area!

The pilot homed in on our DZ with little difficulty. The compactness of the dropping zone was quite impressive, in some cases the loads had landed uncomfortably close together so that the 'chutes were flapping together in tangled groups. The last time I had seen these packing cases was in Aberystwyth, meeting them again here made me feel rather like Stanley as he strode to meet Dr. Livingstone. With the chopper duly unloaded and the pilot having settled down for a brief rest, we wandered over to inspect the condition of the loads. The 'Dangerous Air Cargoes' crate which contained Metafuel, Primuses, matches and an array of glassware and chemicals had become detached from its parachute before impact. Its contents were strewn over quite a large area of tundra in small pieces - the Dayglow orange tape which signified danger winked out at us from willow bushes and tussocks of frozen grass. Some Metafuel remained in boxes, most was powdered finely amongst the dead vegetation. Primuses were dented or broken and the chemicals had evaporated into the clear Greenland air. In the few minutes before the chopper left I scribbled a note to Phil Davies which sums up our loss and my anxiety rather well:

"Imperative you bring 60x boxes of Metafuel, 20 tablets in each.
Repeat. 60 BOXES METAFUEL. Can cope with food problem ....."

The food loads had suffered mixed fortunes. The biscuits had landed intact to a crumb. One 1-ton load was perfect, but the other was a scene of disaster. The fact that all three canoes had been written off in the landing was barely noticeable compared to the havoc wreaked among the ration bags. Splintering tea-chests had ripped through the polythene bags, most of which had burst on impact anyway. The result, when the canvas cover was pulled away, was a sickening morass of tea, sugar, porridge, soup and TVP, liberally laced with splinters and shredded polythene. The tins of jam looked as if they had been hit with a 12-pound hammer and were oozing happily in a corner over a pile of crumbs which had once been a cake. I realised in horror that this mess represented half our food. *If* we could salvage it we would need containers, and the one thing we did not have were spare food bags.

The hero of the hour was undoubtedly Steen Malmquist (the manager of Søndre Strømfjord Airport) who had flown out with us to see us safely ensconced. He returned in the afternoon with three Danish journalists and a large quantity of polythene bags, landing his light plane on the frozen west Eqalungmiut tasia. Towards evening we abandoned the salvaging attempt, knowing that all the food was at least in water-tight containers, even if quantities of it were irretrievably mixed up.

The following morning dawned drizzly. If we had arrived one day later we would have lost half of our food to rehydration! The equipment already dumped at the site selected for Base Camp was covered only by a blue parachute which was weeping turquoise dye over everything, but after a considerable amount of chivvying we began the job of humping loads, setting up base, and getting everything under wraps. By the following afternoon the expedition could begin and the boys decided to "nip down to the fjord" with the radios to try them out. They returned hours later utterly exhausted after a 20 km hike and a 200 m climb, determined not to be fooled by the clarity of the Greenland air again. This, coupled with a lack of familiarity with the scale of the landscape, meant that we were as yet totally unable to judge distances, a potentially dangerous failing.

During the next few days we concentrated on things domestic. John Bell built a lean-to against the mess-tent to house personal and scientific equipment, with cupboards and seats. Our radio schedules with Sisimiut were completely unsuccessful, even with the dipole aerial set on top of a 500 m ridge.

My all-consuming problem was whether we should send a party at once to Søndre Strømfjord Air Base to obtain new radios, or wait for an emergency before sending runners. From our recce in the helicopter the return trip seemed long, dangerous, and uncertain of success. In the end I decided to gamble and risk the journey only in an emergency, so we settled down to abortive radio schedules every night, until we managed to raise the GGU on the evening of 24 June.

The first scientific meeting of the expedition led to a decision to establish a goose-watching camp at the bottom of the valley, as a few geese had been seen there on the first walk. Jesper and Tony eagerly volunteered and descended, aided by Adrian and meas pack-horses. Returning up the north side of the valley we stumbled across our first evidence of breeding geese - a predated nest with the skeletal head of the female buried nearby in the grass. This was an occasion for great rejoicing and sighs of relief all around; there was now at least a good chance that we would have breeding geese in our chosen area.

C 4 LIFE IN BASE CAMP (MAY - AUGUST)

A. D. Fox

Whereas we had originally planned that our Base Camp should be little more than a food and equipment dump, in fact it rapidly developed into an institution, a home from home, that filled a special place in what we came to know as the 'Greenland Experience'. It seems apposite to include here a description of the 'atmosphere' of that loose colony of tents that so coloured our responses to the events of the whole expedition.

Of course, we all had our own private reasons for going to Greenland; the link, however, was more than a fair share of escapism. Even those of us fortunate enough to live in rather remote parts of Mid-Wales would concede to at least some desire to leave behind the rigours of Twentieth Century life. This made the Base Camp phenomenon all the more remarkable. For four months it was very much our home and the centre of all activities. There we were, twelve Europeans thrust into the Arctic tundra, clinging to a few tenuous anchorages of the existence we had left behind.

The first priority on arrival in Eqalungmiut Nunât was to establish a base for our project. Our choice was a fine one, its only fault, for me at least, lay in the 2 km march up from the Drop Zone, a fact that forced some of the group to accept fitness rather earlier than anticipated. Nevertheless, the position was ideal: a small scatter of moraine hummocks set in the shelter of Needle Cairn Heights and the Crusties, with an associated stream pouring clear, white water fresh from the lip of the frozen plateau above. The site was furnished with a magnificent view down Goose Valley to the fjord beyond, a view that was to replace wallpaper and bathroom mirror in its very familiarity. Behind, the Crusties and their distinctive profile rose solid and reliable.

The nature of the moraine substrate, being soft and dry, meant that, in spite of the permafrost petrifying all but the very top layer of soil, fewer tent pegs were spent in anger than might have been anticipated. Later, the icy grip on the soil relaxed and we were no longer treated to the crouching figure of Mr Bell tapping in tent pegs long after lights-out as the ice forced them gently skywards. The site even offered a discrete depression amongst the hummocks for an excellent latrine-with-a-view, although its construction, through a frozen watertable, was problematical.

Man's yearning to make a mark on the landscape was quickly and lustily satisfied. The obligatory flag-pole was raised as a plea to the radio waves that were never to reach us but, for a while, it formed the focal point of the camp and it gave us a pioneering thrill to raise the Union Jack and Danish ensign in a corner of a strange and foreign land. However, it was the erection of the mess tent, itself a pioneer of many distant shores, which really signalled the establishment of our rule. The very able Mr. Higgs produced a Chinese-style, floor-hugging table from unpromising off-cuts, and the tea-chests that had escaped damage in the drop formed the basis of the kitchen suite. The Dartford Warbler on the calendar gave a curious reminder of home and may have been responsible for the inexplicable whiff of gorse-fragrance which many members claimed to have experienced. The floor was quickly paved with slabs dragged precariously at risk of permanent injury to their bearers, from a perched quarry above Base Camp. Indeed, more than one of the valiant quarrymen was witnessed lying tortoise-like on his back, unable to struggle back to his feet, slab strapped to his pack-frame.

The Royal Air Force had very kindly donated vast amounts of water-proof material and several kilometres of rope in the form of parachutes. The bags which had contained them were stuffed with packing material, adding comfort to function, and if the three-piece suite didn't quite match nobody minded too much. Suddenly, the Base Camp phenomenon was born - the distraction complete. With several sackfuls of tea-bags, an inexhaustible supply of water and suitably enormous Primus stoves, we had comfort and all the facilities we could want.

During the first few weeks, the cluster of small tents multiplied and the extensions to the green mess tent proliferated; at the hands of JB a couple of SEAC parachutes became a store, bravely surviving to protect our possessions to the very end despite later indications of imminent collapse. Behind the main tent a massive polythene greenhouse took shape, providing excellent laboratory-cum-study facilities and doubling as an extension to the banqueting hall when a capacity crowd was expected for one of Alison's sumptuous gastronomic occasions. In spite of the meagre rations and

inadequate cooking equipment, these feasts were nothing short of *haute cuisine* and were important for the celebration of birthdays and unbirthdays alike, in helping morale along, and providing an excuse for the entire group to gather as one about a single "table".

The trouble was, that once enclosed and bathed within the eerie green light of its inner sanctum, it was curiously difficult to leave the mess tent. Porridge parties often spanned whole days and nights as participants came and went, providing conversation and euphoria which at times questioned the very contents of the oats packet. Tea, so lovingly prepared in the Empire of old, was hopelessly adulterated. Initially prepared by the early bird, the tea would then brew, steam, and stew throughout the day, passing around and through the gathered addicts at alarming rates. The Great British Bladder came through the ordeal with flying colours. Despite the quirks and vagaries of such a small group, the beverage was comsumed to the satisfaction of all, from JB's often tardy plea for a cup of tea hardly tainted by a tea-bag to Dave's extraordinary capacity to imbibe cold, stewed sludge complete with Branchiopods. Indeed, Mr. Stroud's "Jolly Green Giant" pint mug quickly developed a considerable deposition of tannin which grew almost visibly like some curious coral, diminishing the volume of the vessel and apparently having several discernible trophic levels at the end of four months. Disembowelled tea-bags brought a quality of tilth hitherto unrivalled in the Arctic, and the vegetation shrunk back from the bounds of the camp in horror. Only the confiding Lapland Buntings with their endless curiosity ventured into the camp, even entering the tents to be given 'Original Nut Crunchy' in exchange for their vital statistics.

Without radio contact with the outside world during the first two months we had to be content with one-way conversations with the transistor radio in Base Camp. John Peel became a necessity, while the 'Voice of America' gave us a new perspective on the world and our French was stretched by the Canadian services. It was undoubtedly the combination of the BBC World Service and daily readings from Green & Greenwood and Hamilton Bailey's *Physical Signs in Clinical Surgery* that stood between the group and insanity.

As the sphere of human influence spread across the land, grotesque shapes adorned with unmentionable items of underclothing began to appear between the familar outlines of the tents as the antler-gatherers harvested their bounty. Ideal perches for birds, these became the setting for encounters between Lapland Buntings and some of John Floyd's more vocal socks.

Although it was planned to establish a rota of tasks delegated to the 'Camp Attendant', the arrangement largely fell into disuse and a vague anarchy proved almost functional, albeit at the expense of the likes of Ade, whose proven skills in the sphere of water-gathering and washing up in cold tea were tried to the extreme. It is undoubtedly of considerable importance to delegate someone for this purpose, as without an appointed person the unfinished tasks could well have resulted in friction within the group. The result of many meals consumed during several sittings each day in the mess tent was a paraffin-drenched table with accumulations of miscellaneous powders. This inevitably led to a rather untoward, although not particularly serious, fire under the table towards the end of our stay. The household authorities subsequently ordered a rather more rigorous approach to camp tidiness.

Towards the end of June, the arrival of the ringing party caused a greater degree of urban sprawl. The need to mist-net in relatively undisturbed areas of scrub meant that satellite camps sprang up just outside the main sphere of influence, and new tracks began to appear through the new-grown grass slopes. With the arrival of the new personnel came the added bonus of the mosquitoes and black-flies, so gloriously absent throughout the first two months. The team had taken a strange assortment of insect-repellent devices, most of which, in fairness, were reasonably effective. Perhaps the most bizarre were the "Moon Tiger" mosquito coils, a joss-stick to be burnt in confined areas and guaranteed to give "restful and peaceful nights without being troubled by indiscriminate mosquitoes". This may work well in the Orient but the Arctic Dipterans appeared to suffer less from the effects of the smoke than the human beings incarcerated therewith. It was generally agreed that a packet of 'Woodbines' would have been equally effective and far less damaging to our health. The ringing group was well prepared with small electronic buzzing gadgets about their necks to repel the Dipteran onslaught. Their efficacy was hotly contested, and the source of considerable amusement, as we were whined and dined to a perpetual hum from the corner. The Green Tent was ideal for late evening gatherings of mosquitoes; the effect of warm bodies and several sittings of food and drink was to heat the ridge of the tent to inordinate levels, extending the dipteran day by several hours. From the tent ridge, thousands of mosquitoes would look down in total disbelief at the sumptuous human meal arrayed before them and, quite helpless, we would be bitten until the early hours in those few spots of exposed flesh missed during the last application of repellent.

As the summer progressed, the river that had provided so much tea-drinking began to dry up and the appointed water-purveyor found himself struggling further and further to provide clean water for the ever tea-hungry residents. The camp-site became drier and dustier as all traces of plant life vanished from the vicinity. It was perhaps as well that during much of July the group was based well away from the Base Camp region in the pursuit of geese. The latrine in the meantime had indeed turned into a bog, a botanical lesson learnt by all; we shall, I suspect, all be able to recognise frozen moss mat next time and steer well away in future sewage projects.

The accumulation of material in such a camp is remarkable indeed. Our clearing up operations took several days as we burned everything in a desperate attempt to fall within the helicopter weight restriction. The vast accumulation of gear and samples was packed up and the litter, such as there was, gathered, and fired by Phil Davies who leaned stoically over a fire that was to burn for many days. Strange, then, to view on the morning of our departure, the ghosts of favoured tent sites, the well-trodden tracks to stream and latrine, and the outlines of the constructions that had stood for so long. A ceremonial cairn was built by Will and adorned with a fine set of antlers and, as the helicopter appeared away to the south, we all pondered for a while on this place that had meant so much for four months. As the chopper took off, banked, and gathered height, there was just a fleeting glimpse of the skeleton of something we were unlikely to return to, and we all swapped the experiences of the last four months for the familiar shapes of Søndre Strømfjord Air Base.

The stage having thus been set, let us return to the second week of May and a chronological account of the adventures of the expedition and our responses to the wilderness around us.

C 5

KUK MARSHES - FIRST TREK (7-13 MAY)

J. Madsen

After the first reconnaissance down through the valley to Kûk Marshes on 7 May, where we had seen the first geese, Tony and I decided to travel back down to observe the geese as they arrived. Assisted by Adrian and Alison, we left BC on 9 May and once again we experienced our lack of fitness as we trekked through the vast land of high, dead grass and willow scrub. More or less exhausted, we pitched camp at the inflow of Afon Char to Manx Lake (and from then on all our tent pegs showed unmistakeable signs of having been hammered into the frozen ground), close to an old camp-site used by Greenlandic hunters with the typical remains of modern man.

The following days were spent concentrating entirely on the goose observations. From a hill-top above the marsh we surveyed the entire area, watching the feeding adults and the passage of geese from the south. The days were pleasant with the warmth of the sun and only slight winds, making our observations comfortable. On 12-13 May we stayed on the hill throughout the night, and as soon as the sun set behind the western ridges temperatures abruptly dropped below freezing point. Well-wrapped in several layers of warm clothing, we sat against a rock-hummock, watching the geese and the scenery around us. No winds stirring, a crystal clear sky and the lonely sounds of cackling geese and the sad barking of foxes in the distant hills. That night, I think, gave us for the first time a feeling of how unique this harsh, but beautiful environment was. During the coldest hours we kept shifts, so that one of us was on duty keeping an eye on the geese through the telescope while the other tried to get a few hours sleep. The ice-cold telescope ocular stuck to the eye, the observer behind trying to keep warm while the sleeping bag froze over from the condensation coming from inside

The morning sun greeted us and, satisfied, we finished our observations at 10.00 hours. Very tired, we staggered back to our camp for much needed food and sleep. In the afternoon Adrian, David and John F. came down from BC in order to lay out the breeding bird census grid and to take over our observations.

C 6

THE FIRST GLACIER ATTEMPT (11-12 MAY)

W. J. Higgs

With Base Camp established and goose observations under way Alison and I chose to try to reach the snout of the local glacier which discharges into the head of the fjord-valley visible from Base Camp. The Greenlandic name for this glacier is Inugpait qûat, which I was later told meant "many people's urine". So, on the morning of the eleventh, we booked ourselves out for two days, packed our gear and set out from base in mid-morning.

We descended to east Eqalungmiut tasia and walked the entire length on the ice. Ridgeway Marshes, the extensive area of marsh at the head of the lake, held Mallards, Caribou, two foxes and a pair of geese which flew up from near the lake and circled around us twice before returning to the same spot. Very interesting - perhaps a nesting pair? No time to lose though, so onward to find ten more geese higher up the marsh.

A deep gully was chosen as a route up the very smooth, steep slope now facing us, a very arduous and increasingly dangerous ascent. Where the gully became steeper and narrower towards the top it was choked with large boulders and smaller areas of extremely smooth, hard ice which was impossible to walk on and had to be crawled over when they could not be avoided. This was a marked contrast to the lake-ice which had a crunchy, easy-to-walk-on surface.

By mid-afternoon we had conquered this obstacle however, and had lunch on the plateau proper. Here the inadequacy of the 1:250 000 maps showed up - ridges, peaks, small lakes and valleys were all missing. We got a little lost and had trouble with the compass but, thanks to the distinctive shapes of the larger lakes marked, we found our way to a recognisable spot on the fjord-valley side, 4-5 km from the glacier. The frozen lakes were very useful as easy-walking sections, as well as land marks.

The plateau, at an altitude of 500 m, was a novel environment for me, a memorable combination of stark contrasts and vivid impressions: the absolute silence except for the sound of wing beats of a goose or raven audible high overhead; the coldness of the air and the heat of the sun; a piebald landscape of dark rocks, scree and withered plants with brilliant snowbanks and frozen lakes; water everywhere in the form of ice, snow, and frozen marshes but everything absolutely dry, the dead vegetation crumbling to dust as you walked through it. Walking across the plateau, in shirt sleeves, is hot, thirsty work but pause in the shadow and you are chilled to the bone.

We had some exciting glimpses of the glacier during our steep descent to the floor of the fjord-valley but we were so tired that we pitched our tent on the first good spot, ate our fill, and went to sleep.

Next morning, we were ready to go at 10.30 hours, and chose to skirt the plateau region we had crossed and instead follow the side of the main valley. The fjord-valley was mostly filled by extensive mud flats with a very braided river of melt-water meandering across them; all of this was at the time covered by melting ice. Along the sides of the valley bottom were extensive sand dunes and flat alluvial gravel-beds, but in some places the steep, rocky valley sides fell directly into the mud. Here there was a well-trodden Caribou path on which we made good time and it took us eight hours to regain the head of east Eqalungmiut tasia.

At the lake head we found a pair of geese in the same place as on our outward journey and also two foxes, one of which appeared to be asleep on the lake-ice. It bounded off at great speed as we approached; they run very strangely, the front legs leaving the ground in little leaps. The lake was completely frozen on the south side where it is shaded by Imajuitsoq, but on the north side it was exposed to the sun and we had some difficulty getting to the bank.

We disturbed another pair of geese in a small marsh on the lake-side and on reporting these sightings to the folks back at Base Camp we were told that geese had been around the camp all day and 'resident' pairs had been noted in other areas.

C 7

FIRST HALF: BASE CAMP AND GOOSE OBSERVATION (19 MAY - 20 JUNE)

D. A. Stroud

The evening of 19 May saw everyone at Base Camp for the first time in eleven days. Will and Jesper had just returned with the news that the first goose nest had been found on the north face of Imajuitsoq, leading to speculation that they were cliff-nesters after all. On the strength of this, the huge 'Celebration' cake, brought all the way from Pangbourne and now rather buckled after the air-drop, was started and greatly enjoyed.

When the next day dawned Will's master plan rolled smoothly into action. Small groups were dispatched with ridiculous loads of collapsible hide in metre-square sections, and could be seen struggling across Lakesmeet to the south of east Eqalungmiut tasia. Having partially constructed the hide out of site of the nest about a kilometre away, the nest was visited. DISASTER - the egg had gone, possibly predated by a Raven whose eyrie was 300 m further along the same cliff, and the geese had disappeared. The rest of that day was spent in an unsuccessful search for another nest nearby.

The following week was spent searching for more nests; pairs of geese on feeding areas were watched in an attempt to follow them back to the nest on their daily egg-laying trips. Adie and I remained at Lakesmeet and observed the geese around east Eqalungmiut tasia, whilst Tony and John Bell watched the birds on George Fliot marsh. Will and Alison visited Willow Valley and the area around the Ridgeway Marshes. Jesper found himself a precarious camp-site at the west end of west Eqalungmiut tasia and John Floyd remained at Base Camp searching along the sides of Needle Cairn Heights and Upper Marsh.

The silence that had been such a noticeable feature of the environment on our arrival, and which had been described as so intense that "it presses against the sides of your head" (Floyd 1979), was now broken by a cacophony of song. The incessant melody of the Lapland Buntings was also joined by Snow Buntings and Wheatears singing away noisily.

Strong winds caused some trouble at Base Camp on the night of 24 May. The dipole mast fell down and John alone was faced with the task of trying to prevent the new polythene 'greenhouse' extension to the mess tent from taking off in winds gusting up to eighty kilometres per hour. Fortunately, he succeeded.

The first flowers were seen in this period, the earliest noted being *Salix arctophila* on 23 May. The grasses were beginning to sprout green at their bases but it would be another month before the hills would shed their dusty brown winter mantle and turn green.

27 May was a fortunate day. John Floyd found a goose nest near Base Camp (BC1) and on his way down to Aberchar to inform Tony and John he flushed another sitting female (BC2) from the grass slopes above George Eliot. The nests were visited the following day, the eggs were weighed, and photographed, and the time-lapse cameras were set up nearby. It was decided, in view of the proximity of the nests to Base Camp, to search for another two days for a nest further away and more suitable for continuous observation. If at the end of that time we had not found another nest then we would set up the hide near one of the two nests already discovered.

The night of 27 May was memorable for its coldness. At Lakesmeet a billy of curry left under the flysheet to hydrate gained an inch of ice in twenty minutes. It started to snow at midnight and boots and socks froze solid and became most difficult to put on. Fortunately, temperatures were this cold (-10°C) for only a few nights in May. Although not a serious problem it could be very painful if the fingers became wet. The chore of washing-up was dreaded, as it would be at least twenty minutes before the finger-tips regained sensitivity.

A lined-out systematic search along the sides of Needle Cairn Heights revealed another nest (BC3) on the evening of 30 May. As this was the furthest from Base Camp it was decided to move the hide there next day which, typically, had the worst weather yet encountered. Driving snow, sleet and rain reduced visibility and made conditions most unpleasant. The general thaw of the previous days had raised the levels of Eqalungmiut tasê and the stepping stones at Lakesmeet were now covered by several inches of water, making the crossing hazardous. Eventually, thanks to magnificent efforts in appalling conditions, the hide was reconstructed that day near BC3.

The first hide-watch set out from Base Camp for the hide far too high up the slopes and were eventually forestalled in their trek towards False Eyrie Crag by dint of much shouting and whistle-blowing before they were lost for good. At 19.00 hours we were safely installed in the hide and, despite the poor visibility, we were confident that this was the real thing. Nothing could go wrong this time.

It snowed during most of 1 June and in the evening a föhn wind blew up, driving a fine spray of snow through the cracks in the side of the hide. By now the master-carpenter, John Bell, had installed shelves and a primus stand and the hide was becoming quite cosy. The female goose remained sitting with her head on her back, understandable in view of the conditions. However, doubts began to creep in after the earlier optimism of the log entries:

> " The splodge has an eye and an orange beak!! For splodge now read female Greenland White-fronted Goose. I definitely saw this bird all last night."
>
> "Good grief - I can actually see it!"
>
> "Can see the back more clearly now, with head and bill facing this way."

But later:

> "Examining the spot where I *really did* (honest), I think, see a goose yesterday, - nothing visible at all. If the bird is there it's buried in snow."
>
> "Must now say 'out of sight', since there is no shape that I can honestly say I think is a goose."
>
> "No apparent change... the only reason I can think of to suggest that she isn't dead is that the snow seems to melt quickest on her - body heat?."

And finally:

> "I have see nothing goose-like all night."
>
> "Am beginning to wonder if the bird was ever in sight, and if it has deserted."

By staring long enough at the nest we could convince ourselves that we were watching the back of the goose, and I even went as far as drawing a head and beak in the log. The saga of "Elsie the catatonic female" was to go on for another day yet. During 2 June we had the only case of sickness when one of the observers tried to do away with himself by drinking contaminated water in frustration at not being able to put anything more exciting in the log than yet another 'head on back'.

When the nest mound was finally visited on the morning of 3 June it was found that the nest was deserted/predated and just the remains of one egg were left. What had confused the watchers to an extent, was that the weather conditions for a considerable period of the watch had been such that the head on back behaviour "seen" was what would have been expected. The whole incident cast the camp into a dark mood, but viewed in retrospect it is an interesting example of the way in which one's expectations can influence observations, in spite of attempts to be objective throughout. To make matters worse, an inspection of BC2 revealed that it too had been deserted/predated. These two incidents, bringing to three the number of nests now destroyed, did not ease the tensions building within the camp.

After another day of unsuccessful searching for a nest, we moved the hide to its penultimate position (it was later moved to Base Camp as a wash house), above BC1 during the hot afternoon of 4 June. By now it was estimated that we had moved the 150 kg hide 11 km in distance and in height up 300 m; rather than take it all to bits again, it was carried with much effort in two halves to Observation Hill where it overlooked BC1. This time there was no mistaking a genuine female *Anser albifrons flavirostris* incubating. It was even possible to count her blink rate! Soon the routine of the hide watch took over Base Camp and the gloom and irritation of the previous few days was dispelled.

On several occasions we were disturbed by regular tapping noises on the door and scratchings on the roof. These turned out to be Lapland Buntings and Wheatears that had been getting ideas from Daphne du Maurier. It was particularly unnerving when they flew in through the window-slits and did a circuit of the hide before leaving the way they had entered.

By 9 June the level of the lakes had risen considerably and it was not possible to cross Lakesmeet even with waders. Where previously there had been a tiny stream gurgling through the willows, was now a raging torent. An inflatable boat was left there together with lifejackets and a rope. By the second week in July the water level had dropped to the point where it was crossable with Wellington boots.

Throughout 11 June the wind was increasing. At Base Camp that night the tents were firmly secured and large mountaineering ropes thrown over the mess tent (by this time living up to its name) and the extension. John Floyd was on hide duty and his final entries in the log indicate trouble ahead:

24.18 Hide rocking violently in wind - earth in my eyes.

24.23 Observation not completed because hide blew away.

For objectivity, after a 150 kg wooden hide has just taken off from around you in winds gusting over 80 km h^{-1}, that last statement deserves a prize. Fortunately, there was no floor in the hide so the 2 m cube lifted off over John's head and came to rest 40 m further down the hill. It took with it the telescopes, stopwatches, log books, Primus stove and all the paraphenalia that made life in the hide, if not comfortable, at least not too uncomfortable. At Base Camp the flight of the hide was witnessed and help was soon on the way. After retrieving most of the moveables, checking that the hide would not move further, and was out of sight of the nest, the company retired to Base Camp and demolished vast quantities of surplus porridge and gallons of tea. As we went morosely to 'bed' we reflected that the Chance Master, our pet divinity, had struck again.....

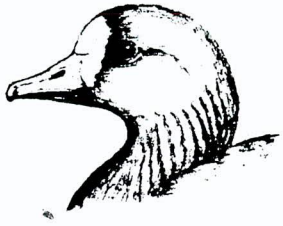
Amazingly it only required a few hours of impromptu carpentry the next day to restore the hide to something like its original condition. After losing the roof the box had been sufficiently flexible to deform and roll down the hill. Upon re-erection no chances were taken and it was firmly buried and roped in place. The watch resumed at midnight on 12 June, but it had started to snow and it was not possible to see whether 'Penelope' was still sitting. At 04.32 hours, however, she rose Phoenix-like from the snow where she had lain completely covered for at least four hours.

The snow-clouds cleared away early that morning to give one of the most beautiful sights of the trip. An orange glow emanated from the fjord peaks to the west and the sky above them was pale blue and pink. Sharply contrasted with the pastel colours of the sky was the harsh black and white of the cliffs and slopes all around. As the snow-line progressed up the valley the sky brightened and the slopes were lit with the creamy-orange of an early morning sun.

Throughout the following week life went on as normal at Base Camp. The hide watches had completely taken over the routine of the camp and our activities centred around observation shifts in the two-metre cube. The walls of the hide became an organ of introspective reflection and were covered with a fine selection of graffiti placed there in quiet moments. Many of these reflected the gastronomic cravings that were racking the camp at this time, for example:

"There once was a guy in a hide,
Whose hunger was oft surely tried,
In the nest were the eggs,
With eyes, bills and legs,
So he ate them - poached, curried and fried."

The hide watches were arranged on a basis of a five-hour shift every twenty hours, four people being responsible for each four-day period. Meanwhile the other four attended to the various scientific projects in hand and undertook exploratory hikes further and further afield as weather conditions ameliorated. On one of their periods off hide duty, the two Johns finally managed to get away to the glacier in the snow of 12 June.



C 8 AN ATTEMPT TO REACH INUGPAIT QÛAT - SECOND GLACIER ATTEMPT (12-17 JUNE)

J. Floyd

Situated only 20 km from Base Camp, Inugpait qûat made an obvious goal for an exploratory excursion. John Bell and I decided to devote one of the periods when we were not on hide duty to a hike to the glacier. As spring progressed and the permafrost melted, the rivers had swollen: now they were near their peak and formed serious obstacles. To put one river behind us we set out on the evening of 12 June in a heavy shower of snow, gained a few miles and crossed Lakesmeet by boat before pitching camp.

On 13 June we began in earnest, climbing out of our 'home'valley via a low col and passing on down into the large valley which forms the southern border of Eqalungmiut Nunât and is a natural route to the glacier which fills its eastern end. Here it was a level expanse of mud and quicksand across which meandered a braided river system of opaque glacial milk. The flats were bounded by a high terrace of glacially deposited sands and gravels. This terrace seemed to be a sort of Caribou motorway, their well-worn tracks through the sand dunes and grassy marshes making our progress rapid, but further on a steep torrent cascading down the valley side and across our path brought us to a halt. We explored the whole length accessible to us and discovered that we had two options: we could swim across the stream where it joined the main river and was slow and broad or we could follow it high up the valley side where it leapt between rocks and was just narrow enough in one place for a risky jump. We decided to try the latter the following morning.

After an uneasy night everything went according to plan and we were soon safe on the other bank. There we were rewarded by the sight of a waterfall with a circular rainbow, so vivid that I could see bright flashes of colour in individual water droplets, shimmering at a fantastic speed in front of my hand when I reached into the spray.

As we continued along the valley the glacier came into view, very dry-looking, dirty-white ice, deeply furrowed and standing above the great heaps of its terminal moraine. Confronted here by another river crossing our path, we stopped. This river was of quite a different scale; it drained a long frontage of the ice-sheet to the north and dwarfed the rivers we had already crossed. It emerged from a long, deep gorge and spilled between huge rounded boulders before widening to join similar channels from the glacier and flow down the main valley. An exploration of the rocks in front of us showed us that crossing was out of the question here. Downstream the river was wide and fast, upstream the sheer cliffs of the gorge, several hundred feet high, made the river itself inaccessible. We decided to camp here for the night and to explore upstream in the hope of finding a safe crossing next day.

We cooked the evening's food on a primitive but effective stone stove fuelled with dead willow. Fires were against expedition policy because of the dry vegetation, but we had inadvertently left our paraffin behind at Rainbow Falls and hence had no choice. The glowing embers and smoky flavours made a welcome change.

June 15 was the day of our attempt to cross what we soon came to know as Barrier River. We followed its course upstream for many kilometres before admitting defeat. We stepped from stone to stone far out into the powerful torrent at many places where rocks seemed to form natural causeways, only to be halted each time by a stretch of churning water too wide to jump.

Realising the futility of continuing further upstream we headed up a ridge overlooking the river and from a high hilltop looked out over the remaining ridges to the great gnarled dome of ice which stretched across the whole eastern horizon, banked high against the dark hills and slowly climbed to a white plain many times their height. Despite our failure to reach the ice we had been richly rewarded for our efforts as our walk along Barrier River took us to some breathtaking sights. We followed its gorge to a huge crashing waterfall, saw strange and beautiful wind-eroded rock, and many kilometres of this fine empty landscape.

Next day we were up early to take a last look at the gorge and its surroundings before walking halfway back to base. The most memorable sight for me was the last bend of Barrier River swirling against the terrace on the valley side, eroding it visibly. Debris splashed into the water from an overhanging band of exposed permafrost every few seconds.

We returned to base by the same route we had taken outwards, a relatively uneventful journey enlivened by the discovery of a drake Teal and a White-front's nest with one egg. We were back in base on the evening of 17 June in time for a meal and a new cycle of watches in the hide.

C 9 MIDSUMMER'S NIGHT AT 627 m (21-22 JUNE)

J. Floyd

As incubation drew to a close and with 400 hours observation data behind us we decided to turn Midsummer's day into a "public holiday". The summer solstice took on a special significance in this arctic environment where the dependance of natural cycles upon the sun is so evident and so it made a good excuse for celebration. On the evening of the twenty-first Alison treated us all to the finest meal circumstances would permit:

MENU

Onion soup au gratin

Brown bread

Omelette in Cheese sauce

Spaghetti Bolognaise

Christmas Pudding

Coffee

Cheese & Biscuits

Celebration Cake.

We consumed it with ravenous festivity, perched on boxes and jerry cans in the makeshift scientific tent, feasting to repletion.

Those still able to move and without commitments in the hide set off to see the midnight sun from 627 m, the highest summit in the vicinity. We arrived slightly late by my (subsequently discredited) calculation of sidereal time but, undeterred, we planted the Union Jack and the Danish Flag on the existing cairn and brewed tea. At first clouds hid the sun but eventually (probably close to solar midnight) it appeared, dramatically set amongst brooding clouds and shadowed ridges. The clouds were strange that night, from a high grey ceiling descended tufts of undulating fibres like resting tornadoes. Stretching away to the west, across the expansive plateau, a view of some 130 km, ridge after ridge of peaks faded away into darker shades of grey until a final ridge of peaks, blue mountains, proclaimed the coast itself.

After rolling a few glacial erratic boulders over a cliff in a booming, echoing salute sounding out over the dark landscape, we headed for base. As we walked across the plateau a pair of geese took flight from a slope ahead, calling loudly, and a small, greenish ball of fluff came running and rolling down the slope. Cheeping weakly, the gosling tottered a few metres to a lake and swam a short distance before fixing its course and attention towards us. Soon it was clambering over our feet, then sitting relaxing while it casually preened in our cupped hands. Imprinting in action! The gosling was very young with thick olive down, enormous feet, and an egg-tooth. It did not want us to leave it behind and forced us to run. After weakly following up the slope it turned and circled back down to the lake again. Here it headed for a pair of Red-necked Phalaropes and desperately tried to adopt them as its next foster-parents.

On our return to base the event took a new significance: a note from a sleepy observer carried news of the successful hatch in Penelope's nest by the hide. The first half of our study was over and relief was mixed with a sense of achievement as commotion and elation reigned whilst we made plans for the next few days prior to the arrival of the ringing party.

C 10 THE ARRIVAL OF THE RINGING PARTY (25 & 26 JUNE)

P. C. Davies

At 06.30 hours (BST) on 25 June the remainder of the Greenland White-fronted Goose Study, Phil Belman, John McCormack and I, set off for Greenland from RAF Lyneham, Wiltshire, to link up with Pauline Eddings who had already flown by commercial flight to Søndre Strømfjord Air Base, and to join the main party in Eqalungmiut Nunât. We did not travel without certain misgivings; Pauline had already established that the total communications black-out which had disturbed us since early May was between Base Camp and Søndre Strømfjord Air Base and not closer to home, and that helicopters could not be relied upon even when booked far in advance (another expedition she met had waited eight days for theirs).

We arrived at Søndre Strømfjord Air Base at about 14.00 hours (BST) rather the worse for wear as two of us had been air-sick and, after a period during which our plans were forcibly revised every half hour or so, Phil and Pauline finally left by helicopter for Base Camp three hours later. John and I waited a nervous hour for something to go wrong, but it didn't, and we were airborne again by 18.00 hours. The views were exhilarating, especially in the direction of the ice-cap, about 32 km away, and after a forty-minute flight we landed at the Drop Zone, 2 km from Base Camp.

It was very interesting to meet the Advance Party again and exchange news on the previous two months, until they discovered the mail that I had brought out and then they all disappeared into private worlds of their own for the rest of the evening, their thoughts completely occupied by those they had left behind - a state of mind I came to understand well before the end of the expedition. We camped a little away from Base Camp, by Goose River where the willow was sufficiently dense to give some background to our mist-nets. My lasting impression was of an outstandingly beautiful country filled with Lapland Buntings.

The next morning I was first up at 06.00 hours and unfurled the mist-nets we had set up the night before; the first bird caught itself just as breakfast was served. Cold porridge anyone? We spent the day ringing and being shown round by the 'locals'. The first day's ringing produced 32 birds: 23 Lapland Buntings (13 pulli), 8 Redpolls, and one Red-necked Phalarope. We had also had our first sightings of our main quarry, the Greenland White-fronted Goose.

C 11 THE WALK TO THE NORTH VALLEY (27 JUNE)

J. Floyd

At this point the Advance Party dispersed to explore the remoter parts of our region while the ringers familiarised themselves with Goose Valley and its environs. For two months we had been more or less limited to the vicinity of our valley, both by the demands of the behavioural study and by the harshness of the conditions on the plateau. The chance to venture into unknown territory was eagerly welcomed.

Eqalungmiut Nunât is bounded to the north by glacial meltwater flowing across salt levels in the deep North Valley. Our first visit there began at midnight on 26 June. The night was clear and still, the land's warmth rapidly radiated away through the thin arctic atmosphere and the pale blue sky. Ice crystals spread across open water, creasing the surface, fusing into richly ornate lattices.

As Adie, Alison and I crossed the plateau northwards, ridges hid the sun until, rounding a high precipice and entering new territory we stepped into its dazzling light. Although low above the horizon the sun was brilliant, a fresh gold which infused our surroundings. A still lake mirrored the cliff above; the glowing rocks echoed our voices with a cathedral hush.

A kilometre or so further on, beside a meandering stream, the sun had caught each rush-blade where it had extruded a droplet at its tip so that the banks were strewn with points of refracted light. Here spring seemed late; few flowers were open and the Atanârssuk River flowed beneath thick slabs of ice. A Caribou bolted through the shallows and sunlight flared in the spray, lit its steaming breath and rimmed its velvet antlers.

The sun climbed and mosquitoes began to stir as we passed the shores of a great and complex lake, white ice spreading between ridges and islands, still and silent. By the time we approached North Valley down sweeping grassy slopes the mosquitoes teemed in the warm morning air and we were glad to reach a small open gorge where the breeze from falling water and the shade in its slanting walls gave us a brief respite. Here the rock was cold and smooth, of many subtle hues, and under running water it became translucent like polished marble.

North Valley was hot, its mosquitoes unbearable. We headed straight for the refuge of wide sandflats by the river where we could rest and bask in the sun. The valley was 2 km wide at this point, with golden sands, blue lagoons, and green, green grass giving a great sense of openness compared with its southern counterpart. Behind us the valley sides rose high and steep, cliffs in many places. One face showed a steep 'V' of folded, many-coloured rocks, sinuous bands composed like figures in a vast Gothic window.

Our return from the valley was plagued by moquitoes; perception and enthusiasm evaporated beneath the oppressive humming hordes, reducing our walk to mere endurance. It was a sad way to return - head down, inwardly cursing, unable to speak for the ever-present possibility of choking on a mouthful of the insect menace. Quickly covering the 17 km to Goose Valley we were back in base by evening. It had been a walk of little event and somewhat marred by the nature of the homeward journey and yet it was notable for its pioneering quality, opening up the land to the north of the Atanârssuk valley for the first time.

C 12 THIRD ATTEMPT TO REACH THE ICE-CAP - SUCCESS! (27-30 JUNE)

W. J. Higgs

This walk occurred after the finish of the continuous observation of the nesting geese and prior to the commencement of ringing. It was undertaken partly from a desire to set foot on the ice-cap and partly as a survey of an unexplored area preparatory to the ringing campaign.

The 27 June was a beautiful, cloudless day and already rather hot by 07.00 hours; the mosquitoes were already on the go and we expected the worst. John Bell and I gradually climbed up on to the plateau, where the slight breeze gave some relief from the "mozzies" and made good time to Raven Chasm, a deep, narrow gorge with a spectacular waterfall. Here we took a breather; the air was richly scented with *Rhododendron* and the fall sparkled between banks of yellow *Draba*, white *Cerastium* and creamy *Saxifraga's* before plunging in a cloud of vapour into the dark ravine below.

By mid-day we had reached Large Lake - fish were rising and one corner was packed with broken ice. We passed many small unmapped lakes during the day's walk, nearly all of which contained one or two Long-tailed Ducks and we were treated to a display of agitated flying and splashing by one female.

As we travelled eastwards we began to see a few single Caribou and one herd of thirty, including several calves, grazing peacefully. On being disturbed the males stayed behind briefly to bellow at us. Another group of Caribou seen a little later were shaking their fur out in clouds and biting at their backs. After covering some 25 km we pitched camp, collected plants for the presses, and retired, the ice-cap only seven beckoning kilometres away.

The next day was cold and grey, keeping the mosquitoes at bay: perfect walking weather. We had a bit of trouble with unmapped geographical features; a sheer, extensive cliff and a torrential river foiled us in their different ways. There were occasional ones and twos of geese along the ice-edge and their droppings could be found consistently if suitable sites were examined. We were surprised to find a Lapland Bunting's nest within 2 km of the ice as these birds had been very scarce for the past few kilometres. Herds of Caribou were present right up to the ice.

The ice-cap reminded me very much of the sea, both in its obvious similarity as a vast landless zone and also in the way the clarity of its climatic and geomorphological effects on the landscape decrease with distance from it. At the edge of the ice, of course, these geomorphological effects are at their most obvious and are present in every stage of formation and decay. This zone was reminiscent of a huge quarry; massive sand dunes and gravel hills descending into muddy lakes; stark, newly exposed rock faces jutting here and there, with curiously perched boulders on every available surface.

I was struck by the dirtiness of the ice close to the edge. There is no clear boundary but rather "gravel with little ice" changing to "ice with a little gravel". A river of varying width flows along the boundary, often disappearing under the ice where it can be eerily heard. Beyond this, clear "bottle-ice" showed through between the stones and queer groans and other noises emanated from beneath our feet. We made acquaintance with a large crevasse, wandered for a few hundred metres to establish thoroughly our claim to having been on the ice-cap, and then returned to dry land to head for a tongue of ice which we rightly assumed to be the glacier at the head of North Valley.

This, to my inexperienced eyes, seemed to be fairly active with well-defined moraines closely associated with the sheer face of the snout and loud thuds regularly came from this area. To achieve a good view of the glacier involved considerable climbing over and around unexpected obstacles and we were already beginning to tire before we started on our journey back. We therefore only managed to put in 6-7 km before pitching camp for the night, exhausted, in a marshy part of the dunes in North Valley.

Most of the following day was spent approaching and skirting the great lake, Atanârssuk. All of the lakes we passed were very clear and rocky, with steep shores and no sign of life apart from the inevitable Long-tailed Ducks. Some of the larger lakes still had up to half of their surface covered with slushy ice. We took the journey at an easy pace, covering about sixteen kilometres of fairly straightforward walking on good Caribou paths. The route we chose followed the lie of the land, staying within the valleys and following chains of lakes.

On 30 June we awoke to the sound of continued rain and tried to go back to sleep. This happened several times until John gave the order to move. We breakfasted and peered out at the rain, not as heavy as it sounded but the mist could be a problem if it came down any further. We continued to skirt the shore of Atanârssuk to its logical conclusion, a disappointingly small outflow for such a mighty lake. We saw a few Snow Buntings, including two pairs feeding young within a hundred metres of each other, two pairs of geese, and the first flightless goose of the expedition!

The trek ended rather differently from the way it had begun as we plodded wet and tired on a compass bearing through low cloud and fine rain which set in for several days and delayed the commencement of goose-ringing.

C 13 THE TREK TO NIAQORSSUA - THE WESTERN FRINGE OF EQALUNGMIUT NUNÂT (2-4 JULY)

J. Floyd

Early July saw a lull in our work as the parent geese had hatched their eggs but few of the non-breeders were yet flightless. Adie and I decided to make a long excursion to explore the land to our west and discover the numbers and distribution of geese there. At this time we were living nocturnally to avoid the mosquitoes and, not wishing to carry a tent, we took advantage of this to prolong our walk from the evening of the second to the morning of the fourth of July.

Starting at 22.00 hours we walked steadily through the damp grey hills as low cloud obscured the plateau and the dim night sun. Few birds moved at this hour but after several kilometres we disturbed thirteen geese, including a family group, from a feather-strewn lake shore. They did not fly but swam down the lake until we lost them behind a curve of the shoreline and could not relocate them; they must have taken to the land. This behaviour was novel to us but soon proved typical of the moulting geese and nine days later we were to ring seventeen geese on this lake.

We came upon three more flocks on our walk. The next was on a lake we named Mistwater. It was high in the next range of hills; dense swirls of mist drifted from its surface to meet the cloud ceiling hanging low above, as if the water were about to boil. Several of the geese here could fly but seemed reluctant.

Higher in these hills the mist turned to snow, but soon it was time to descend again. Following a stream we clambered down a large gorge; on one side sheer cliffs vanished in the snow three hundred metres above our heads and our path wound amongst huge slabs of fallen rock. The largest example of a common feature of the landscape, this almost dry gorge must have been cut by meltwater when the ice-sheet was closer.

We emerged near our most westerly point, where the two great glacial valleys bounding Eqalungmiut Nunât merge to form an arm of Nagssugtôq and a raised headland, Niaqorssua, overlooks the junction. Here we spent most of 3 July, watching birds unique to this corner of Eqalungmiut Nunât beside permanent sea-water. Eider ducks, Iceland and Glaucous Gulls - our list rapidly grew and was completed by a breeding colony of beautiful Black Guillemots. It was strange and welcoming to be smelling salt in the air again, and to be beachcombing along the tideline with its sparse scatter of shells and seaweed.

As time passed we realised the fjord was very tidal even here, 120 km inland; mudbanks shrank and the water spread further up the southern glacial valley. Turning from the broad blue fjord we followed the tide and headed up the valley on the first leg of our return route until we reached a high cliff about which gulls glided and called. We rested and watched these very white birds with their unusual high-pitched cries, the ringing "kee-yow's" echoing beautifully off the rocky slopes.

We reached the gullery clifftop at midnight, the long rays of sunshine catching the ridges of the plateau all around us, turning the peaks a burnished gold, the fjord a dark glinting blue and the sky filled with fluffy clouds in banks of shadow around the sun. A lake in the mountains across the valley reflected the sun, a cat's eye lens in a dark massif. Then a diver wailed nearby, the wilderness complete, and it felt so good to be in a land as untouched as this.

But this reverie had to give way to the reality of the long hard slog before us; we were far from base and rapidly tiring. The diversions of an aerial dispute between Peregrines and the discovery of our first Phalarope chicks were welcome but we had still had enough long before Base Camp came into view beneath the rising sun. We had tried to stay awake for too long and over the last few kilometres I suffered from mounting exhaustion; the pain in my feet stopped, colours and sounds seemed unnaturally intense, time ran slowly and my thoughts became confused. The final stage of this 56 km walk was agony for both of us and the difficult terrain had predictably resulted in severe blisters. So, back in camp at 06.00 hours on the morning of 4 July, we were ready for a very long sleep.



C 14 LLYN ANNE AND RIMWATER MARSH (25 JUNE - 8 AUGUST)

J. Madsen

When the goose family from Upper Marsh had moved up to the plateau and another nesting pair had been found on Rimwater Marsh, a party of observers (David, Tony and I) followed the track of the geese. On 25 June we left BC and walked to the ridge between False Eyrie Crag and Needle Cairn Heights to a small clear-water pool which Tony named Llyn Anne. Here we pitched camp - our home for the next forty days.

The camp site proved to be ideal for our purpose. We had an hour's walk to the luxuries of BC (by the end of the period we were able to manage it in thirty minutes) and were in the vicinity of the geese for most of the time. The only interruptions in our observation programme were the ringing tours, an activity not consistent with behavioural studies of the geese.

Tony soon left the party to join the ringers and to do some work in the lowlands and was replaced by John M^{c}, still fit and healthy - the TVP diet had yet to take effect. The plateau watch required a complete change from the nest-watch in several ways. From being stationary around BC we were now forced to be very mobile to follow the movements of the geese. We often had to walk many kilometres to find them and were not accommodated with a comfortable hide to watch them from. In the beginning the extremely shy goose families often spotted us before we did them and several times we had to return to Llyn Anne without having made any worthwhile observations. We had to adapt our methods to these difficult conditions, first of all by becoming familiar with the new surroundings and the nature of the geese and making long-distance observations through the telescopes. Another difficulty we had to overcome was the weather conditions. The Arctic summer had come with cold spells of rain and snow, sometimes for two or three days when we were forced to remain indoors passing the time reading, cooking, drinking tea and sleeping.

Nevertheless, the period on the plateau as a whole constituted one of the richest experiences in Greenland. The summer had a further dimension that we did not find on the lowland - because of the shortness of the season and the primitive environment we felt the daily changes more acutely as the season progressed in this real wilderness of barren rocks and sparse vegetation. This feeling was enriched by our movements as we saw many different landscapes as a contrast.

On 8 August we broke up the camp at Llyn Anne in order to join the rest of the expedition at BC on their holiday period, for the last time walking down the west ridge along the familiar track that we had trodden between the two camps countless times in the last six weeks.

C 15 RINGING: THE EARLY DAYS (27 JUNE - 10 JULY)

P. C. Davies

We moved camp on 27 June and suffered from mosquitoes for the first time, but alas not the last. We camped between Base Camp and DZ and established the pattern we were to follow until we started catching geese, of moving camp frequently and ringing almost continuously as we circled clock-wise around Base Camp.

The next day we ringed our 100th bird, moved camp again, still down hill, and watched a pair of Great Northern Divers, my first sighting and in breeding plumage! After setting up the nets again we retired at 03.00 hours. The 29th was the hottest day so far at 27°C. Alison walked up to Base Camp, about 5 km away. I found the thought exhausting but did find the energy to bathe in the river as a strange warm wind kept the mosquitoes at bay and made it all very pleasant. Ringing was a bit slow; I think the birds found it too hot to fly. I watched lazily as a male Snow Bunting, resplendent in his summer plumage, perched and sang all over and around the mist-net but refused to co-operate and get caught. We didn't catch any adults until they had moulted, which was a pity. In the evening it rained, which cooled everything down a bit.

On the 30th we moved camp, by a circuitous route and an inflatable ferry fixed up by the advance party, down to Kuk Marshes. It rained continually, a light persistent drizzle which did a very good job of soaking people, especially when it had all day to do it in. We camped by Long-tailed Pool and set mist-nets to catch a pair of Ringed Plovers, but they were not to be caught. Pol made some tea and we discovered that the water in the area was decidedly salty, but eventually she found us a drinkable supply. My spirits were as low as the cloud cover.

It was 1 July, the rain had stopped and the following day we would have to replenish our paraffin supplies; Base Camp was 8 km away and 300 m above us; the walk did not seem attractive. We spent most of the day exploring the area and ringed only 14 Lapland Buntings. In the afternoon we decided to walk part of the way back to Base Camp. The walk up to George Eliot, where we camped, was so miserable for me because of my lack of fitness that even the sight of my first Gyrfalcon could not cheer me up.

On 2 July the nets were up by 04.35 hours, the first bird ringed twenty-five minutes later and ringing continued until 13.00 hours when we headed for Base Camp. It was our best ringing day so far, 54 birds of four species including our first Wheatear. Even the walk up to Base Camp was relatively painless. The ringing party set up camp and in the evening there was an excellent communal meal, only the goose watchers being absent.

The night of the 2nd was very wet and I had pitched the tent on a steep slope; Tony never let me choose the tent site again. The morning revealed that it had snowed on the surrounding hills, making us feel that this really was the Arctic. Alison allocated lakes to us all to inspect for flightless geese, and I arranged to go with John M^{c} and Dave Stroud to collect a time-lapse camera which had been placed at a distant goose nest. The three of us set off in the early morning of the 4th on a warm, dry day and, in addition to recovering the camera, we got superb views of two pairs of Great Northern Divers, one with young, and John picked up a Red-necked Phalarope chick. We got back to Base Camp in time for another communal meal, this time in celebration of Will's birthday.

The next day we ringed our only Ptarmigan, a male that appeared to take a liking to Pol and allowed itself to be hand-netted. Later on we moved up to Ptarmigan Gorge to be closer to the plateau where we expected most of the geese to be. The next three days saw the worst weather of the whole trip, with almost continuous rain, sleet or snow. The only ringing possible was that of Wheatear

and Snow Bunting pulli on the cliffs of Ptarmigan Gorge. On the 9th the entire party split up into pairs to search for geese; we discovered 42, in three widely separated groups, but unfortunately we disturbed them all, our technique obviously needing revision.

However, the next day Phil, Pol, Tony and I approached Lake Uniform and Tony sighted twelve geese and got us all "to earth" without the geese seeing us; there followed a whispered conference and then Tony and I backtracked and circled around the lake behind a convenient ridge. When we were all in position a strident whistle signal sent us all racing towards the lake and for once we outmanoeuvred the geese. We ended up spread out around the lake with the geese in a tight bunch in the middle. Phil and I erected 150 m of net in a 'V' formation on twenty aluminium poles; it took us two hours to make sure there were no gaps for the geese to squeeze through. Then we walked away from the nets, Phil ringing three Red-necked Phalarope chicks on the way. The geese swam and then ran straight into the nets. We raced after and caught eleven of them - one managed to double back. We returned to camp in high spirits as we now knew that we could catch geese once we had located them.

C 16 CAMP DAVID AND TEILHARD TARN (11 - 18 JULY)

J. S. McCormack

With the discovery of a flock of seventeen non-breeders on Zulu on 10 July, it was decided that three of the expedition members would camp in the vicinity to observe them. They would then be able to direct the ringing party as to the most likely method of catching the geese, knowing their local movements and habits. On the afternoon of the 10th DAS, JM and I camped at Teilhard Tarn. It was a bitterly cold afternoon and by 18.00 hours conditions had deteriorated, with any period of immobility leaving us cold and miserable. Indeed it was so cold that watches on two flocks were abandoned after some hours and by unanimous decision we decided to confine ourselves to camp for that first evening. Camp David could not boast the comforts of its namesake. It consisted of a single tent which was designed to accommodate one person in comfort, two with a squeeze and the third - well, we all just managed to fit in.

After a rather windy night, the following day turned out to be relatively fine and proved most co-operative for our first major assault on the geese. These were unsuspectingly grazing on the western end of the lake and we awaited the arrival of the other expedition members upon which the tension mounted and we discussed assault and contingency plans. It was remarkably reminiscent of the last-minute pep talk in the changing rooms prior to a big match. The objective was to keep the geese in their present position whilst stealthily surrounding them to prevent their escape. We did not want them to go on shore (where experience told us they were impossible to relocate once hidden amongst the vegetation) or onto the other half of the lake which would render the eventual drive and capture more difficult. Jesper and I were to make our way around to the far side of the lake and position ourselves along the top of a slope overlooking the lake. Meanwhile John Floyd, Ade and Will were to move to the top of the very steep, north-facing slope on the other side of Zulu where they could cover the lake from the south. The six of us had four radios between us and John Bell had the other two. He was perched atop a summit overlooking the whole lake and was to co-ordinate the round-up. When everyone had got into position, those on the north side were to stand up and show themselves to the geese, moving slowly down the hill to the lake. Their appearance would flush the geese from the north bank where they were feeding and whilst they were swimming to the other side, those people on the south slopes would appear. At this point there would be a rush to the lake side and before the geese had realised what had happened they would find themselves in the centre of the lake, surrounded and with nowhere to escape.

Such was the plan, which appeared foolproof to us, but of course it hinged on the willing co-operation of the geese. As we were to discover they did not always oblige! It took an hour and a half to get ourselves, on the northern side, into position since we had to circumnavigate the lake without ever allowing the geese to see us. Eventually we were ready, concealed behind boulders but keeping the geese in sight. However, something had disturbed them and they had moved off and were swimming towards the eastern end of the lake and to certain freedom unless action was quickly taken. Jesper saved the day by quickly walking around a range of hills to appear at the extreme end of the lake, thus turning the geese back. At this point we rapidly descended, as did those on the southern shore, half-running, half-falling down the 200 m slopes to the lake. Before we could say "Hey Presto!" we had the geese surrounded; but this was only half the battle as we now had to manoeuvre them into the nets once they had been set up.

The geese were tightly bunched in the middle of the lake, heads erect and constantly trying to find a means of escape. Occasionally a bird would break from the flock and, with its body nearly totally submerged, try to swim ashore and to safety. It was interesting to observe that whilst artificially densely grouped there were many more aggressive interactions than normal. Several times there were severe fights amongst members of the flock.

With the nets set up and the geese successfully surrounded, the next thing to do was to herd them into the pen. It was here that the inflatable boats were employed, small plastic dinghies whose disadvantage was the length of time required to inflate them, particularly if one had forgotten the foot-pump! Once in the water and manned by Will and John Floyd the final phase of the catch began. Our first move was to fall back behind the geese leaving them a way of escape in the direction of the nets. Those of us on the shore would guide on the lateral plane whilst the boatmen would keep them moving forward. Everything went smoothly until the geese were within 50 m or so of the shore; they became very hesitant, turned around and swam towards the oncoming boats trying to escape. Fortunately the persuasion of those on shore and the two boatmen, beating their oars against the water, turned the geese and once more they were heading in the right direction. By now we were shouting and whistling, breaking the Arctic silence with our vocal outpourings in an effort to drive the geese ashore and into the nets. Our persuasion triumphed with the first few geese stepping ashore and, a moment later, all seventeen were running as fast as they could in a vain attempt to escape across land. However, they were consistently faced with a wall of netting and eventually all went into the pen.

Once in the pen, Pauline entered with them and passed them out one by one as they were required by the ringers. A collector would take them from her and deliver them for processing 100 m away. At this point excitement was running high and there was a virtually continuous clicking of camera shutters. By the time all the birds had been ringed and released the day was well and truly spent,

although with no nightfall to look forward to it seemed to go on forever. All of us, quite fatigued, returned to camp and decided that tomorrow was to be relatively restful, a scouting of the surrounding district for further flocks to be the sole task.

The next day was quite pleasant; a warm breeze from off the ice-cap succeeded in making it a good day for reconnaissance and so, after a late breakfast of porridge and tea, I set off north crossing Zulu at its junction with Welsh, and on up to the plateau. From here, stretching away in the distance, was the mountainous panorama of wilderness, merging in the distance with that massive sheet of white, the ice-cap. I continued on until I finally came to a large lake, long and narrow with a small peninsula protruding halfway across it, called Mirrormere. After nearly two hours scanning the lake I finally located a flock of geese, nine in all, and with mission accomplished I promptly returned to Camp David for a hearty meal. Arrangements were made that night with the other members at Base Camp to meet us at the lake, and so we prepared for an early start in the morning.

David, Jesper and I set out from camp, taking with us one of the boats and a radio, and more than an hour later we arrived at Mirrormere. The first thing we had to do was to locate the geese and fortunately this proved relatively easy as they were grazing on the peninsula. We radioed this news back to the approaching Base Camp party but reception was bad and little of our message was received, so we sat down behind a boulder to shelter from the mosquitoes and the wind and waited. We had a long wait, continuously scanning the horizon to the south for their appearance, before they came. As we were unable to contact them by radio we had no idea as to how far away they might have been.

Eventually a movement was seen on the horizon; through binoculars the massive figure of John Bell was made out, with the others appearing in the background. Half an hour later they had reached us and after a quick lunch a plan was drawn up. With each assigned his particular task and the geese in the smaller portion of the lake, we set off. Again Dave, Jesper and I were to go the long way round to the other side of the lake and we were soon in position out of sight of the geese. Once they had been surrounded the nets were erected at the outflow of the lake where the ground was gently sloping and ideal for our purpose. The nine geese were finally driven into the nets, ringed, weighed, photographed and released without incident. With the boats deflated and the nets dismantled we set off on the long journey to our respective camps. The immediate area was now almost completely surveyed except for a region to the west of our camp at Teilhard Tarn.

With confirmation that there were geese on Spidermere we decided to attempt another catch on 15 July. We realised that they could possibly be part of the flock we had already ringed on Zulu, but with goose legs very difficult to see in this terrain the only way to find out was to catch them. The day started early and by 09.30 hours we were on the move, following the discharge from Zulu along a deeply glaciated valley until we came to the lakes Yankee and Doodle. At the end of Doodle we met the stream flowing down from Spidermere where we stopped for lunch.

After we had been suitably refreshed we moved up to the lake and dispersed to take up our usual positions. Initial inspection revealed no sign of the geese and I was about to return to the others when a movement caught my eye at the north end of the lake. I spotted them through my binoculars sprinting for their lives along the shore, running surprisingly quickly. I lost sight of them for a moment but knew that unless I acted quickly we were going to lose them so, depositing camera and binoculars where I stood, I set off to try and prevent their escape. The geese were in fact running towards me and I found out why a few moments later when I appeared over the top of a small hillock and there below me were six geese swimming quite unperturbed on a very small tarn. I'm not sure who was more surprised, as for a split second we met eye to eye, before they decided they were not going to hang about and immediately scattered into the surrounding birch and willow scrub. Having pinpointed where two had disappeared I went to the spot but was baffled and disappointed when there was no sign of them. Suddenly, not more than a metre from my feet, two geese flushed and ran back onto the water. Another goose made for the tarn a few minutes later but further searches revealed no more. It was some time before the rest of the party arrived to begin what we thought would be an easy capture.

Initially the geese were herded from the lake shore, but whenever they got near to the nets they would turn and swim to the middle of the lake. We then guessed that the birds were already wise to the procedure and our fears were realised when we glimpsed a Darvic. Nevertheless we continued, using the boats on the next attempt. Finally, after much frustration we managed to drive them into the pen where, needless to say, we found them all to be ringed.

We left the area three days later and moved back to Llyn Anne camp, satisfied with the results of our efforts, but sad that such an enjoyable period at Teilhard Tarn was over, where even the mighty föhn wind could not shift us. We spent the last few days battling against the gale that threatened to put an end to our camp by blowing tent and occupants over the edge of the nearby cliff.

C 17 EAGLE CAMP AND ATANÂRSSUK (24-30 JULY)

A. D. Fox

With the intensive campaign in the west now completed we decided to concentrate our ringing efforts in the northern half of the region. Adie and JF were already installed on the plateau in the centre and the rest of us were to journey out to the hitherto unexplored north-eastern corner adjacent to the ice-cap.

The idea of a trek from Base Camp down to the far end of Atanârssuk did not enthral, however, spirits rose with the prospect of ringing more geese and we broke camp at 10.00 hours. The day was perfect, in a damp Great Britain it would have been a dream, but our experience of the previous weeks warned of a day of agony avoiding mosquitoes - the stillness and warmth were to bring them out in their countless millions. The tug up the slope was quickly past and we followed the pass below Crusties peak, PCD and I going ahead and leaving the rest to follow on later. Phil was laden down with the now familiar shape of the furled nets with accompanying miscellaneous ringing gear, while I trudged behind with a meagre load of personal gear and the camping equipment for two. The route past Oscar and Papa to Lake Line was familiar and easy walking; this was softer plateau, firm under foot, each footfall disturbing bursts of colour - yellow *Potentilla* and the occasional vivid pink

Thrift. The weather was gorgeous, sparsely clouded, blue above and a warming sun playing upon the dancing wings of the butterflies, strangely incongruous as they chased and tumbled over the Arctic tundra dotted with dandelions! A flightless drake Mallard on Lake Line 4 hinted at autumn's swift approach and the vociferous Phalarope on the next lake had already donned winter garb.

Phil and I halted at the North end of Lake Line and the chatter of Wimbledon and Ynyslas (dreams of home) ached as we waited for the rest to catch us up. Ade and John Floyd popped down from their hill-top haven on 612 m, and the company assembled for a conference. Mr Davies looked on in horror as I blithely offered our four day ration of tea to the troops and it was decided that Ade and John should stay where they were to cover the areas north of Castor and Pollux looking for geese, while the remainder sped on to the east end of Atanârssuk to look for White-fronts in the northern corner of Eqalungmiut Nunât.

After two hours of lunch and discussion, as well as considerable modification to the landscape by assorted trundlers, the group set out to walk the length of the huge lake, planning to camp at the far end. The reaction to this decision differed according to personality, and we each set off at our own pace, resulting in rapid fragmentation of personnel. Atanârssuk is some 11 km long, a blue gap between the pursed lips of the ridges to the north and south which plunge sheer and deep into the watery depths. A mysterious place, and the only certainty about the lake was that nobody we asked could translate the name! This was how I had envisaged Greenland - grey, grim, angular cliffs; a private landscape of Caribou and Snow Buntings. The great scar of azure liquid was a major feature of Eqalungmiut Nunât and presented a considerable barrier to the Caribou following the forage. Generations of the creatures must have encountered the lake in their timeless pursuit of grazing with each thaw, so that their highways are cut, old and clear, through the vegetation of the margins. It was these tracks that bore us ever east along the edge of the lake that afternoon. A birdless and still landscape in which the mosquitoes soon found a band of helpless humans, burdened by equipment, sinking each weary step in the print of the man before and quite unable to fend off the insect hordes. This was to be the worst day for the merciless insects as swollen wrists and faces were later to witness and scratching echoed from the tents long after sleep had brought apparent itchless relief.

It was along one Caribou track that it was realised that perhaps *Rangifer tarandus* was not the intelligent exploiter of such a spartan environment we had thought. Such was the dropping of heads on the route that we had followed a track down to the very edge of the lake only to find sheer 40 m cliffs plunging straight down into the bottomless inky waters - an abrupt end to the path. Encumbered with complete ringing gear, it seemed a natural course to inflate the boat perched on David's back and to row the personnel and equipment around the base of the cliff to the lake margin beyond. With the gathering flies and low morale, this did indeed seem infinitely preferable to the climb back over the cliff top which lay behind. Our resident fireman proved himself just as much at home in water and conducted trips around the bay and, whilst in the boat out on the lake, each of the team was given a much-appreciated rest from the onslaught of the "mozzies".

With great loss of time, the cliff was by-passed and the march resumed, albeit at the expense of the submergence of PCD's binoculars.

Both fringes of Atanârssuk are steep and uncompromising and the strategy of hugging the lake side in order not to get lost was, on reflection, a misguided one. JB, Jesper, and Alison (we later discovered) had found the walk along the cliff tops to the south of Atanârssuk very easy and quite why we vehemently clung to the lake now seems obscure. Eventually, after clinging precariously to steep faces and scary scree slopes, my chump gave out, and with clenched teeth I climbed up the treacherous scree slopes and moss-mat that so slowed our passage, and dragged my unco-operative body up to the ridge above. A worried supporting cast followed, unsure what Mr Fox in this mood might be capable of; however, we all emerged on the tops without mishap and the trek continued.

A shriek behind - we turned sharply on our heels - the cliffs dropped sheer for 20 m to the scree slopes plunging into icy waters beneath. Eyes were inextricably drawn to the water below. We all assumed the very worst. We shouted and a weak cry was heard. Dave hurried back and we retracked along the ridge. After anxious seconds the motley pair were met - the story told: John Mac had dislodged a small boulder which had dropped on top of Willy's head and caused a minor landslide. Will had clung on and held matted crimson hair, shrugging the injury aside. We had had another fortunate escape and once more a serious accident had been avoided.

It seemed very late when I finally stumbled upon Jesper and JB. The pioneer twosome had seen geese - 24 birds in all - and were understandably unwilling to continue to our rendezvous beyond. At this stage, the thought of putting off geese and possibly losing them from ringing returns was incentive enough for all to stop and make temporary camp for the night. A nagging worry was the absence of Alison who had gone on ahead, but our fears were allayed when an orange tent showed itself at the head of the lake - yet another lucky flaunt with Fate - the fragmentation of the group was unforgiveable.

Our camp-site for the night was to be dubbed Eagle Camp, a perched area well above the margin of the lake. The scratched and furrowed bare rock, cupping hollows of stagnant water, was an ideal site for watching the little band of geese which Alison had forced gently back towards us. A weary William trudged on to see if Alison was OK and the rest of us prepared for the coming night's observations on the band of geese.

I volunteered for the second watch and was treated to a display of Arctic Fox avoidance as the poor thin carnivore made a vain attempt at goose trapping. The sun sank on the feeding geese as the fox trudged off for easier tuck and they set off to move slowly down the lake towards Alison. The observations were finally abandoned as they drifted from telescope-sight. Without geese the hapless band of watchers settled to bed. The sun gave a final claw and scratch at a curious sandwich sky, and the ice crept silently between the tents along pools and puddles as a grudging sleep overwhelmed each of us.

The next day dawned hot and uncomfortable - I woke from slumber stiff, disturbed, weary, and face to face with JB's feet. The idea of putting Phil Davies, John and myself in the same tent may have been a good idea from the point of personalities, but the three largest expeditioners in a Vango was obviously not what the original designer had envisaged. I doubt that any of us had moved all night long and the proximity of the others resulted in some of the highest temperatures ever recorded above the Arctic Circle.

It took until 13.00 hours to shake off the effects of sleep and then we began to assemble for another move. Before we left, however, all in camp were entreated to the spectacle of two Eagles on a passing visit to examine the brash and noisy intruders to their domain. The adult birds

soared violently upwards, wheeling round and round each other as if linked by some invisible cord, pallid tails spread, before disappearing away to the south.

The 25th had begun sunny and warm but a freshening wind brought cloud later and eventually rain in the evening. Another camp was created at Lake 29 with a reassured Alison and the group began to look for the geese which had headed that way. In the absence of the rest of the ringing team, Phil and Pauline, there was little the group could achieve and, having spied out the immediate lakes, enthusiasm waned and the day, like so many before, passed quietly. In the evening we talked to a silent radio-set in the hope of news from 612 camp or the ringers but to no avail, and we turned instead to the great Trafalgar that was unfurling on Lake 29 as the Stroud and Bell camps commenced pitched battle in the dinghies. A watery truce was finally struck and the oars laid to rest as the "Snowbies" began to roost, and, most willing, I copied their example and climbed merrily into the sardine can to settle once more to tropical sleep.

We woke late again from precious slumber and Will left to look for Phil and Pauline on the north side of Atanârssuk, but they were quickly sighted progressing along the southern edge. Another conference of war followed. Groups again dispersed to search for geese - Phil Davies and I set off for the lakes to the north, finding eleven geese on Worm which unfortunately we disturbed, pushing them onto a nearby lake where they joined a family with three goslings. The non-breeders were resented by the gander, the resultant aggression seeing off some of the newcomers and even forcing some to flight. Due to the inadequacies of the radios (well, probably the inadequacies of the radio operators) we were unable to call up the rest of the group, who, in the absence of word to the contrary, continued after us. Somewhere near Spaceman we must have crossed unseen and Phil and I returned to camp to find a *Marie Celeste* group of Vangos. The ringing group caught 13 geese in our absence near Worm, including the three goslings, but no thanks to poor organisation and failing communications. Fortunately, the lessons were learnt and the next few days proved highly successful in the ringing of geese.

C 18 THE NORTH LAKES GOOSE SURVEY (27 JULY)

P. C. Davies

At 07.00 hours on 27 July Tony and I rose and breakfasted in preparation for what was, for me, the most memorable day of the Expedition. Whilst we ate we watched a steady stream of Caribou (50+) heading south around Atanârssuk ; we were to head north, flying in the face of Nature perhaps? At about 08.00 hours, during a break in the Caribou traffic, we set off and for the first 2 km we used the excellent tracks worn by generations of migrating Caribou. The weather was warm and dry and we were determined to achieve something after the confusion of the last two days.

To the west of Spaceman we saw a family group of Purple Sandpipers, the first confirmation of successful breeding in Eqalungmiut Nunât; the young could only fly weakly and could not have travelled far. Just over the ridge on Lake 26 (we had run out of names and exhausted the phonetic alphabet so lakes were now numbered for identification) was a Red-throated Diver with young and to the East on Worm we could see the eleven geese that had been ringed the day before. We continued on our northerly direction along Lakes 32 and 33. On the latter, a very narrow lake with a steep descent for us and sheer cliffs rising directly from the water on its northern shore, there was a family of six geese, both parents and four young. This party was ringed the following day and the whole family have since been sighted on Islay, Scotland.

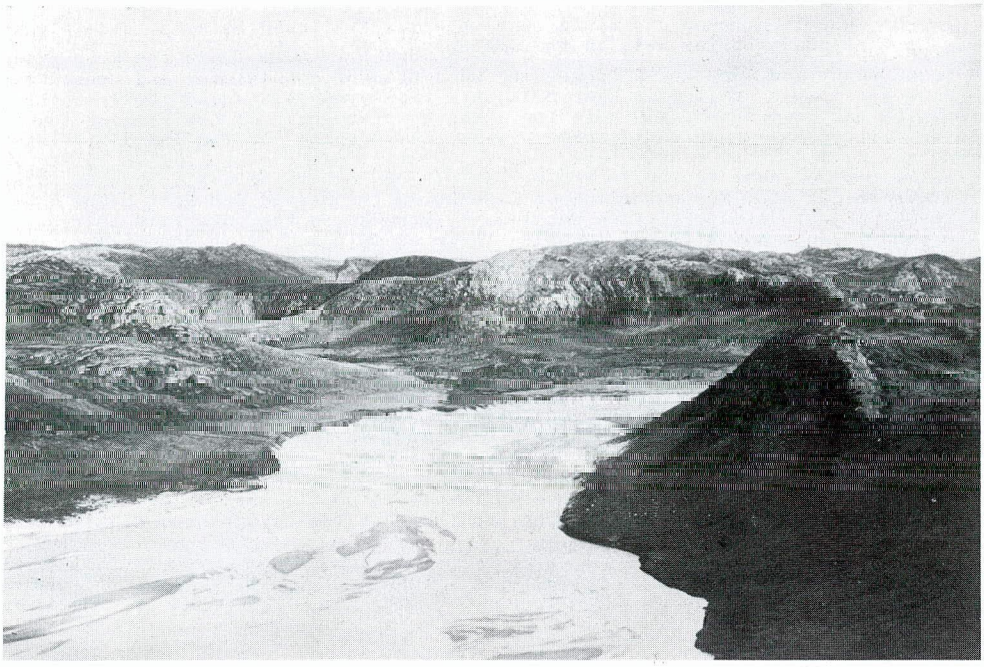
We detoured around the western end of the lake and continued on, past 34 and on to 35 which held our largest flock of geese so far, nineteen. They were non-breeders and appeared to have almost completed their moult. Lakes 39, 40 and 41 were without geese but 41 was littered with feathers and droppings. As we had so far made such good time we decided to press on to the North Valley. The cliffs on our side were 400 m high and looked down upon a 2 km wide glacial melt-river in a flat-bottomed, recently glaciated, valley containing large areas of sand dunes. The far shore rose less steeply but following the slope upwards we could see the ice-cap between the hills and the sky-line except where a few of the higher peaks obscured the view. To the west we could see a few of the snow and ice covered peaks of the coast, a vivid contrast to the high summer conditions around us.

Reluctantly we turned away and headed roughly south-south-west (a little too roughly as it turned out). My navigation not being all that it should be took us far to the Left (an accusation that is not often levelled against me). However, correction was made and we lunched overlooking Lake 38. The area we had covered was basically a high plateau; the only Lapland Buntings we had seen were on the lower, lusher, south-facing slopes, the remainder of the area being inhabited by Snow Buntings and Wheatears.

The first stop after lunch was Lake 37 and Tony spotted seventeen geese, I found 42 for a moment but when I borrowed his binoculars twenty-five of them became Long-tailed Ducks - the dunking in Atanârssuk had not improved the optical qualities of my binoculars! Lake 36 was occupied by one flightless Mallard and after that we spent some time examining a rock feature along the southern shore of Lake 37: it was about 1 km long, 7-10 m high on both sides and only 5-12 m thick and remarkably regular. It was like a natural version of the Great Wall of China.

South of Lake 36 the scenery changed quite abruptly. Lakes 22, 23, 24 and 25 are on a flat, high plateau and are irregularly shaped. They are surrounded by boggy, occasionally extensive, marshes and this is in marked contrast to most of the area where the hills fall steeply into the lakes and any boggy areas are limited to the infalls and outfalls and are much smaller. Strangely, this area was almost birdless but we did find a complete Caribou skeleton, oddly appropriate in this still, lifeless place. We left the plateau by climbing a steep, high ridge set, inevitably, at right angles to our route.

Lakes 18 to 20 were checked in quick succession since they were small, close together and without geese; we were also getting hungry. We retraced our morning route around the end of Atanârssuk on the Caribou highway and were back at camp by 17.45 hours. We had checked twenty-three lakes, found 53 unringed geese and thoroughly exhausted ourselves - we felt we *had* achieved something.



North Valley showing glacial sandur from the pass above lake 39 looking north.

C 19 NIAQORSSUA AGAIN (1-4 AUGUST)

J. E. Bell

By this time the non-breeding geese had regained their flight feathers and hence our efforts turned to catching the goose families we had noted over the past month. We began this final stage of the expedition in the south-western corner but the geese evaded us and the days took on the shape of a sight-seeing tour.

Dave and I set off for The Gullery travelling round by False Fyrie Crag and X-Ray Pass. The value of studying the map before setting off was proved by the fact that I forgot it completely. It was in X-Ray Pass that we found an extremely rich area of garnets in a friable mixture of quartz. Shortly after leaving the outflow of Spidermere we located the camp of Phil Belman and Phil Davies, Pauline and Alison who had preceded us by a day. Adrian and John Floyd had moved still further down the peninsula and had a magnificent campsite overlooking the seaward end of the fjord.

As Dave and I had not been in the area before a brief evening stroll was in order, first of all to look at The Gullery. This is a magnificent array of south-facing cliffs, towering 300 m above the milky waters of the fjord, and which proved impossible to traverse. I daresay an experienced climber would have succeeded but even then it would have been dangerous because of the crumbly nature of the rock, most of which is metamorphic and contains much mica. The view from the top of The Gullery gave us our first sight of the tidal part of the fjord. The flat, braided river system gives way to sea water and there, clearly demarcated, is the colour difference between the fresh and salt waters. Indeed it is this phenomenon that gives this part of Nagssugtôq its name, Kûp Akua, the meeting of the waters.

On our return to camp we noticed that on the far side of the fjord there were tents and boats. Since we had come to regard Eqalungmiut Nunât as our land I, at least, felt as though the Greenlanders were intruding; nonetheless we looked forward to meeting them. Dave and I immediately began to speculate how it might be possible to attract their attention without giving the impression that we were in distress. We tentatively suggested that someone might canoe over to meet them, but it would be a long haul, not only because of the distance but also due to the swift currents which undoubtedly flowed in the main fjord channel.

Phil Davies remarked that he had heard shots during the day, so it seemed likely that the Greenlanders were hunting Caribou. The fact that guns were being used removed the possibility that they may have been hunting for furs, since a gunshot wound reduces the value of the pelt. The boats in the fjord no doubt were their transport from home, but were probably also used for fishing by gill-netting across the channels as the Char returned from the sea to spawn in the freshwater of the lakes and streams. The following day we came across several small cairn-like structures with a smaller chamber at the base about every 200 m along the side of the fjord. These were almost certainly traps for Arctic Foxes, whose fur is a valuable source of income to the Greenlanders.

Early the next day we spent a few hours searching for geese to ring, but unfortunately they eluded us and so we split up to explore some of the more picturesque areas of the peninsula, while Phils D & B set off with Pauline to try to catch a few seabirds on the cliffs of The Gullery. For the 'tourists' the first port of call was The Gash to the south of Gormenghast. These two features are *so* extreme in an area of rounded contours that they take some time to appreciate. It is likely that The Gash was scoured out, in fairly recent geological time, by glacial meltwater. Particularly spectacular were the cliffs of Gormenghast Mountain which rise vertically 250 m from the boulder-strewn depths of The Gash. The very bottom of the gorge is filled with house-sized chunks of rock split from the towering cliffs by frost action. At the seaward end of The Gash Dave had the good fortune to find a large lump of Soapstone - extremely soft and easily carved. This is still done to some extent in Greenland but the traditional devil figures made from this material, *tupilât*, are these days made for the tourist market.

At Niaqorssua, a close examination revealed quite a selection of birdlife including Glaucous and Iceland Gulls, Tysties, Eiders and an immature Purple Sandpiper. Adrian, in the meantime, returned to some Black Guillemot nests found on an earlier trip and located a couple of Tystie pulli sleeping in a crevice at the top of the low cliffs.

The day was done and the sun once more began to set; here we lose its radiance behind the near peaks before it truly sets and as such it drops away as a fierce golden orb. The air rapidly cools as the warmth falls away behind the mountains across the fjord and the sombre colours of night begin to take their place. To the south a cloud front approached and the high altitude winds ruffled barbs along its upper edge like feathers. A coy gleaming moon looked on from behind a scant veil of cloud to the east; whilst in the west a distant plane of silver-grey cloud turned pale purple in the hues of the sunset. The ranked peninsulas looked sullen as they edged into the ebbing mirror waters of the fjord; the remaining channels through the mud shone like ribbons of silver; and fingers of purple, western cloud, began to stretch and deepen across the sky.

On the following day we marched dutifully Basewards, accompanied by a barrage of mosquitoes which only abated in the cool breezes of X-Ray Pass.

C 20 THE GREENLANDERS IN EQALUNGMIUT NUNÂT (AUGUST)

W. J. Higgs

During our stay in Eqalungmiut Nunât it became increasingly obvious that 'someone else' had been there, the evidence being a recent campsite at the head of east Eqalungmiut tasia together with occasional finds of live and spent ammunition. In the first few days of August we discovered who had left these signs, as the Greenlanders arrived in six fishing boats to make their regular summer camp on the south bank of the fjord at Aqâtâq. The camp remained a permanent feature, while the number of fishing boats and associated motor boats and *umiaks* (lightweight, canvas covered, rowing boats) fluctuated as they ranged abroad in search of Caribou (*tugto*) and Arctic Char (*eqaluk*). These two commodities were the central reason for their presence, although there was a social aspect as these summer camps are a long-held tradition, and there was a large contingent of old people, children, and other non-combatants.

Our first meeting with the Greenlanders occurred when three of them ascended Goose River with their umiak on a Caribou hunting expedition. The umiak, filled with equipment, was dragged overland up the course of the river, the lush vegetation of the valley bottom providing a good surface for such travel. On the lakes it was rowed in a style novel to all of us, the rower standing upright facing ahead, the power-stroke coming from a downward push using the weight of the body, and the oar-blades ascending almost vertically, set at an angle. They pitched camp at the head of the lake and a couple of days later JB and myself decided to pay them a visit, taking a tin of syrup as a peace-offering.

The Greenlanders' camp consisted of one largeish (3/4 man) tent, standing close to the lake edge, next to the umiak. This was later supplemented by piles of Caribou flesh and antlers along with the usual quantities of domestic refuse associated with these camps. They were not at home, but as we heard shots from the plateau above we decided to wait awhile to see if they would bring down the kill. While we waited we discovered a family of geese on a small lake 500 m from the camp and fetched Phil and Pauline from Lakesmeet to try and catch them. The attempt was a failure, due to the reluctance of the geese to leave the water. During our efforts to drive them off the first of the hunters appeared on the skyline above and proceeded to take an extremely circuitous route down (apparently to avoid disturbing us) even though he was carrying a very heavy load of dismembered Caribou. We estimated that he was carrying most of the meaty bits of two Caribou, which caused him to take a rest every two hundred metres.

This young lad, by the name of Kaba, came across to watch our antics as he passed and joined in with our arm-waving and shouting. I attempted to communicate with him and learned that they were indeed from the camp near Kûk and were here for Caribou and Char. I pointed to the goose family and questioningly mimed shooting them, but he shook his head. The birds were still there two days later when we made a second attempt to catch them. Most breeding birds in Greenland are protected during the breeding season.

Following the catching attempt, we made our way home past the Greenlanders' tent where all three were at home tending a large pan of Caribou meat on the boil. John and I were beckoned over as we passed and were invited to join in with the meal. It was not the best stew I have ever tasted, being composed simply of boiled Caribou chunks with no salt or other seasoning. The *modus operandi* was to seize a chunk, pull it to the side of the pan, and cut off a suitably sized piece for consumption with the fingers.

Communication continued to be a problem and no further useful information was transmitted. However, during the 'conversation' I intimated that they should "come up and see us sometime" and before we knew it we were in the umiak heading for Base Camp with the two younger chaps. We gave them a rousing porridge party and they left in the dark beneath the first star we had seen for several months.

As our stay in Eqalungmiut Nunât drew to a close, I decided to cross South Valley in our (very) collapsible canoe to pay a visit to the Greenlanders' main camp. My arrival was initially greeted with blank stares of surprise, but soon some 'kaffe' and custard creams materialised, I imbibed, surrounded by an attentive audience of happy, grubby children of all ages. A baby was proffered and I gathered, after some prompting, that I was expected to shake hands with it and say 'how do you do'.

I had not paid much attention to the problem of how to actually communicate, but became rapidly aware of it as the deafening silence assumed embarrassing proportions. However, a blonde lady in the later stages of pregnancy eventually sat down beside me and saluted me in English - we talked for a couple of hours while the sun went behind the hill and we began to shiver. The party then retired to a large tent where coffee and Caribou kidney fat were served. I questioned, and was questioned, through my interpreter and some of the salient points which arose are enlarged below:-

They were not interested in geese or any other birds as quarry, and were in Eqalungmiut Nunât only to hunt Caribou and catch Char for their commercial return. This assertion was certainly borne

out by the three hunters who ascended Goose River. The inhabitants of the camp were, however, at pains to point out that profit was not the only motive for the summer camp - they were people who prefered the traditional way of life - unlike many modern Greenlanders, and the social aspect of the expedition was borne out by the age range of the participants. It was a family affair. When I asked about the shooting of geese in general, one man volunteered that he knew of about seven which had been shot that year, though not at the summer camp. The idea of systematically collecting goose eggs was apparently foreign to them. There is an interesting account of the hunting and fishing activities carried out at this particular camp in Hertz (1977).

It seems from this discussion and from later talks I had with Greenlanders that certain settlements have traditional quarry species - for instance, these people were Caribou hunters, whilst the inhabitants of Ikamiut in Sydostbugt make special forays after White-fronts. It is the habit amongst Greenlandic hunters to disregard other quarry when they are looking for a particular type. However, it must be remembered that 'traditional' hunters are not the commonest form in Greenland, and also that the above assertions are 'second hand' and not a result of my own personal observations.

They were not particularly interested in our presence, except as a potential nuisance affecting their Caribou hunting. When I attempted to explain what we were doing they seemed quite familiar with the necessity to study game species, and they explained to me how their Caribou hunting is governed by complex rules to maintain their numbers through bad seasons. It was appreciated that we might be interested in the welfare of the geese for the same reason, and it was suggested 'from the floor' that any decline in numbers of the White-fronts was due to hunting in Britain and Ireland.

Opinion was strong on the subject of Ravens and Foxes, to the effect that efforts should be made to reduce their numbers because of the damage they do to sheep (in SW Greenland) and birds' nests. Also, Foxes carry rabies in Greenland. I attempted to introduce a discussion on whether these animals were more or less common than in the past, but got little response.

Eventually I left the camp late that evening and canoed back across the river to our tents at Manx Lake, where ADF, AH, DAS and I had opted to spend our last free days. The growing darkness of the nights was becoming an increasing hinderance and made the return journey more hazardous.

The following morning we were treated to a return visit by the Greenlanders. We were consuming a leisurely second cup of breakfast tea when a voice outside the tent enquired "Villiam?". It was David, one of the teenagers, together with a mixed party of about 15 others who were making their way up Goose Valley in search of Caribou. We were able to tell them that there were few animals in the vicinity and that the highest densities were to be found to the north and east. They found that this distribution of the Caribou was unusual and indicated, without bad feeling, that we had probably scared the animals away from their normal feeding areas at this time. After much discussion they decided to go around the northern branch of Nagssugtoq to Ugssuit Nunât, near to where we had seen large herds a few weeks previously.

Before leaving, however, the younger boys spent some time trying out our canoe and one of the hardier lads leapt into Manx Lake and started to swim around. A considerable chase ensued in which the 'seal' was duly dispatched and the hunter returned triumphant. However, even the canoe proved to be no match for the motorised umiak that appeared to ferry them back.

Once they had returned to the 'other side' we had unfortunately to think more seriously of our own return for we had only four short days in which to complete the packing. Thus, regretfully, the tents were packed and for the last time we trudged up the long, long slope to Base Camp.

C 21 THE EDGE OF THE ICE-SHEET (11 16 AUGUST)

J. Floyd

As our stay in Eqalungmiut Nunât drew to a close we allowed ourselves a short holiday. For me this was a last chance to visit the ice-sheet, something I had not yet accomplished. I began my walk on the evening of 11 August, putting several kilometres behind me before nightfall. On the 12th I walked most of the remaining distance to the ice, pitching camp near the summit of the highest hill in Eqalungmiut Nunât, a few kilometres from the ice beyond. *En route* my most notable observation was of a loose grouping of perhaps fifty Caribou behaving strangely. They were very active, apparently agitated and frequently grunting or barking. Several deer had lost an antler though the other one was still in velvet. This was probably a rutting group.

The 13 and 14 August were spent exploring the edge of the ice whilst based at my hilltop camp-site. As the ice drew close the land became increasingly bare, moraines in particular were sparsely vegetated, and rocks less thickly coated by lichen than elsewhere. Large channels of meltwater emerge from the ice at frequent intervals and flow to one or other of the great glacial valleys bounding Eqalungmiut Nunât. These channels limit access to the ice to a stretch of about 4 km, spanning the watershed between the two valleys.

This was the first time I had been close to permanent ice and it would be futile to try to describe all the new things I saw so a few brief impressions must suffice. Here the ice is receding and the processes of deposition are in evidence; bare moraines bounded the ice, which was dark grey with accumulated debris slowly melting at its edge, and occasionally a rock would clatter down to add to the moraines. A series of lakes at widely differing heights are damned by ice and moraine. They are joined by cascades, eventually draining into a large river which emerges from under the ice through a cavernous opening. Meltwater also trickled over the surface of the ice or emerged from narrow tunnels and deep grooves. Freshly exposed ice, in crevasses or where blocks had broken off into the lakes, was a delicate turquoise.

The ice is striated and has been deformed by great pressures; points of compression show as clusters of pinnacles divided by deep crevasses. These dramatic formations were scattered far from land, slowly petering out as the ice gently undulated up to high, white snow-fields. As I stood on the summit by my camp on the night of 14 August, watching the season's first few stars, the ice seemed to glow whitely during the brief darkness. The combined sounds of flowing water, falling rock, and cracking ice were just audible as a low rumble to the east.

Walking over a lake-strewn plateau on the way back to base the next day I discovered that Red-throated Divers will reply to imitations of their cries - my first conversation on this solitary hike. Later that day, while watching a pair of divers responding to my mimicry, I saw two figures on the far shore, also watching the birds. John and Phil were returning from their own holiday, a final attempt to reach the glacier. We camped together that night and returned to base the following day.

C 22 INUGPAIT QÛAT REVISITED - THIRD GLACIER ATTEMPT (12-15 AUGUST)

J. E. Bell

Phil Davies and I took the opportunity of the general holiday to see if we could reach the glacier in South Valley. We left Base Camp on the evening of 12 August and strolled at an easy pace, past the ringing camp at Lakesmeet, and moved gradually upwards to gain the top of the col between Ímajuitsoq and Angmat by 21.00 hours. As it was a fine evening we chose to pitch camp here and to go for a walk up on to the shoulder of Angmat, hoping for a good sunset. Our reverie was broken by voices close by. Scrutiny of the shadows in the fading light revealed two young Greenlandic boys, carrying a rifle and a collection of Caribou antlers. We chatted (or rather, drew a series of diagrams on an old envelope, since there is no common ground between their language and ours) with the boys, Lubas and Isak, and after about fifteen minutes "conversation" we parted company to go to our respective beds.

On the following day the weather was most unpleasant, just like April showers in Britain. There was a great deal of rain and very high humidity such that one became soaked wearing an anorak or not. The walk along the fjord is neither particularly interesting or demanding, most of it being on flat gravel or sand terraces, so we occupied ourselves with continual chat to fend off the boredom. The major highlight of the walk is the picturesque Rainbow Falls, so called because at about 11.00 hours the sun shines up the narrow gorge and straight into the spray from the falls, causing a rainbow to span the channel.

This was the second time I had walked over to this part of Eqalungmiut Nunât and on several occasions it was possible to make comparisions with the first trip. The most remarkable difference was the reduction in the number of Caribou. On the same route on 30 June I observed 60 animals against only four on this occasion. The most distressing change that I saw was that the Greenlanders had passed through, leaving their usual trail of litter - a pitiful sight.

Our abode for the night of 13 August was beside a stream. The source of water in this area on my first visit had been a lake about the size of a football pitch which, in the space of six weeks, had disappeared completely. However, our walk was to be curtailed by water in the shape of the Barrier River once again. The volume of water here is enormous and, because it flows straight from the ice-cap, it is very cold and brown. A brief sortie showed us that the only chance we had of crossing was near the fjord-valley, where we would have to strip and attempt to wade 60 m across the current - not to be recommended.

Lying awake that night, I came to the conclusion that the best way to cross would be to wear waterproof trousers and anorak as a primitive wet-suit, albeit rather inefficient. On the 14th I waded in to knee-depth in fast-water and found it virtually impossible to move. We tried again where the river was somewhat slower and waded in to a depth of one and a half metres; however, it took all our strength to avoid being swept away. Phil and I clung on to each other's rucksac frames but the force of the current and the fierce cold drove us back to the shore after only 30 seconds in the water. Despite having to give up this attempt, the 'wet-suit' idea had worked fairly well. I felt suitably inspired to try further crossings at other likely places, but all to no avail, and the glacier, which was so tantalisingly close, remained untrodden.

The last day away from Base was filled with a walk westwards towards Mont Blonk. There was a distinct autumnal feel to the day, despite the clear skies and sunshine, mirrored by the reduction in the number of mosquitoes. Our final campsite was beside a small tarn on the eastern slopes of the mountain, from the summit of which we enjoyed a fine sunset to bring to an end this brief holiday before we returned to the chaos of Base Camp.

C 23 PACKING UP BASE CAMP (16-20 AUGUST)

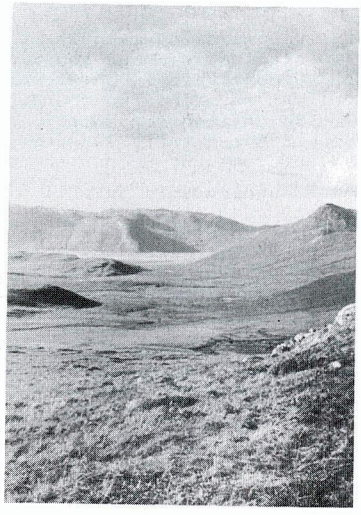
A. M. V. Higgs

The last few days of our stay in Eqalungmiut Nunât have, for me, the unreality of a bad dream. The first evening of everybody's return to Base after the holiday break was taken up by a marathon discussion on the format of the final report. This became very heated and achieved little except a decision that all material should be published together in one volume. Next day we faced the seemingly impossible task of reducing the vast sprawl of Base Camp into an ordered assemblage of packages, each one weighed on the 5 kg Pesola balance, ready to be lifted out by helicopter. From the outset we had been determined to leave our site of operation just as we had found it and all we would leave behind was an area of nitrogen-enriched soil, every fragment of our stay being air-lifted out. These last days were thus spent scavenging for litter, packing and weighing equipment, and burning all rubbish.

As the pace began to slacken and the havoc became progressively more and more localised, I stole away and climbed above the camp to take my last sight of the land we had come to live in. For four months we had reacted to this landscape with every sense. Our eyesight had become keen, our hearing sensitive, and our feet too often sore. I felt that I had lived these four months totally and I wanted, in these final moments, to drink in the last drops of the essence of Eqalungmiut Nunât.

The high winds of the final week died abruptly as our last day dawned calm and bright. Across the valley rang the sound of a mighty horn. David, who for weeks had been trumpeting down anything remotely tubular, had climbed up the Crusties to keep our last scheduled radio broadcast and to take down the aerial mast, which he found worked remarkably well as an alpine horn. Below in the valley, a skein of geese made a low-level fly-past towards the South and we turned our thoughts to civilisation in the form of Søndre Strømfjord Air Base.

Precisely on time, a red speck materialised over the western mountains and grew into a helicopter. Ten minutes later we lit two flares to guide the pilot in and as the 'chopper flew towards us it was time for a photographic session. For a while it seemed that the pilot was attempting to land on top of the assembled luggage but after a prolonged bout of hovering and several abortive attempts at what appeared to be pollination, the vast machine lifted off and perched instead on top of a nearby moraine. The horror of the pilot on seeing our luggage was all too apparent and it transpired that the weight restriction we had been given was considerably more lenient than it should have been. However, under the circumstances there was little we could do but pack and pray, so, after wedging every cranny with packages, the pilot performed a practice take-off without us and then pronounced the aircraft ready to go. We crammed in, pressed our noses to the windows and, amid a cloud of dust, lifted smoothly from the ground. Below, the heaps of antlers that had been so carefully amassed and then sadly abandoned beside the cairn, were the only signs that we had ever lived in this place we had called home.



Goose valley looking south from above Base Camp.

C 24

COASTAL CRUISE TO SISIMIUT (20-26 AUGUST)

D. A. Stroud

The saddest aspect of our long-awaited return to civilisation was that, apart from the noise, it did not really feel any different to be back. We had secretly been longing for it to be strange, to experience culture shock, but our sudden return only demonstrated that we are all Twentieth Century Man (*Homo sapiens industrialis*) at heart, whether we like it or not. In fact, by taking equipment and creating our own Base Camp culture, we had never really left Civilisation at all.

On arrival at Søndre Strømfjord Air Base much had to be done before we boarded the bus that would take us to the port. All too soon the time had come to say goodbye to Jesper and John McCormack who were leaving the next day on an SAS flight to Copenhagen. Within quarter of an hour we were at the port boarding an old landing craft that took us out to the MS *Disko* . Some excellent views were obtained of Glaucous and Iceland Gulls flying about the stern of the ship, and as we set off down the milky-green waters of Kangerdlugssuaq we were wondering what else was in store.

The highlight of the day was undoubtedly the first non-expedition meal - fritters, boiled potatoes, onion sauce and soup. However, the real ecstasy came with the cold orange juice. It was this, and the warm comfortable lounge, that kept the bulk of the group inside playing a marathon game of cribbage that lasted well into the next week. Those foolhardy enough to brave the worsening elements were rewarded with one of the most impressive sights we had yet seen. In the centre section the fjord narrows considerably and huge 1000 m cliffs rise perpendicularly on either side. To the south, glaciers from the Manîtsoq ice-cap extension flowed out through the cleft cliffs and tumbled down onto rocky moraine along the edge of the fjord. On the northern side, the rock ascended into needle-thin spires which towered precipitously above the boat. These serried ranks gave the impression of a huge natural organ, an illusion enhanced by the high winds moaning through the superstructure of the *Disko* . Low cloud and mist obscured sections of the cliffs, never allowing them to be seen in their entirety. The pale metamorphic rocks had darker dykes intruded into them, which had been deformed to produce tortured patterns. After several hours the thickening mist obscured this spectacle and we were forced below.

Having travelled at full speed down the fjord, the *Disko* reduced her speed to seven knots as soon as the coast was reached and wallowed sickeningly all the way to Sisimiut.

Those up early enough the following morning had good views of Kittiwakes and Great Shearwaters, but nothing to compare with what we were to experience on the return trip. It was a murky, overcast day when we docked. After several exploratory trips we finally settled on a camp site about a mile from the harbour, just outside the town at the base of the 600 m peak Kaellingehaetten - 'the Hag's Hood'. We were all settled in by late afternoon and almost before one could say "Water Pipit" the mist nets were up and once more tea was being brewed in vast quantities. Normality had returned.

Sisimiut is the second largest town in Greenland with 3,981 inhabitants in 1978 (Nûk (Godthaab) has c.9 000). It is in the curious position of being the most northerly town with all-year round sailing facilities, and yet the most southerly with enough winter snow to warrant the use of dog sleds inland. The dogs are kept chained in open areas between houses in summer. Although they are fed about 1 kg of meat per week in summer (1 kg per day when working), they were amongst the healthiest dogs we had ever seen. Frequently a pack would start to howl and the call would be taken up by dogs all over the town until all were baying as if their lives depended on it. This was slightly unnerving at first, but we soon got used to this regular cacophony. The lunchtime whistle of the fish-factory was always guaranteed to produce a canine chorus.

Soon after our arrival we had visited the tourist office to enquire the whereabouts of Preben Schleimann, a hunter whom we had been advised to contact. By fortunate coincidence his wife ran the tourist office! On 22 August we talked to both for some time and arranged to meet Preben Grossmann, a friend, the following evening.

During the early hours of 23 August the camp was visited by an Arctic Fox which managed to consume a quantity of TVP stored under Alison's flysheet before being scared off. The amazing thing was that it appeared to enjoy it! Fortunately we had not had any trouble with raiding foxes in Eqalungmiut Nunât.

We spent a most enjoyable evening with Mr and Mrs Grossmann talking about geese and most subjects with any relation to Greenland and admiring his collection of relics. Amongst the many stories he told us was one of a fishing boat returning to Sisimiut early one year when it started to be hit by birds flying out of the fog. In a period of ten minutes 4000 D.Kr. (about £400) of damage was done to the radar, radio, and spotlights. When it was over 930 dead King Eider were picked off the decks, but as these were later sold to the hospital for 11 000 D.Kr. those concerned made a considerable profit!

The next three days were spent wandering about the town, rediscovering gastronomic delights at the KGH store, mist-netting near the tourist office, collecting samples of algae, sediment, and *Littorina* and finding that sea-watching was not a profitable exercise. John Floyd alone managed to find enough energy to climb to the top of Kaellingehaetten, only to find a cairn with a visitors' book!

The evening of 24 August was spent with Mr and Mrs Nielson, relatives of a friend we had made on the *Disko*, and was enjoyed by all. Rationing of alcohol was introduced in Greenland by popular consent, on a basis of thirty-six cans of beer, or equivalent, per month for each adult over the age of eighteen. Tourists can get ration points (without which no alcohol can be bought) by showing their air ticket. Since we had no way of proving how we had got into Greenland or how we were going to leave (the RAF does not, unfortunately, provide booking facilities) only Alison and Pauline were able to buy drinks with their SAS tickets. This small quantity was not nearly enough after so long an abstinence. Even so, late that night as we picked our way back in the dark across the boggy tundra between camp and the town, Tony and Alison managed to collect boots full of cold arctic bog as souvenirs.

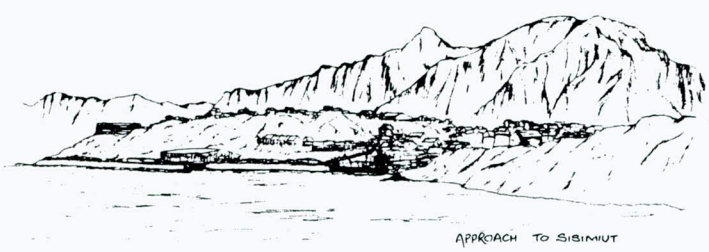
The wooden houses of the town cluster on rock outcrops overlooking the harbour and fish-processing factory. Sisimiut was founded in 1764, largely as a result of whaling activity in the Davis Strait. The oldest part of the town has at its centre the church with its large whale jaw-bone arch, but now the town has spread from this nucleus and buildings cover a considerable area. There has been much rural depopulation in Greenland in recent years; of the population of the Sisimiut Kommune (administrative district), the proportion of those living outside the town in smaller settlements has fallen from just less than a third in 1960 to about a sixteenth in 1978. This has undoubtedly made the provision of centralised services easier, as was apparent from the modern schools, technical college, hospital, harbour and heliport. Unfortunately this rural depopulation has become a vicious circle as it is increasingly difficult to provide services for the smaller and more isolated communities. This is probably an inevitable consequence of limited resources for development, but it is to be hoped that the traditional rural way of life and culture is not too adversely affected by these demographic changes.

Regretfully we had to leave with the *Disko* on the 26 August. After an extended breakfast we eventually broke camp in mid-morning and made our way down to the harbour. As it was Sunday afternoon many of the townspeople turned out to see the ship off, and our departure was given a maiden voyage feel by several hundred people waving and cheering, honking of car and fog horns, and even a volley of rockets! The ship was accompanied by several motorboats and waterskiers for some distance south.

About an hour out of Sisimiut a bank of fog began to envelop the ship, but not before we had a superb view of a Pomarine Skua chasing a Kittiwake. Several Great Shearwaters began to approach the stern; soon groups of up to five were seen flying with Fulmars close by. Then, as numbers increased, "(Expletive deleted), will you look at *that*!". A flock of about 300 had materialised alongside, settling on the surface and flying about in the mist. Both the numbers involved and their closeness meant that some excellent photographs were taken. The temperature drop upon entering the fog meant that frequent trips below for hot coffee were needed, but it was only with the final departure of the Shearwaters that one could retire with an easy conscience. The stunningly good views of so many was one of the ornithological highlights of the trip.

As we approached the entrance of Kangerdlugssuaq the mist began to clear and at about 01.00 hours the first Aurorae were seen. At first they appeared as pale green needles of light, like searchlights in the western sky, but they quickly changed shape and varied considerably in intensity, sometimes disappearing for several minutes at a time. As the hours wore on they moved higher in the sky and became more intense. On several occasions the classic folded curtain forms could be made out. Eventually, at about 04.00 hours they vanished overhead.

As the *Disko* slowly steamed up the fjord the dawn broke and most of us were able to catch a few hours sleep before breakfast and disembarkation.



APPROACH TO SISIMIUT

C 25 A VISIT TO ÂUSIÂT (21-25 AUGUST)

W. J. Higgs

The expedition was by no means finished with our departure from Eqalungmiut Nunât and, shortly after arriving at Søndre Strømfjord Air Base, we were on board the MS *Disko*, northward bound. The Greenlandic weather put on a grand show for our trip, providing a sunny send-off which turned into a fantastic display of föhn-type, columnar clouds to enhance our passage down the 110 km of the equally fantastic Kangerdlugssuaq. Later during the few hours of semi-darkness, the clouds cleared enough for a brilliant display of the Aurora and, as we turned north out of the fjord, the sun began to shine down the valleys on our right, narrowly sandwiched between the distant ice-cap and the low cloud.

The rest of the group disembarked at Sisimiut the following morning, leaving me to sail on to Âusiât (Egedesminde) where I had a rendezvous with a schoolteacher correspondent, Mr Kjeldsen. Approaching the town a few small icebergs - of a tabular sort - hove into view. Then the fog closed in, and our final approach was in low visibility, picking our way between the many low, rounded, rocky islands that surround the town. Exciting stuff for me, but no doubt an everyday experience for the crew of the *Disko*.

I descended the gangplank into a sea of Greenlandic faces. Apparently there was a Danish children's gymnastic team on board, who were visiting Greenlandic schools, and this was the reason for the considerable excitement. Asking one of the assembled throng I soon found my man who was somewhat preoccupied with settling in the gymnasts, but later that night I met him properly at his home, and began two days of the real stuff of travelling - as opposed to tourism - living as a welcome stranger within the community.

Mr Kjeldsen spoke very good English, and we talked about seals and Caribou, geese and falcons. We discussed the meaning of the Greenlandic names of Eqalungmiut Nunat, and the pros and cons of dog sled vs. skidoos. Last but not least, he introduced me to some real Greenlandic food. Although a good range of European foods is available in the KGH supermarkets (including fresh fruit), the locals are very keen on Greenlandic produce, and we dined on Greenlandic salmon and whalemeat, with raw halibut fins, auk livers and seal blubber for a late-night snack.

Next day I started my exploration of the town with a visit to the civic offices, asking about local hunting practices and generally looking for a chat with someone. Unfortunately, nobody could speak very much English, and so they referred me to the expert - Mr Stenshoj - ex-Sirius patrolman and now hunter, insurance agent, boat owner, and postcard printer of Âusiât. We sat in his front room, with its Musk Ox and Polar Bear skins on the floor, and talked for hours. It was his drink ration day, so the talk flowed free on his adventures in the north-east, on whaling, how to hunt seals, dog sledging, and the activities of the local hunters. He confirmed what I had heard about Greenlandic hunters tending to stick to one quarry at a time, and confirmed also that the people of Ikamiut in Sydostbugt have a tradition of goose-hunting, although this was carried on mainly by the older men, and was becoming less popular. Geese also tend to be shot by fishermen in Disko fjord.

That evening, I met some of the younger locals at a party in one of the obnoxious apartment blocks. Quite a rowdy affair, with large amounts of beer being drunk, and British/American pop music - 'The Sultans of Swing' being particularly popular that night. Most of these people - in their late teens - spoke reasonable English, good enough for political arguments, which they were all eager to have with me. Women's Lib is approaching fast, though the young Greenlanders' insistence on the value of their traditional culture poses some problems for its integration.

On the morning of 25 August I gave my second lesson in the rather alarming town school, on the natural history of the goose. The children were, as their master said, 'rather wild', but very enthusiastic about their wildlife. I caught the MS *Disko*, southward bound after its tour of Disko Bay, at 11.00 hours with fond goodbyes and promises to return to Âusiât, and ten hours later I was reunited with the others at Sisimiut. The ship stayed here overnight, so there was a chance to explore the town and admire the eighteenth century church, but all too soon it was time to board the *Disko* for the last time, homeward bound at last.

C 26 THE RINGERS' CAMP AT SØNDRE STRØMFJORD AIR BASE (27 AUGUST - 1 SEPTEMBER)

J. Floyd

On arriving at Søndre Strømfjord Air Base from Sisimiut three of us, Phil Belman, Pauline and myself, preferred to savour the wilds of Greenland for as long as possible while the others decided to enjoy the comforts offered by the hotel. Hence, we established a small camp about 6 km east of the air-base, choosing a site amongst dense willows, between a lake and a meltwater river, which was well suited for mist-netting.

Phil and Pol caught surprisingly large numbers of Redpolls and, on 31 August, two Arctic Redpolls, a species which, at least up to 1974, had been ringed only once before in Greenland.

I spent my time quietly, reading or wandering. On 30 August I set off to walk upstream to the ice-cap but it was further than I expected and I turned back short of the ice. I rode the last few kilometres to our camp in the back of a military police truck, not under arrest as feared by Phil and Pol but "enjoying" a very bumpy lift.

By now the nights were really dark for several hours and we spent the evenings watching some fine displays of the Aurorae, shifting white or green streaks and curtains of light apparently stretching vertically to awesome heights. At these times we also watched a great number of satellites; during one hour we counted fourteen. Perhaps we were under an orbit which passes over both the Soviet Union and the U.S.A. witnessing a further intrusion of the Twentieth Century into this wilderness.

C 27

THE END (27 AUGUST - 2 SEPTEMBER)

A. P. Fowles

For those of us who chose the easy way of life while we were at Søndre Strømfjord Air Base the time was one of relaxation and the priorities were rest and cleanliness as we tried to scrub out the grime of four months rough living from our well-worn clothes. It was a time when we re-acquainted ourselves with the taste of beer, were trapped once again by the hypnotism of a TV set, enjoyed the comfort of soft beds and big armchairs, and rejoiced in the variety of food *cooked for us* in the service canteen.

The days followed a very similar pattern as we lazed around, put finishing touches to logs and field notes, played pool, and prepared ourselves mentally for the return to Britain. The night of 28 August, however, was a special occasion as we celebrated Tony's birthday in fine style and learned anew the powers of drink. This probably accounted for the following day being so quiet, although Alison and Will wandered a fair way off the base in their search for Musk Oxen, to no avail.

On the morning of 30 August we had an informal meeting with the airport manager, Steen Malmquist, to tell him what we had found in Eqalungmiut Nunât and to hear his tales of the area. Just as we arrived in his office a pale Gyrfalcon dashed across the runway and proceeded to hunt over the willow scrub 150 m away; it was our last sighting of this impressive falcon and not a bad way to say goodbye. We talked for two hours and without question we would gladly have taken up more of his time to listen to his interesting anecdotes about the local wildlife, of his years with the north-east Greenland patrol, and of his researches into the Viking settlements of continental west Greenland.

The trimming of numbers continued the next day as we waved farewell to Alison, who was taking the SAS flight to London via Copenhagen, envious of our male privilege of travel on the Hercules. Pauline planned on staying in Greenland for a short while to continue trapping passerines on autumn passage. At 06.00 hours on 1 September, our last day in Greenland, Tony woke Phil and I and we strolled across to the deserted canteen for an early breakfast. Mr Malmquist had told us of the whereabouts of a small population of Harbour Seals in the fjord and we set out to take a close look at them. It was a good morning's walk and most welcome to be back on the tundra again. The plants were well into their autumn now and reds and browns predominated; few flowers were left but the scarlet *Vaccinium* berries, like a scattering of gems, provided a splash of colour. There were only four seals in the fjord but one was fairly close to the shore and we sat for half an hour watching it sunning itself and slithering into the water for an occasional cooling swim.

Soon it was time to head back to the base, complete our packing, and make our way across to the control tower to await the arrival of our friendly Hercules. Squadron XXIV had been on a training run and had flown low-level all the way down the coast from Qânâq - a spectacular flight by all accounts. It took an hour to load up and refuel but finally all was ready and we were on our way home.

We were calling in at Mestersvig on the north-east coast to pick up Wally Herbert and an RAOC Expedition and the journey across the ice-cap was to be another low-level training flight. It was an unforgettable experience as we flew for two hours at an altitude of 600 m above the vast expanse of inland ice. The north-easterly flight took in most of the significant features as we passed from low-altitude, low-arctic conditions at Søndre Strømfjord Air Base to high altitude, high arctic conditions in Scoresby Land. In the west the ice begins at a height of 600 m, suddenly passing from glacial moraines to the dirty belt of fringe ice. Here it is sliced and deeply gouged and the runnels are filled with moraine debris, while streams of glacial milk cut through this jumble and run along the foot of the dirt and gravel. Further on, the ice-dome becomes smoother with meandering ribbons of meltwater and, a feature unique to this western zone, many shallow pools of clear turquoise with thin skins of ice across them. We kept climbing while the dome rose to 3000 m, with occasional inexplicable ridges that looked like spines of mountain peaks breaking through the flatness. Then for a long time there was nothing but a panorama of featureless whiteness, glaringly white, the only pattern being the arrow-heads of wind-shaped snow.

The captain gave warning that we were approaching the coastal mountains and from the windows we could see white dots on the horizon. Closer still we were coming into an unreal impressionistic world; brown, smooth rocks jutting from white ice-dunes; toothed nunatak peaks, snow-capped angular faces; glacier tongues; fjords; all rock so brown, weathered; no vegetation visible. Then down into the fjords themselves; ice-bergs amid pack-ice, clustering at the foot of glaciers; the deep, dark, green waters of the fjord; turquoise of ice below water; gulls flying across the packed ice. Then over Scoresby Land: rock became sandstone, dropping sheer and unvegetated into the fjords; ice-bergs everywhere of incredible shapes and sizes; barrenness; a flat undulating tapestry of rich colour, purples, greys, greens, oranges, dull blacks, maroons; the colour in bands indicating rigid botanical communities; and then back to the fjords and the ice as we flew into Kong Oscar's Fjord.

A cloud of red dust greeted our arrival at Mestersvig, a place of legend in the field of Greenlandic biological studies, and as the cargo doors opened we stepped out onto the gravel runway. Mestersvig itself is a collection of some twenty or so modern Danish-style houses which seem curiously out of place in the ancient and magnificent landscape. The pyramidal mountains encircle the settlement, many of them with jagged peaks like shattered bone. Here, at 72°N, it was already late autumn and becoming very cold as the sun, a great red orb, set behind the distant mountain tops.

The proposed one-hour stop ticked away as the piles of cargo were loaded on board and it was dark by the time everything was crammed in. Half an hour later, as we cruised at 9 000 m with an outside air temperature of -44°C, we had our final views of Aurora Borealis. It was difficult to pick out much detail against the harsh background glare of the plane's interior lighting but in the northern half of the sky there were definite pale green streaks of light. The rest of the journey was spent cramped and huddled, trying to catch up on lost sleep until, at 04.20 hours BST, the announcement came that we were over Birmingham and beginning a slow descent towards RAF Lyneham. Down below, the city presented a sight to rival those northern lights. In a velvet blackness, the street lamps were set like jewels - necklaces of sodium orange and the dim white glow of ordinary lights. Every individual lamp was discernable in clusters and patterns like constellations on the land for each discrete group and road system.

Finally the order came for 'seat-belts on', then touchdown and the long taxi-ing around the runways of Lyneham. The cargo doors drop open and we can see that it has been raining substantially - nothing changes. An hour's wait while we got our luggage and some of the equipment passed through Customs and then at long last into the Departure Lounge for emotional reunions with family and friends. Amidst all this happiness, though, was a tinge of sadness at the knowledge that the expedition was over, that the people we had lived and worked with for the last four months were going their separate ways, that we had seen the last of Greenland, for this summer at least.

For most of us the drive home was experienced in a tired daze but we were still struck by the vitality of the British countryside: hedgerows and trees, the essential living greeness of it all, Wood Pigeons, Herons, and Black-headed Gulls, myriads of butterflies, and the familiar life of country towns; in many ways it was good to be back.



Nunataks from RAF Hercules, north-east Greenland.

D1 THE DISTRIBUTION AND ABUNDANCE OF GREENLAND WHITE-FRONTED GEESE IN EQALUNGMIUT NUNÂT

D. A. Stroud

Abstract

Greenland White-fronted Geese were seen in Eqalungmiut Nunât from 7 May until our departure on 20 August. Upon their arrival large numbers were seen on mature flats at the head of Nagssugtôq, probably a regular feeding site for migrating geese prior to local dispersal or further northwards migration. After about 17 May, most birds had left this area to feed on low altitude wetlands, mostly in pairs. In June fewer birds were seen flying as most were either nesting or were flocking with non-breeders. All but one of the seven nests found were below 300 m. Two families were observed walking to higher ground after hatching, so that movement to the higher lakes, where both families and small flocks of non-breeders spend the summer, is evidently regular. The summer population of Eqalungmiut Nunât (750 km^2) was estimated to be about 415 ± 70 (325 ± 50 non-breeders and 90 ± 20 birds in families). The largest survey revealed 107 geese in an area of 150 km^2. Mean brood size of sixteen families was 3.50.

INTRODUCTION

The breeding range of the Greenland White-fronted Goose extends from Nûk (Godthab) (64°N) to the north of Upernavik (73°N) (Walker 1860; Salomonsen 1950a), and the study area of Eqalungmiut Nunât (67°30'N) is thus moderately central (Figure A2.1). As part of an aerial survey of Caribou (Vidar Holthe *in litt.*), the area between Kangerdlugssuaq (Søndre Strømfjord) and Nagssugtôq (Nordre Strømfjord) was covered between 22-30 June 1977 (Figure D1.1). About 10 - 15% of the total area was overflown at altitudes between 70 and 100 m, and observations of geese made on the flights bear out Salomonsen's (1950a) statement that "in the interior of the Sukkertoppen and Holsteinsborg Districts the White-fronted Goose is very numerous and to the north extends its breeding grounds westwards, gradually approaching the coast, which is reached at about Agto in the southern Egedesminde District".

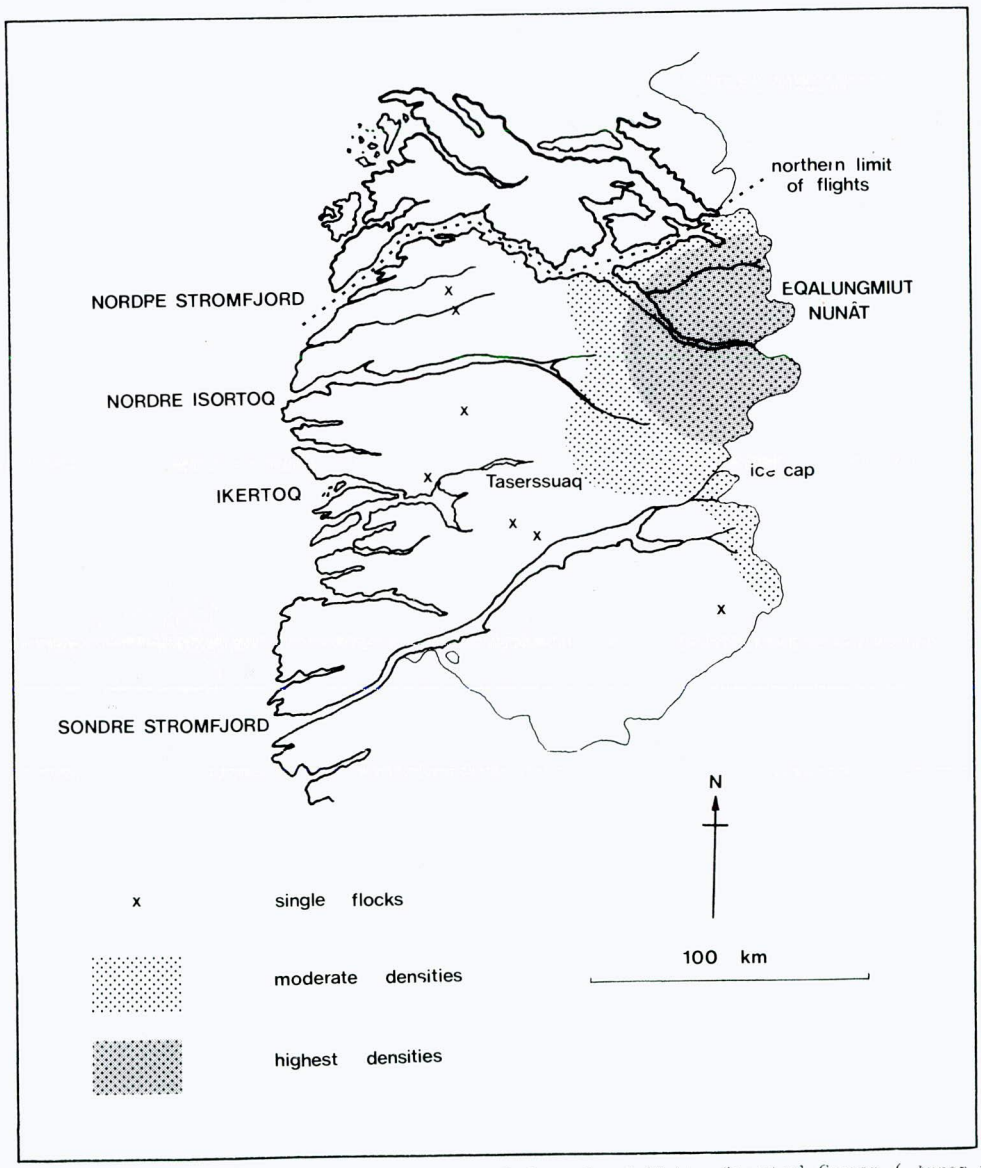


Figure D1.1. Observations of moulting flocks of Greenland White-fronted Geese (*Anser albifrons flavirostris*) in central west Greenland during 1977. Flock sizes ranged from 7 to 54 birds, usually 15 to 20. The first family was seen on 30 June (Vidal Holthe *in litt.*).

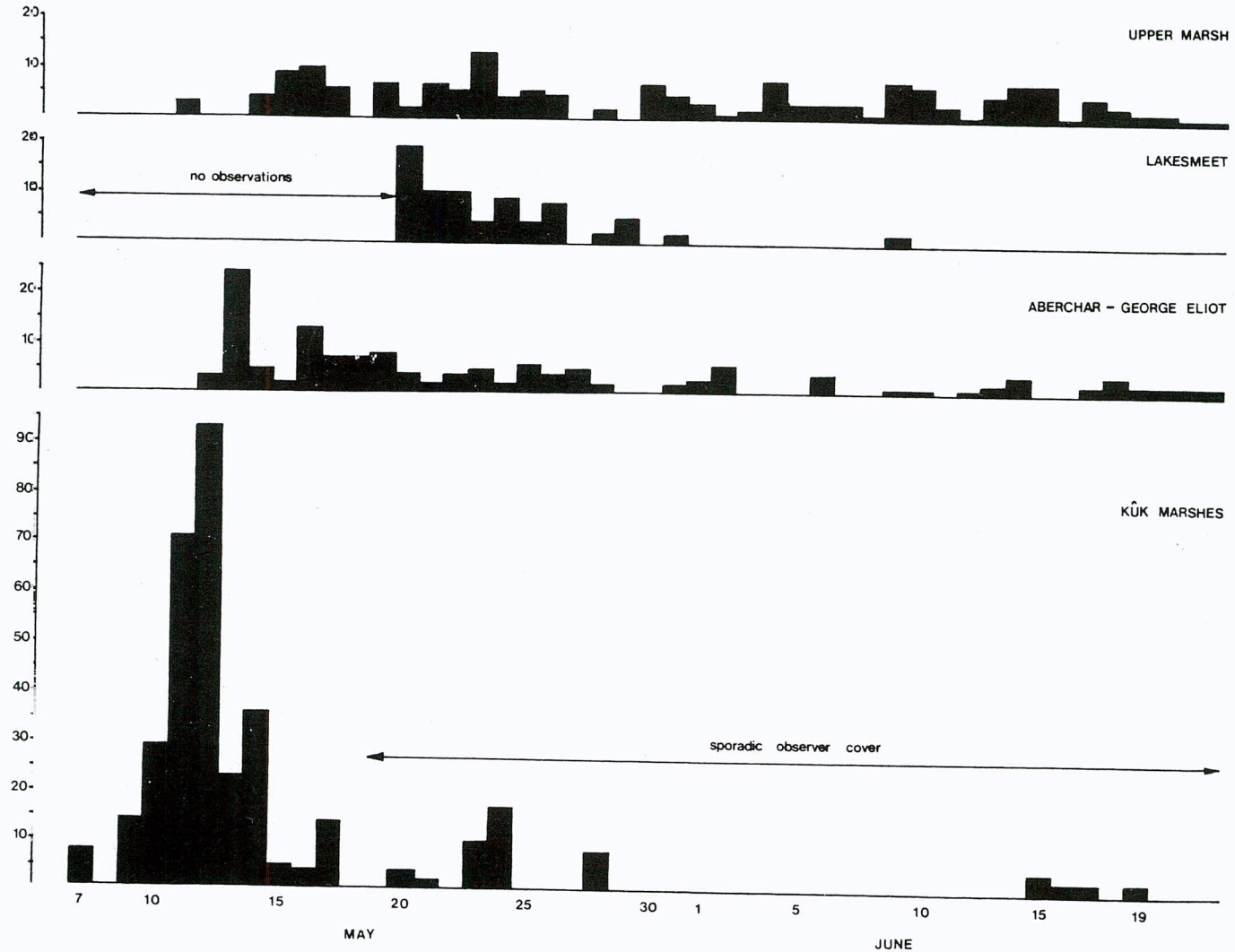


Figure D1.2. Numbers of geese seen at various sites in Eqalungmiut Nunât during May and June 1979; periods of poor observer cover at sites are indicated.

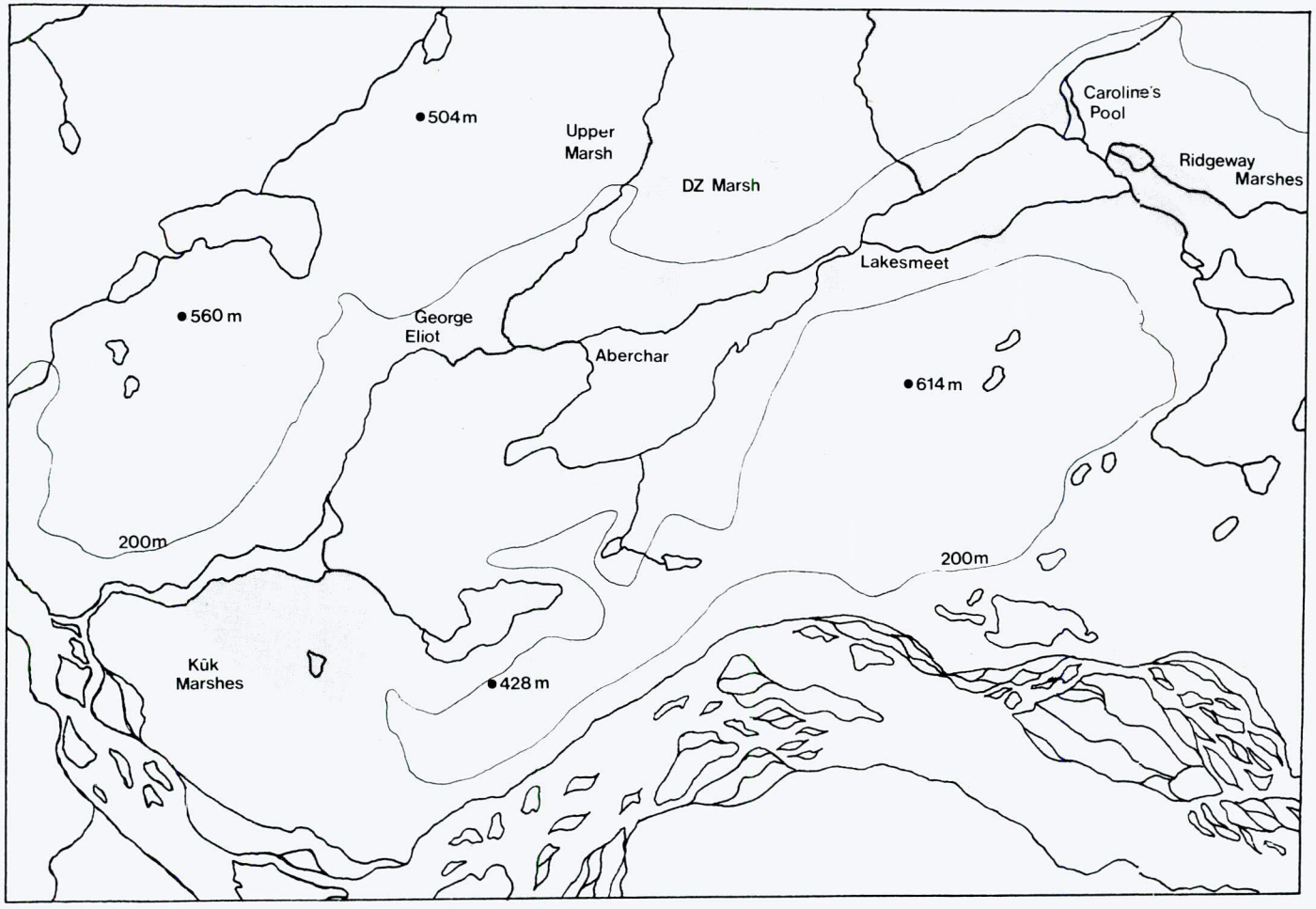


Figure D1.3. Lowland Eqalungmiut Nunât showing the feeding areas of the geese in May 1979.

Records were kept of all observations of White-fronted Geese in Eqalungmiut Nunât and are summarised in four periods (pre-breeding, breeding, hatching to moult, and post-moult), corresponding to distinct phases of both goose and observer activity. During the pre-breeding period the same pairs were undoubtedly recorded several times each day moving between feeding sites, so estimation of total numbers is impossible for this period. While there were over 50 observations of flying geese each day during the second week of May, in July and August few flight movements were seen due to moulting or breeding behaviour and only seven observations of any geese were made during 13 - 20 August. The distribution of observers in different areas of Eqalungmiut Nunât is described in section B4.

Throughout this account, the term 'non-breeder' is taken to include adult failed breeders as well as juvenile non-breeding geese unless otherwise stated. Reference to the lowlands includes all ground below 200 m in the south-west of Eqalungmiut Nunât (see also section B3).

PRE-BREEDING 7 MAY - 25 MAY

Arrival

The first goose was seen in Eqalungmiut Nunât at 16.15 hours on 7 May flying at about 200 m altitude north-west across Kûk Marshes with at least four other pairs seen in the same area that day. This area of mature flats (section I1) formed the main feeding and roosting area for the next ten days (section D2).

Distribution

The Kûk Marshes provided feeding for flocks of northwards-migrating birds in early May. The build-up of numbers to a peak of 93 on 12 May is shown in Figure D1.2 and behavioural study was undertaken at this time (section D2). Two skeins of 25 seen flying north on 16 and 17 May were the last evidence of major migratory movements and after this date most geese present in Eqalungmiut Nunât lowlands remained for some weeks. Adult birds generally were first to arrive, followed a few days later by non-breeding second summer birds, identifiable by their lack of dark belly-bars. In many cases, however, family parties arrived together and second summer birds continued to associate with their parents until the onset of nesting. Copulation was once witnessed at Kûk Marshes (section D13).

After 17 May, there was considerable movement to and from Kûk Marshes, most birds flying in the direction of Eqalungmiut tasê. The movements are difficult to interpret, but geese seemed to be spending most of the time within the lowlands and foraging on the fringes of the higher ground as the thaw progressed. The main feeding areas during this period are shown in Figure D1.3.

The first geese seen at George Eliot Marsh, 3 km from Kûk Marshes, were three on 12 May. Numbers were seen there regularly and on associated streams and pools until 27 June, declining as other feeding areas became available, and with none present in July and August. Several small early thawing flushes south-west of George Eliot were also frequented in early May with groups of ten to twelve feeding in relatively tiny areas.

On 20 May, an evening roost of geese was discovered on the frozen marshy flats between Ímajuitsoq and Lakesmeet. The habitat was *Ledum palustre - Calamagrostis purpurescens* heath with large areas of wetter *Equisetum* marsh. The area was unusual in having many small hummocks and hollows and often extensive systems of small gullies thus providing a complicated topography. The area seemed to be used as a roost as well as a feeding ground, and in the evenings additional birds would fly in to join those feeding there during the day. Counts were difficult because of the terrain, but those made (probably underestimates) are shown in Figure D1.2. Numbers here and at Upper Marsh, 2 km north-west, suggest that the same birds used both sites between 19 and 26 May.

One of the major feeding areas in May was the wetland complex around the east end of east Eqalungmiut tasia, particularly Ridgeway Marshes. At different times geese were seen feeding almost everywhere from Caroline's Pool to Willow Valley and the Pass of Jennings lakes, an area of about 20 km². The patchiness of observer cover makes a census of this area impossible, however it is thought that the site was very important for the geese, and many probably dispersed here from Kûk Marshes.

Geese were frequently seen feeding on Upper Marsh and during May most of the geese there were paired. From June, we were able to identify individuals here with certainty, but on the basis of behaviour the single male seen on the marsh after 30 May was probably the male of the Upper Marsh nest (BC1: see section D4). On 26 May during a visit to Atanârssuk and the Lake-line, six pairs were seen, the only sightings from the plateau in May. This may reflect the lack of observations in this region (Figure B4.1), but the few other trips across the plateau also failed to record geese. During an excursion to the glacier Inugpait qûat on 11 and 12 May several pairs of geese were seen on flats north of the South Valley sandur, a habitat similar to Kûk Marshes, whilst others were seen flying over the hilltops (*c.* 400 m) north of the glacier. Much movement was also seen along Willow Valley to and from Ridgeway Marshes.

Activity

In May, most birds seen were solitary pairs, or occasionally in flocks of paired birds (Figure D1.4). In several cases two to four juvenile geese with few dark belly markings were associated with older birds. These were most likely last year's young, which left their parents after the hatch of the season's young and were functionally part of this younger family (section D9). Most of the day was spent by the adult pairs feeding or roosting at one of the wetland sites, where the principal foods taken were *Hippuris vulgaris* and *Eriophorum angustifolium*, as well as some grass roots (especially *Puccinellia deschampsioides*), *Triglochin palustre* and others. The diet at this time is more fully described in section D8. Most of the nests found later were close to the wetlands in which the geese were feeding at this time, so it is probable that they were also prospecting, although no such behaviour was specifically seen.

Most flights in May were of north-east/south-west orientation within the boundaries of the lowlands (Figure D1.5). However a few geese were seen flying south from, or north towards, the plateau or beyond. Most of the northwards flights were in the late afternoon or early evening (17.00 - 20.00 hours) although a few geese were seen flying north in the early morning (02.00 - 03.00 hours). Thus it is possible that some were using the higher ground for roosting, feeding during the day at lower altitudes.

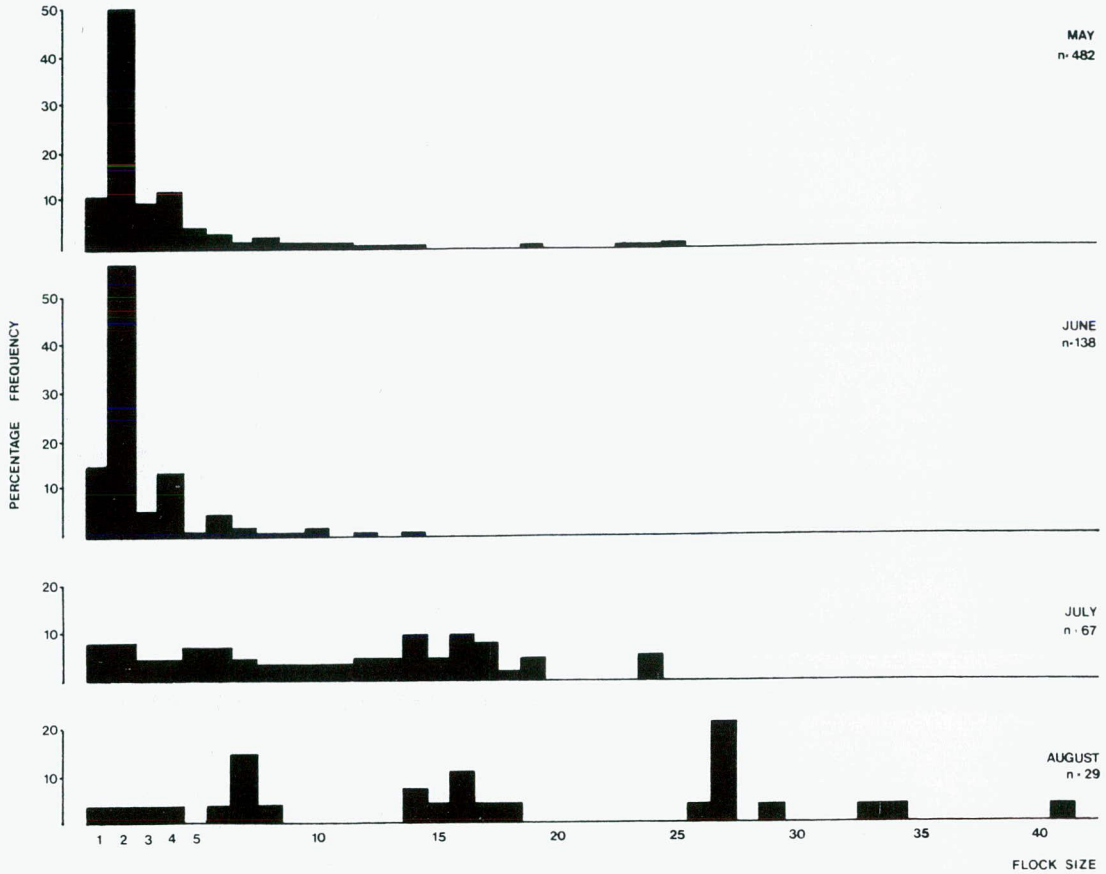


Figure D1.4. Percentage frequency of flock sizes by month, Eqalungmiut Nunât, 1979. Sample sizes are: May 482, June 138, July 67 and August 29 records.

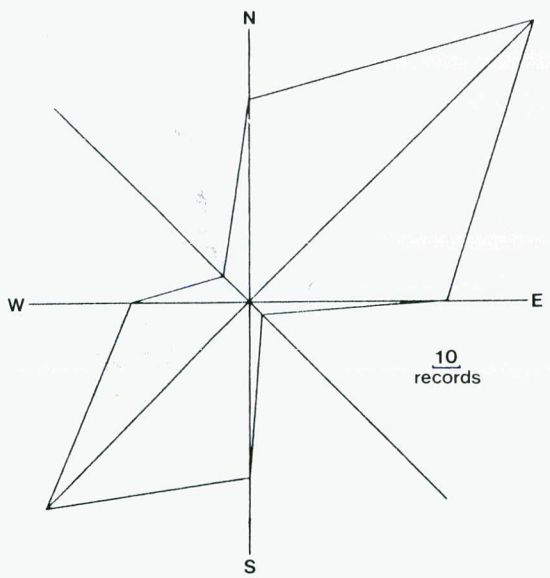


Figure D1.5. Flight directions of all geese seen in flight between 7 - 25 May (n = 516). The long axis of Eqalungmiut tasê is east north-east.

Discussion

The route taken by the migrating geese north from their wintering grounds is the subject of much debate. Some arrive in Iceland about 20 - 25 April and move through quite quickly, although little is known of their occurrence there at this time. It is unlikely that there are any major staging areas in Iceland, and those seen there in spring may represent stragglers from the main migratory flocks. The food there is thought to be newly sprouted sedges and the overwintering bases of *Eriophorum* (Gardarsson pers. comm.). Some, according to Salomonsen (1950a), round Kap Farvel and travel up the interior of west Greenland, sometimes reaching Nanortalik, in the extreme south, as early as 27 April. Others cross the ice-cap direct, being seen on the radar screens of the USAF Distant Early Warning stations (S. Malquist pers. comm.; Salomonsen 1967a, 1979a; Wilson 1981). Geese are not infrequently seen on the east coast of Greenland (section D14) and spring sightings range from 20 May to 4 June. Relative numbers using either the direct ice-cap route or the coastal route are not known, but in the past observational bias has probably led to the importance of the ice-cap route being underestimated.

At Søndre Strømfjord Air Base the first geese are usually seen about 2 May (S. Malmquist pers. comm.) and in Sisimiut between 5 and 7 May, sometimes earlier, as in 1977 when they arrived on the small offshore islands on 1 May (P. Grossmann pers. comm.). Large numbers congregate in specific areas to rest and feed before moving north or dispersing locally to breed. Near Kangerdlugssuaq there is an area of grassland where large numbers are traditionally found in the first week of May (S. Malmqiust Malmquist pers. comm.); another such area is in the lowlands where the lake Taserssuaq flows into the north-eastern arm (Maligiaq) of the fjord Ikertoq (67°00'N, 52°20'W) (Figure D1.1) (P. Grosmann pers. comm.). Both these areas and Kûk Marshes are lowland sites where the thaw is earliest and where the first food plants become available from the frozen substrate.

Fencker (1950) found that the geese usually arrive at the end of April and beginning of May at Sarqaqdalen (70°06'N, 57°08'W), initially in groups of four to five, later up to 30 and on occasion 50. In 1965 the thaw in Sarqaqdalen was late (8 - 10 May) and geese arrived almost immediately after this (Jensen and Preuss 1972). As the valley bottoms in this region are filled with snow, on arrival they feed on the hillsides on "*Empetrum* and dead grass", in the evenings roosting by the sea. With the spring thaw, the geese apparently move on to the Nûgssuaq plateau to eat *Equisetum* and grass. Evidently, in any region the selection of feeding area immediately after arrival depends on the state of the thaw. In the coastal climate of Sarqaqdalen, snow cover is apparently less at higher altitudes than on similar dates in Eqalungmiut Nunât.

In conclusion, the geese seem to follow a regular pattern of dispersal on arrival in Greenland, feeding intensively at a few traditional lowland sites for the first 10 days or so after arrival, and then gradually foraging further away following the thaw as it progresses altitudinally.

BREEDING DISTRIBUTION 26 MAY - 25 JUNE

Observer activity was largely restricted to the river and lake system of the lowlands near Base Camp and this is reflected in the distribution of located nests (Figure D1.6). Most clutch initiation took place in the period 19 - 24 May, approximately 15 days after the first arrivals were seen (section D4). The nests and the selection of nest sites is described in section D4, whilst aspects of breeding behaviour of incubating geese are presented in sections D5 and D6.

Non-breeding geese moved on to the plateau during June, but remained in some numbers in the lowland wetlands with far more movement between the two after 18 June. The geese were probably spending a greater proportion of their time on the higher ground (where the lakes were beginning to thaw (section J2)) and less frequently visiting the valley feeding areas. Small flocks began to appear on the upland lakes in the third week of June.

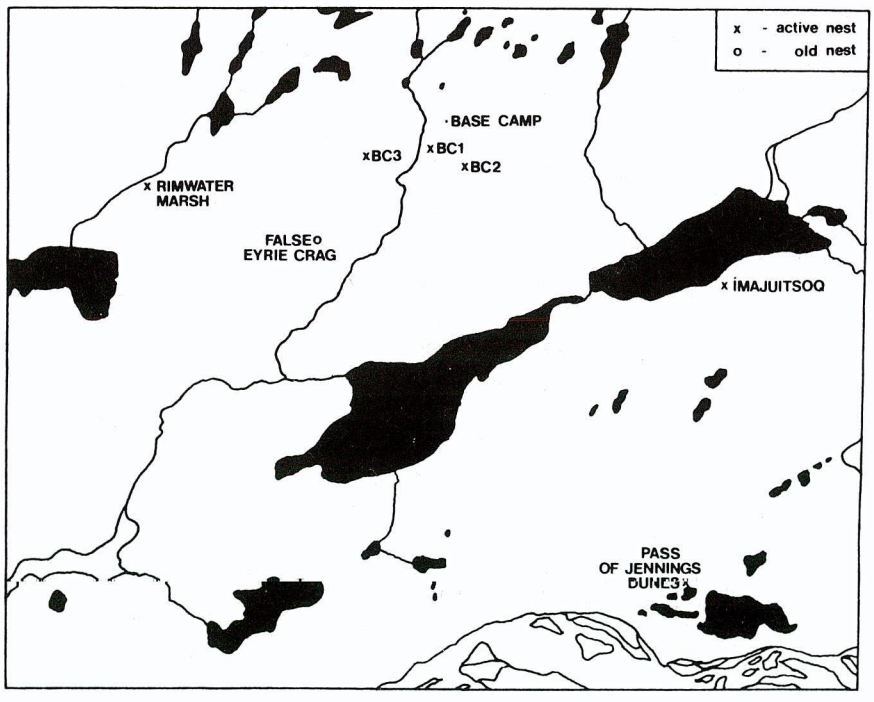


Figure D1.6. Positions of six of the seven active goose nests found in Eqalungmiut Nunât in 1979, together with one nest from a previous season.

HATCHING TO MOULT 26 JUNE - 10 JULY

During mid to late June, geese that had not bred, or whose breeding attempt had failed, began to aggregate prior to moulting into larger flocks on the upland lakes, where they remained until August. Two families with young (Upper Marsh and Rimwater Marsh nests) moved from the nesting marshes up towards the plateau lakes, evidently a common occurrence since most nests were found at low altitude, whereas all but one family, (and these were capable of flight) were found on plateau lakes. The reasons for the move are thought to be similar to those causing the non-breeders to move. The lake systems of the uplands provide a network of lakeside grazing areas with refuges from Arctic Foxes, and the interconnecting streams provide easy routes for movement between feeding areas. The later thaw at altitude results in plants being at an earlier stage of growth compared to the lowland marsh areas and hence of better nutritive quality (see sections D8 and F1).

MOULT AND POST-MOULT DISTRIBUTION 9 JULY - 20 AUGUST

Most areas of Eqalungmiut Nunât were visited during the moult period although attempts to reach Amitsuarssuk were unsuccessful due to a swollen river.

An attempt was made to census the area immediately north and east of Base Camp on 9 July, when the entire area shown in Figure D1.7 (100 km^2) was surveyed for geese. The total of 60 non-breeders and two families discovered, by simple extrapolation, gives an estimate of 450 non-breeders over the whole of Eqalungmiut Nunât (750 km^2). The most extensive survey was carried out on 25, 27 and 29 July to the north of Atanârssuk and east of Castor and Pollux (Table D1.1). The area covered was 150 km^2 (Figure D1.8) and the same extrapolation gives a total of 400 non-breeding birds. However, if the lowland parts of Eqalungmiut Nunât are excluded (150 km^2 - these are known to have held only one family at the time), the total comes to about 320 non-breeders. Sixteen families were seen in Eqalungmiut Nunât (a total of 88 birds) which together with the non-breeders gives a summer population of about 400 geese. Because extrapolation from the above survey gives a lower number of families than was actually seen, the observed number has been used. It is likely that this remains an underestimate since the land bordering the ice-cap was not thoroughly covered.

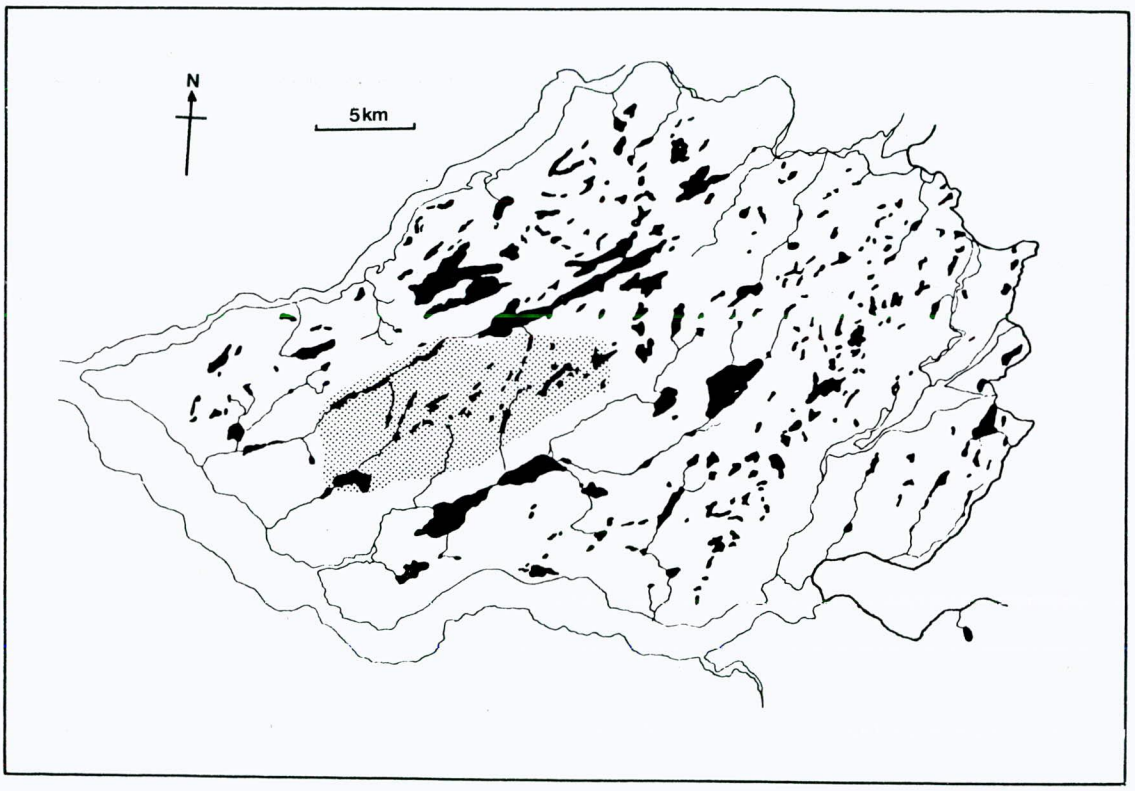


Figure D1.7. Area covered by census of 9 July 1979.

The accuracy of such a simple extrapolation is open to question, depending on an even density of birds, which the aerial survey of 1977 (Figure D1.1) and our observations (Table D1.1) tend to invalidate. These and other observations suggest the possibility of higher densities close to the ice-cap during the moult. Since our survey was carried out in this area, this would inflate any population estimate. Erring on the side of caution, numbers of geese are probably as follows: non-breeders 300 - 340, families 90 - 100 (individuals, post-hatching); and thus a total population of 390 - 440.

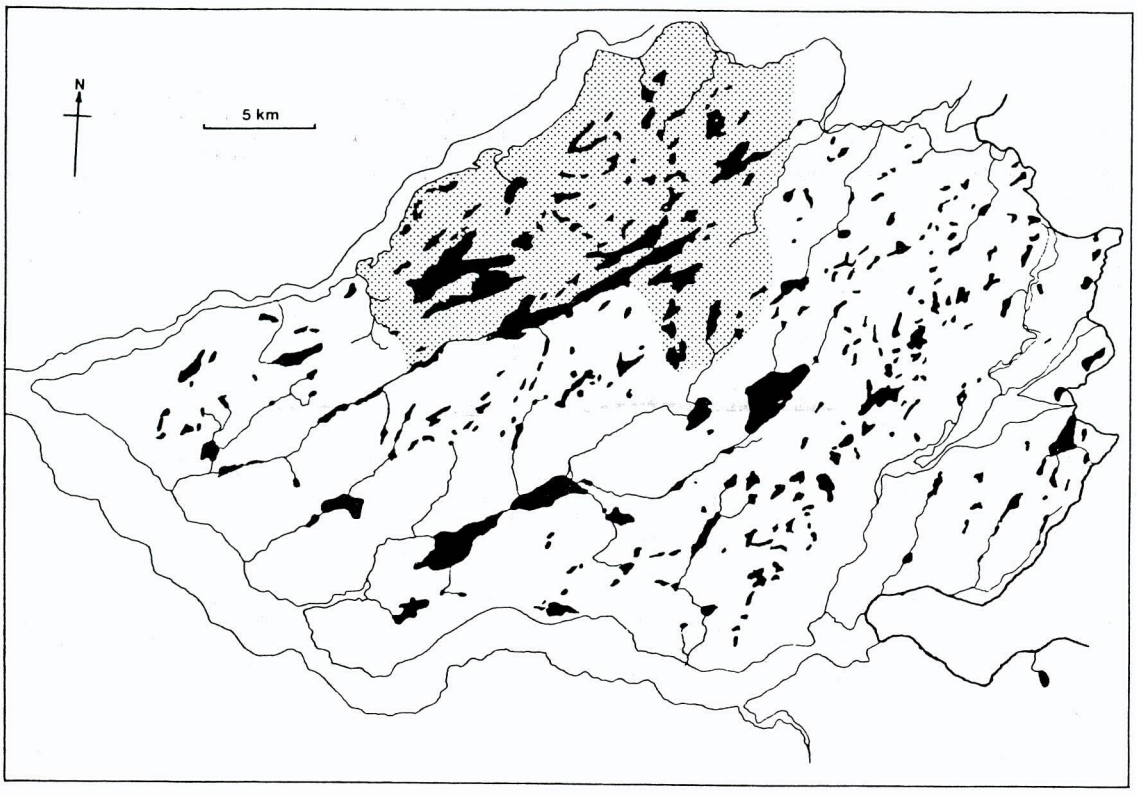


Figure D1.8. Area covered by census of 25-29 July 1979.

TABLE D1.1. Distribution of geese in northern Eqalungmiut Nunât. 25, 27 and 29 July.

LAKE	NUMBER	(PARENTS	GOSLINGS	NON-BREEDERS)
Lake 31	14			14
Lake 33	6	2	4	
Lake 35	19			19
Lake 42	14			14
Lake 37	17			17
Lake 58	15	2	3	10
Lake 73	10	2	3	5
Atanârssuk	6			6
	—	—	—	—
TOTAL	101	6	10	85

Movement of non-breeders during moult

ZULU

A flock of non-breeders spent July near Zulu; all were ringed on 11 July and their movements before and after this are of interest (Table D1.2). Despite the disturbance caused by the ringing, the flock was seen at its normal feeding site on Zulu on 12 July, but further activity in the area caused the birds to scatter; two days later they had moved 7 km downstream to Doodle and Spidermere (Figure D1.9), although numbers seen on 14 July indicate that at least six of the birds in the Doodle and Spidermere flocks were not ringed. The rings of the geese on X-Ray could not be read, so it is not known if they had moved straight to X-Ray or had travelled to Doodle or Spidermere first.

AXEWATER

During July and August a flock frequented the plateau in the region bounded by the lakes Hotel, Quebec, Uniform and Axewater (Figure D1.10), and it is likely that most of the sightings in the area involved the same birds (Table D1.3).

Movements of families during moult

Due to distinctive belly and breast markings (section D12), the movements of several adults with families could be followed (Table D1.5). The family from Upper Marsh was watched from June to August. Most movements between lakes would have been fairly easy for a small gosling to undertake. The route between Welsh and Foxtrot was more severe however, and was about 1.5 km, much of it along a boulder-strewn, narrow gorge with a drop of 200 m between the lakes.

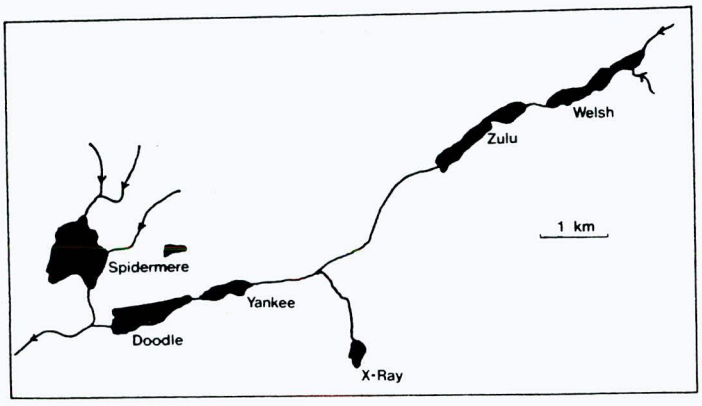


Figure D1.9. Lakes of the Welsh to Doodle drainage system.

TABLE D1.2. July movements of Zulu non-breeder flock.

DATE	NUMBER	LAKE	
June 28	5	Welsh	(with Welsh family)
July 1	10	Zulu & Welsh	
July 3	6	Zulu	
July 9	17	Zulu	
July 10	17	Zulu	
July 11	17	Zulu	(ringed A12-A24 and A26-A29 inclusive)
July 13	12	Zulu	(with a family of 7 birds)
July 14	8	Doodle	(at least 3 ringed)
July 14	15	Spidermere	
July 15	6	Spidermere	(at least 4 ringed)
July 16	10	X-Ray	(all ringed with a family of 6 birds)
July 31	11	Zulu	(at least 6 ringed)

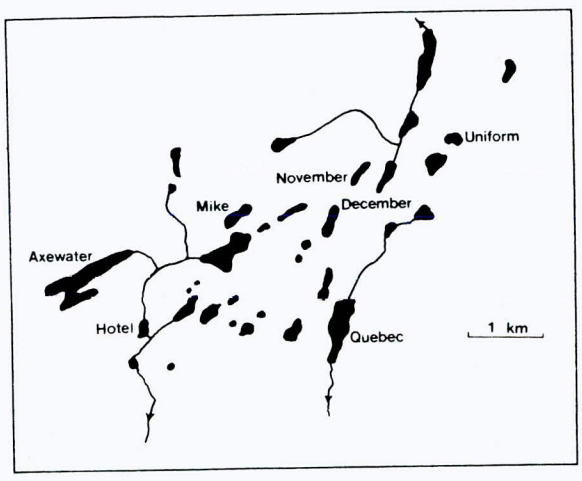


Figure D1.10. Lakes of the Axewater region of plateau.

TABLE D1.3. Flock size of geese in the Axewater area.

DATE	NUMBER	LAKE
June 27	10	Axewater
July 2	13	Mike
July 5	13	November/December
July 9	12	Quebec
July 10	12	Uniform
August 2	6	Axewater
August 3	7	Axewater
August 4	16	Axewater
August 5	15	Crusties
August 6	16	Axewater
August 10	14	Hotel
August 14	6	Axewater
August 19	6	Crusties
August 20	18	Crusties

TABLE D1.4. Family size of all Greenland White-fronted Geese in Eqalungmiut Nunât, 1979.

DATE FIRST SEEN	LAKE	YOUNG	
July 16	X-Ray	4	
July 17	near 410 m	4	
July 17	near 410 m	5	
July 20	Charlie	5*	Upper Marsh family
July 20	Charlie	5*	Welsh family
July 22	Atanârssuk	1	
July 26	Lake 31	3*	
July 27	Lake 73	3*	
July 28	Lake 33	4*	
July 29	Lake 58	3*	
August 2	Axewater	1*	Axewater family
August 2	Axewater	3*	
August 9	E. Eqalungmiut tasia	6	
August 12	Lake 70	2	
August 15	Lake 69	5	

Mean brood size : 3.5 $\pm$ 1.50 (s.d)

* indicates ringed broods

Family size

It was not possible to make regular observations on most families and this, together with the large distances over which families move, complicates any calculations of totals. As the young grew, families moved less, tending to congregate both with other families and, more loosely, with non-breeders. Thus after 16 July most families can be identified with some degree of confidence. Only sightings after this date have been used in the compilation of Table D1.4.

Behaviour during moult

On commencement of moult, non-breeders became far more secretive than previously. On observing humans at distances of over 1 km, they would swim to the bank of the lake furthest from the observer and disappear into the vegetation. Once hidden they would skulk away from the area. Their perfect camouflage, and the ability of large flocks to vanish whilst under observation with binoculars and telescopes, caused incredulity at first; however by our taking every precaution against being seen, moulting geese could be watched with success. Towards the end of the moult, non-breeders became more tolerant, tending to swim to the middle of the lake rather than skulk away on dry land.

The behaviour of families was different from that of non-breeders, as they took to the lakes when alarmed rather than hiding in the vegetation. This agrees with Salomonsen's (1950a) observation that they will try to hide only if there is no lake nearby. Once on the lake it was much more difficult to compel family groups than non-breeders to leave and walk into the catching nets set up on the bank (section D10). On 8 August attempts were made to catch a family of six young. On the first attempt the male left the family and ran off up the lake side to hide in the vegetation. The female and young remained on the lake hiding in emergent *Menyanthes* at the edge, and finally, when approached with boats, flew across the lake on apparently their first flight, to land and feed seemingly unconcerned close to the ringers. This was closer than any geese had allowed approach for months and was no doubt a

TABLE D1.5. Family movements in June, July and August (Gosling number in brackets).

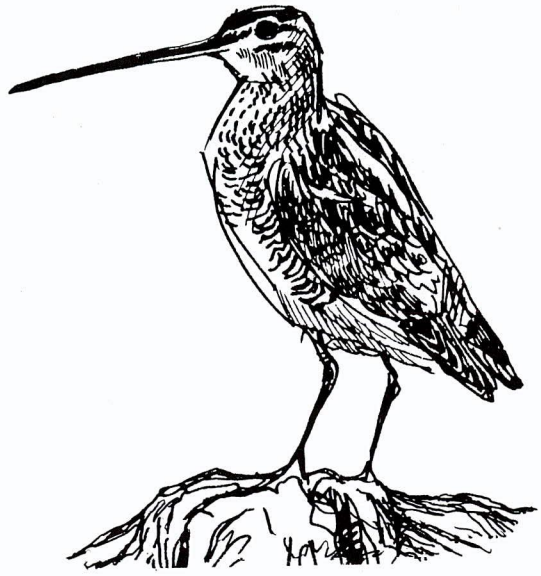
DATE	UPPER MARSH (5)	WELSH (5)	AXEWATER (1)	ATANÂRSSUK (1)	AXEWATER (2)	AXEWATER (3)	RIMWATER MARSH (5)
22	Upper Marsh						
23							
24	Charlie						Rimwater Marsh
25							
26			?Charlie				Rimwater marsh
27			?Delta		?Echo		Rimwater marsh
28		Welsh					Rimwater Marsh
29							leave Rimwater marsh
30							
1	?Foxtrot	Welsh					?Foxtrot
2			Echo				
3		Welsh					
4							
5							
6							
7							
8							
9		Welsh					
10		Welsh					
11	Welsh	Welsh			?Echo		
12	Zulu	Welsh					
13	family (5)	on Zulu					
14	Foxtrot	Foxtrot					
15	Foxtrot	Foxtrot					
16							?X-Ray (4)
17							?Yankee
18							
19							
20	Charlie/D	Charlie/D					
21							
22	Delta	Delta		Atanârssuk			
23	Echo	Echo					
24				Atanârssuk			
25							
26							
27							
28							
29							
30							
31							
1	Axewater	Axewater	Axewater		Axewater	Axewater	
2	Axewater	Axewater	Axewater		Axewater	Axewater	
3	Axewater	Axewater	Axewater		Axewater	Axewater	
4	Axewater	Axewater	Axewater		Axewater	Axewater	
5	Axewater	Axewater	Axewater		Axewater	Axewater	
6	Axewater	Axewater	Axewater		Axewater	Axewater	
7							
8							
9							
10	Axewater	Axewater	Axewater		Axewater	Axewater	
11	Axewater	Axewater	Axewater		Axewater	Axewater	
12							
13							
14		Axewater	Axewater		Axewater	Axewater	
15	Axewater	Axewater	Axewater		Axewater	Axewater	
16		Axewater				Axewater	

reflection of their ability to escape by flight if necessary. It was also the only occasion on which a family was seen to split up, and it is possible that the early disappearance of the male was due to his still being flightless.

FLOCK SIZE

Flock size has been calculated on a daily basis; that is, while avoiding inclusion of the same birds twice in any one day, the same flock has been counted separately if seen on more than one day. Thus the grand total of geese for each month does not indicate the numbers of birds present; figure D1.4 does, however, reflect changing gregariousness.

The modal flock size changes from two in May and June to 14 and 16 in July, and to 27 in August. Individual young geese associated with adult pairs were occasionally seen, but in June the groups commonly contained several pairs. In July and August family flocks were seen consisting of one to six goslings and parents. As the month progressed bigger flocks developed, particularly on Axewater, where all but one of the flocks over 25 were seen in August.



D2 PRE-NESTING FEEDING BEHAVIOUR OF THE GREENLAND WHITE-FRONTED GOOSE

A. D. Fox & J. Madsen

Abstract

Greenland White-fronted Geese were observed feeding for up to ten days between the peak arrival period and the onset of nesting in west Greenland. Birds fed on highly nutritious subterranean plant perenniating organs for 68% of their diurnal activity, roosting only during the period of sub-zero temperatures. Attendant vigilant ganders in solitary pairs enabled female geese to feed for maximal uninterrupted periods. The males gained advantage from joining flocks of other geese spending less time alert with a corresponding increase in the proportion of their time spent feeding, although there appeared no advantage to females in social feeding. Patterns of movement suggested there was a diurnal rhythm to feeding determined by freezing of the substrate.

INTRODUCTION

Nutritional reserves acquired by arctic-nesting geese prior to the spring migration are limited by the increase in body weight the birds can carry and at the same time maintain adequate periods of flight (Ryder 1970). The condition of the birds on arrival is of considerable importance in determining reproductive success, and in the case of the Lesser Snow Goose, Ankney and MacInnes (1978) suggest clutch size and successful incubation are directly related to the nutrient reserves of the female. In most species, the female goose feeds very little before and during egg-laying and incubation and must have accumulated sufficient reserves to sustain egg-laying and maintain condition throughout incubation. Generally, nesting commences shortly after arrival on the breeding grounds, being limited by the period of rapid yolk development (Raveling 1978) and by weather conditions which may cause complete breeding failure in some years (Ogilvie 1978). However, the pre-nesting period varies considerably according to species. In typically high arctic geese such as Lesser Snow Goose and Ross's Goose, it is suggested that the stimuli causing rapid yolk formation are related to the events just prior to, or at the time of, migration to the normal final staging areas, the geese commonly nesting within three to five days of their peak arrival on the nesting grounds. In low arctic species such as Cackling and Brent Geese, the initiation of nesting occurs 10-13 days after peak arrival with rapid yolk formation stimulation dating from events just before, or at the time of, migration from the final spring staging areas to the nesting areas.

Fencker (1950) and Salomonsen (1950a) observed in the low-arctic Greenland White-fronted Goose a period of feeding immediately after arrival on the nesting grounds. Fencker found that the phenology of arrival of the species at Sarqaqdalen (70°06'N, 57°08'W) was relatively constant with arrival in early May and feeding until the first eggs are laid between 20 and 28 May. Similarly, S. Malmquist and P. Grossman (pers. comm.) give the mean arrival dates as the first week of May, with extreme dates of 2 May for Søndre Strømfjord Air Base and 1 May (1977) for Sisimiut respectively. The first birds seen in Eqalungmiut Nunât 1979 were sighted on 7 May.

The first geese noted in the study area spent considerable periods feeding on Kûk Marshes, an area of mature glacial sediments adjacent to a glacial melt river. After 7 May, this area formed the central feeding site for all birds in the vicinity, numbers reaching a peak of 93 on 12 May and subsequently declining over the following days, until by 17 May the passage was largely completed and the birds had dispersed away to higher latitudes (Figure D1.2). Egg-laying commenced on average on 22 May, giving a pre-nesting period of at least 10 days.

On the basis of behavioural studies, it is suggested that the female can at least maintain her general nutrient status and hence increase her chances of reproductive success during this phase. This is achieved during the pre-nesting time by the female maximising feeding activity while the gander spends the majority of his time alert in a protective function.

METHODS AND STUDY AREA

A description of the Kûk Marshes complex is given in section I1 and is shown in Figure D2.1.

Faecal analysis and direct observations showed the arriving geese to be feeding on the perennating rhizomes of *Puccinellia deschampsioides* and bulbils of *Triglochin palustre* as well as the developing shoots of *Hippuris vulgaris* submerged in some of the pools (see section D8).

The entire area could be watched from a ridge 300 m north of the marshes, affording concealed approach from the nearby camp, as well as simultaneous viewing over all of the important goose feeding sites. Observations using 20-45 x telescopes commenced on 9 and 10 May when preliminary watches were carried out, culminating in a full 24 hour continuous watch on 11 May.

Two methods of data collection were used as follows:-

(i) At 15 minute intervals, the marsh complex was scanned and the locality and activity of all geese present on pools and marshes noted. The activity states used in the study are listed in Table D2.1.

(ii) Concurrently, pairs of birds were watched whilst actively feeding and the behaviour of both birds noted and timed.

The latter method was intended to time changes in the behaviour of birds and examine patterns of alertness and feeding in foraging pairs, with the exact time of each change in activity of the pair being noted. It was not possible to determine whether these birds were breeding pairs, but the generally late arrival of the young non-breeding birds in Eqalungmiut Nunât, together with the distinctive behaviour of these pairs suggest that the birds under observation were likely to have been nesting geese.

The data collected using method (i) were segregated on the basis of pairs feeding in flocks and those feeding in isolation. These results were analysed in two forms: firstly, the data were summed on an hourly basis, and the proportion of time spent in each activity was calculated and expressed as a percentage for both goose and gander in isolation and in flocks; secondly, the length of time spent in a particular activity without interruption was calculated for goose and gander in both situations and mean values were calculated for each hour of the day. Data are combined from 11 and 12 May, and are derived from observations taken from different pairs throughout the marshes, although several pairs contributing to the study were watched in both solitary and flock situations.

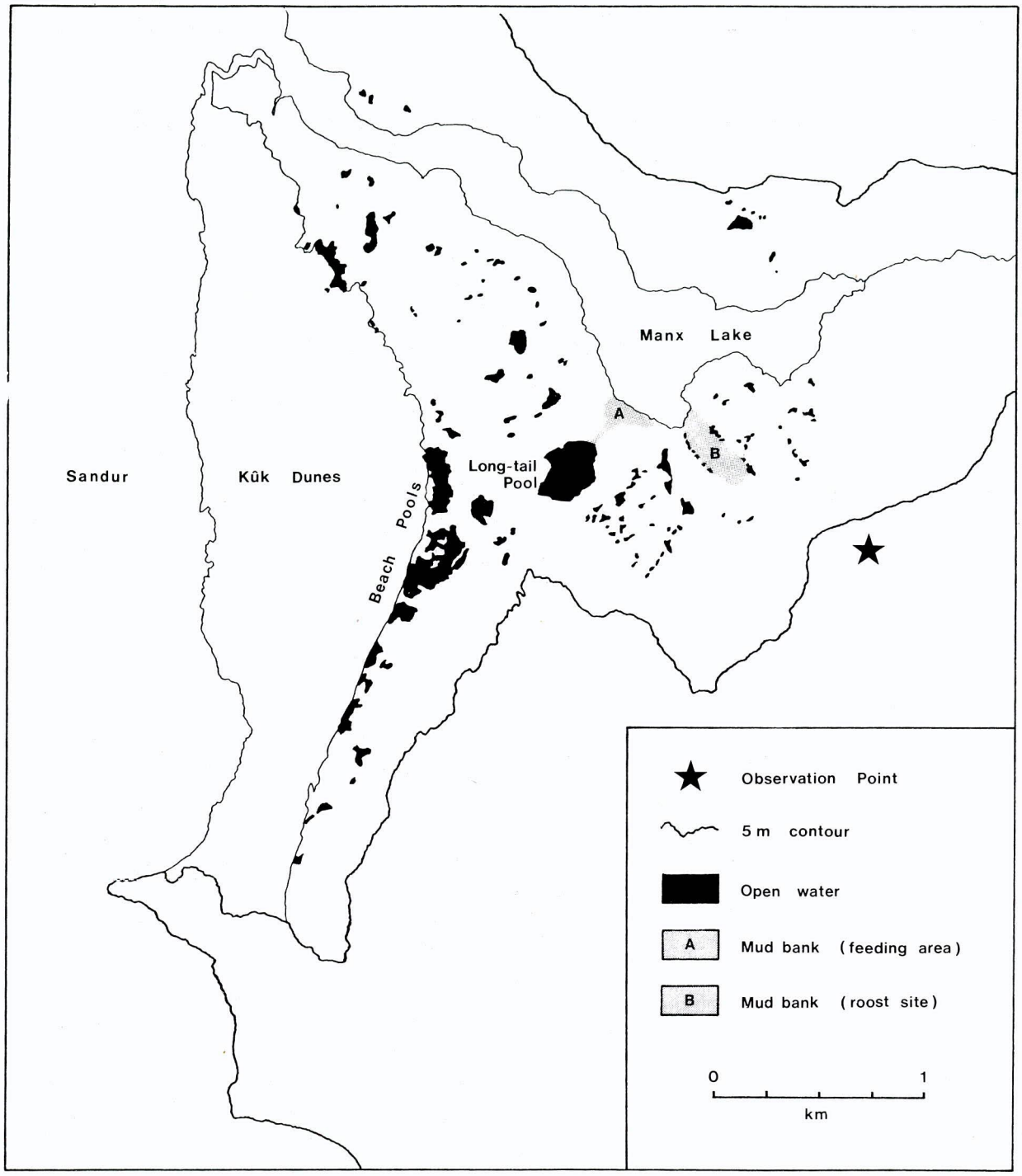


Figure D2.1. Map of Kûk Marshes, showing important feeding and roost areas for Greenland White-fronted Geese (*Anser albifrons flavirostris*).

TABLE D2.1. Table of activity states used in the behavioural Study of Greenland White-fronted Geese on Kûk Marshes

1.	Feeding	-	including all actions involved in various types of feeding, e.g. grazing, up-ending, feeding below the surface of water, probing in mud etc.
2.	Alert	-	equivalent to the posture of extreme head-up (Inglis 1977).
3.	Inactive	-	equivalent to stand and sit postures of Inglis (1977) and excluding obvious roosting.
4.	Walk	-	movement with head in head-up posture.
5.	Roost	-	standing or sitting with head on back in typical roosting posture.
6.	Swim		
7.	Chase/chased	-	behavioural interactions of geese, according to direction of aggressive encounter.
8.	Preen		
9.	Drink		
10.	Fly		

RESULTS AND DISCUSSION

Total Goose Numbers

The total numbers of geese at each quarter-hour count are presented in Figure D2.2 and show the gradual build-up of geese at the wetland site during the three day period to a maximum of 93 birds on 12 May. Fluctuations in number partly result from birds lost from sight amongst vegetation, but generally reflect the passage of birds through the site.

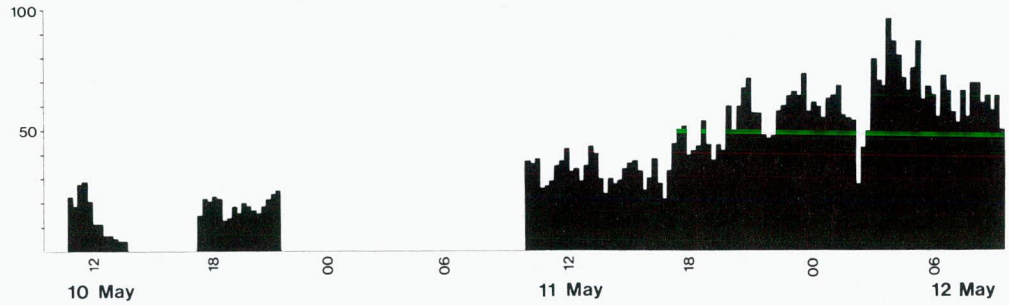


Figure D2.2. Build up in numbers of geese seen at Kûk Marshes, May 1979.

Usage Patterns within the Marshes

There appear to be diurnal patterns of movement on the marsh; the usage of the two most important feeding sites is shown in Figure D2.3. During daylight hours, the majority of the birds present utilised the areas of bare mud, Mudbank A in Figure D2.1, adjacent to Long-tail Pool, the numbers declining during the day. The sun set on Kûk Marshes around 21.00 hours, causing the pools and mud banks to freeze so restricting foraging for roots and bulbils. This factor was thought to be largely responsible for the movement back from the marshes to the 'Beach Pools' on the extreme southern edge of Kûk Dunes, the last open water surfaces to freeze over. The subsurface food items gradually became inaccessible as the substrate froze, forcing the geese to open water surfaces which were the last to freeze. In the open water birds were taking *Hippuris vulgaris* with *Triglochin palustre* and perhaps the perennating organs of *Potamogeton filiformis*. By 06.00 hours, many of the areas of standing water thawed and the birds dispersed again throughout the marshes.

Behavioural Patterns

Observations from quarter-hour scans on 10, 11 and 12 May are pooled and shown in Figure D2.4.

(i) Feeding: 68% of the total diurnal activity of the geese was spent feeding (representing a mean of 16.4 hours/day), although there were considerable differences between sexes as described below. There is a decrease in feeding during the coldest hours (between 01.00 and 05.00 hours) with a peak in foraging activity immediately preceding the short roosting period. This is similar to patterns observed in feeding geese on the wintering grounds in Europe (e.g. Owen 1972a).

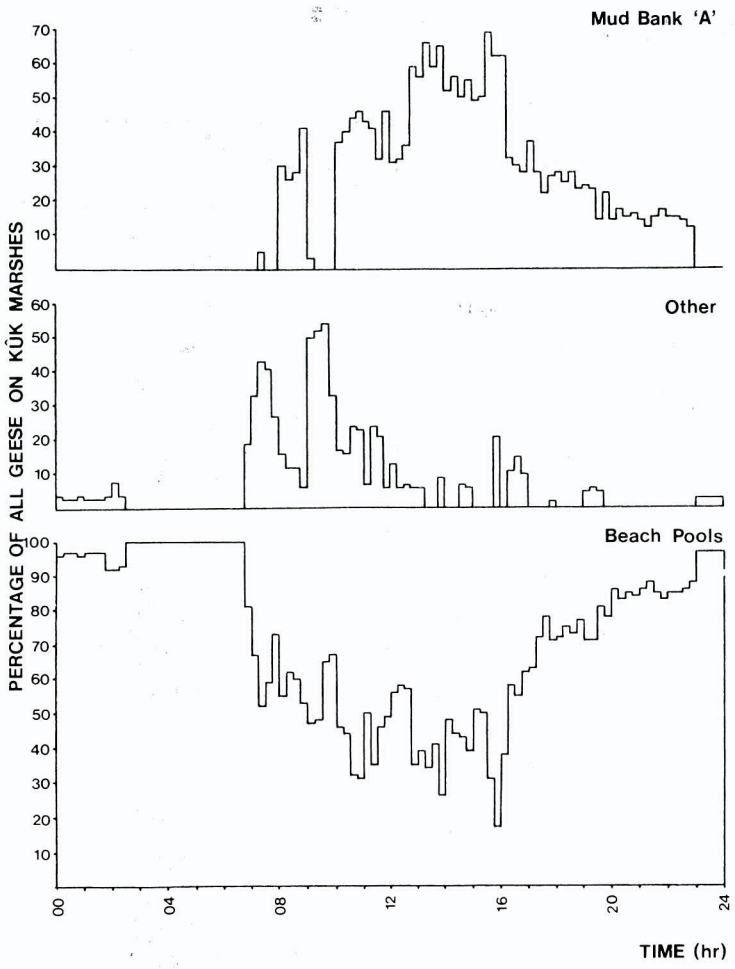


Figure D2.3. Usage patterns of the most important goose feeding sites, Kûk Marshes, May 1979.

(ii) Roosting: 11% of diurnal activity was spent roosting (2.6 hours/day), regular roosting occurred only during the periods of lowest temperatures.

(iii) Alertness: 10% of the diurnal activity was spent alert (2.3 hours/day), with the constant lower proportion of alert birds during the roosting phase resulting from the gathering of geese into larger roosting groups.

(iv) Resting: No trends appear in the patterns of inactivity which amounts to 6% of the diurnal activity (1.5 hours/day).

(v) Preening: Most preening activity took place during the main roosting periods, comprising 3% of all activity (0.7 hours/day).

(vi) Other activities constituted 2% of total diurnal activity (0.5 hours/day).

Behavioural Studies of Feeding Pairs

Table D2.2 summarises the results of the activity studies of foraging pairs from which the following points arise:

(i) In both solitary and flocked pairs the goose spends significantly less time alert and more time feeding than the gander.

(ii) In terms of the proportion of time spent feeding, the gander gains advantage from joining flocks with a corresponding decrease in the proportion of time spent alert.

(iii) There is no significant advantage to the female in social feeding, either in terms of increased feeding or decreased alertness.

(iv) In terms of the uninterrupted periods spent in each activity, the relationships are essentially the same as for the proportion of time spent in the same activities, although the large variances within the data result in many of the comparisons not being statistically significant.

Analysis of vigilance periods of the gander and diurnal activity allocation to alertness indicates that as the percentage time allocated to vigilance increases, the non-vigilant period shortens and periods of uninterrupted alertness increases in length (Figure D2.5), a relationship demonstrated in the House Sparrow by McVean and Haddlesey (1980). No such relationship exists in the female, or for either sex in feeding activity (Figure D2.6), so it would seem that the vigilance schedule of the protecting gander is critically controlled.

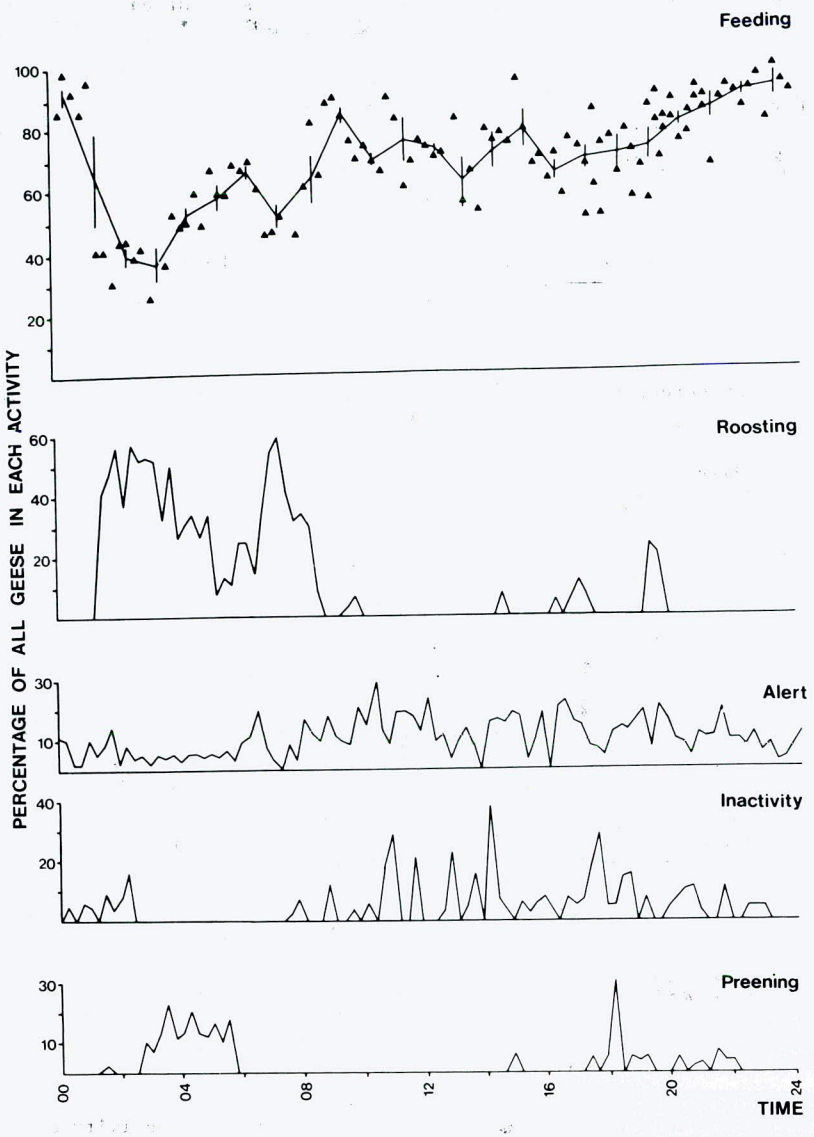


Figure D2.4. Activity patterns of Greenland White-fronts on Kûk Marshes, May 1979.

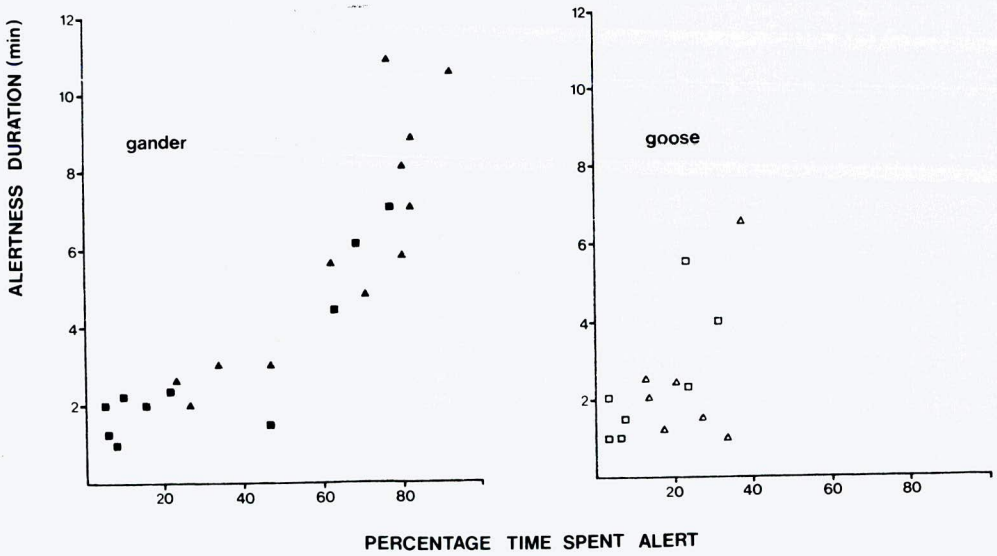
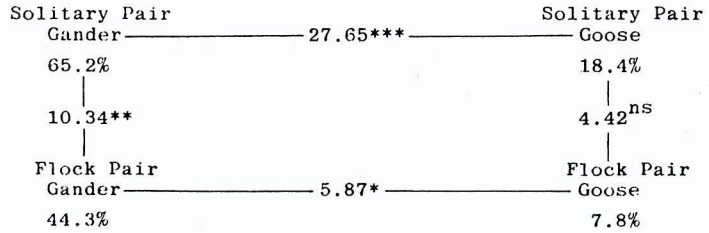
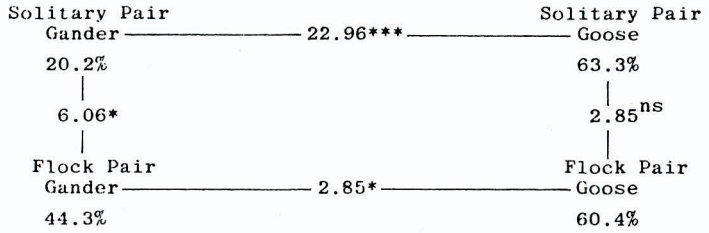


Figure D2.5. Vigilance schedules of Greenland White-fronts on Kûk Marshes, May 1979. Squares indicate flock feeding birds, triangles indicate solitary feeding birds.

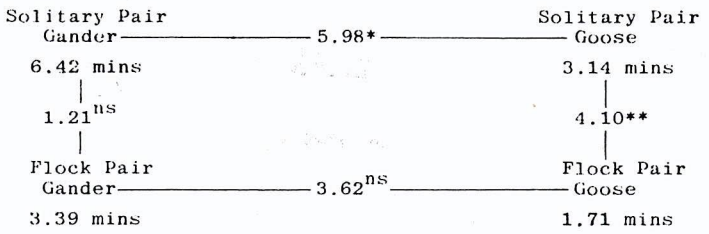
TABLE D2.2. Comparison of activity scores of male and female geese in flocks and solitary pairs. Values are means and the F-ratio and level of statistical significance are given for each comparison (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).



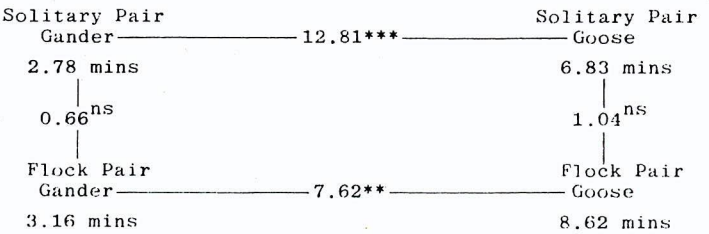
(i) Comparison of mean percentage time spent in alert activity on an hourly basis.



(ii) Comparison of mean percentage time spent feeding on an hourly basis.



(iii) Comparison of mean length of time spent uninterrupted in alert activity on an hourly basis.



(iv) Comparison of mean length of time spent in uninterrupted feeding activity on an hourly basis.

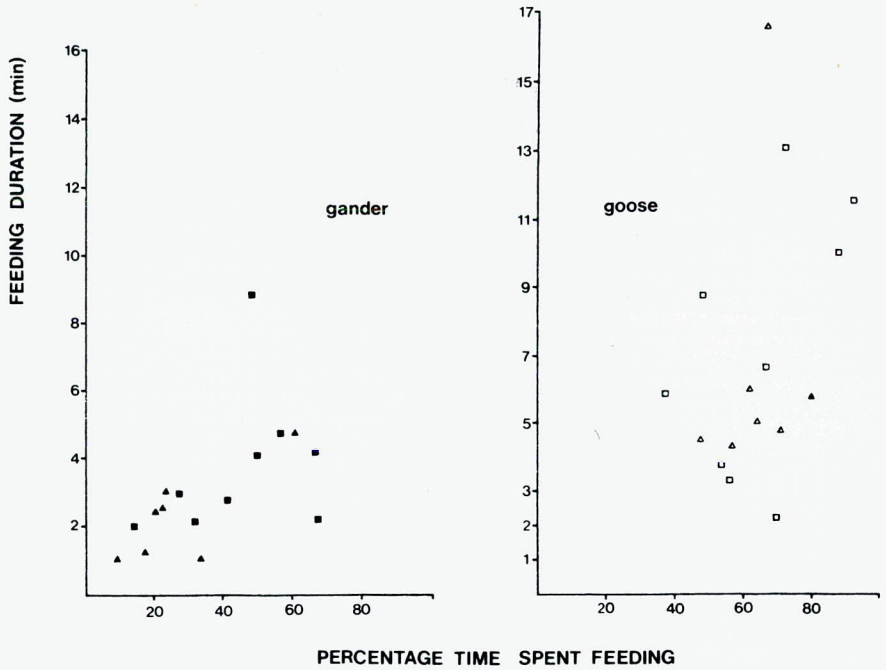


Figure D2.6. Feeding schedules of Greenland White-fronts of Kûk Marshes, May 1979. Squares indicate flock feeding birds, triangles indicate solitary feeding birds.

TABLE D2.3. Comparisons of periods of simultaneous feeding by goose and gander in solitary pairs, and flocks, Kûk Marshes, May 1979

	Total Observation Time (min)	Total time when either gander or goose was feeding (min)	Total time when both birds feeding together (min)
SOLITARY	489	232 (47.4% total)	11 (4.7% feeding)
FLOCK	461	311 (67.5% total)	105 (33.8% feeding)

TABLE D2.4. Comparison of length of time spent in uninterrupted bouts of feeding and alert activities in a solitary goose pair on Upper Marsh, (21 May, 1979) (n=50)

Gander Feeding mean 8.11 secs ← 13.699** → Goose Feeding mean 26.00 secs

Gander Alert mean 22.33 secs ← 12.99** → Goose Alert mean 6.67 secs

TABLE D2.5. Comparison of length of time the goose spent submerged feeding on *Hippuris vulgaris* in Afon Char between presence of alert gander, and attendant feeding gander, near Afon Char, 24 May (n=40)

Gander Activity	Mean Goose submergence duration	
Alert	3.1 secs	0.00^{ns}
Feeding	3.1 secs	

Gander Activity	Mean Goose alert duration	
Alert	3.4 secs	11.48**
Feeding	7.1 secs	

In solitary pairs, there was always a discrete change in activity between the two birds, the initiation of feeding by one bird resulting in the resumption of alert posture in the partner, contrasting with the shared feeding activity observed within the flocked pairs. Table D2.3 illustrates this benefit of flocking in terms of increased time spent feeding simultaneously as well as a general increase in feeding as a percentage of all activity. It was not apparent which of the sexes in a solitary flock triggered off the change in activity, although it appeared on most occasions that it was the alert bird which initiated the change. However, in cases where sloitary pairs flew to join a flock, it was invariably the gander which initiated the flight.

In flocks, 64 agonistic interactions were observed between pairs. The gander was involved in significantly more encounters than the goose (U-test, $\chi^2=11.9, p<0.001$), driving away other feeding pairs at distances up to 10 m. These findings are similar to those of Boyd (1953), although the distances involved between geese in aggressive encounters were much greater than those recorded in Europe in winter. Furthermore, these interactions seemed very intense with pairs often pursued into flight. This may be due to the patchy and scarce nature of the food resource as well as proximity to the onset of nesting.

The vigilant behaviour of the gander in solitary pairs was also observed after the main dispersal of the geese from Kûk Marshes but before nest initiation. Two instances are shown in Tables D2.4 and D2.5; these observations are in accordance with the patterns noted from Kûk Marshes.

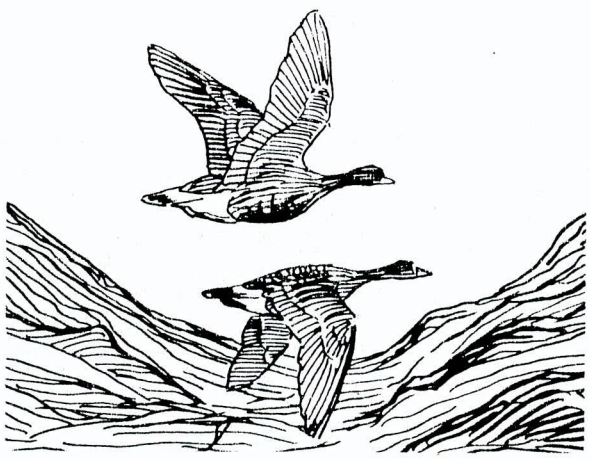
CONCLUSIONS

Any supplement to the reserves of the female on arrival on the breeding grounds will improve her general nutrient status and increase her chances of reproductive success. In 1979, between the peak arrival date (12 May) and the mean date of nest initiation (22 May) there was apparently sufficient time for the female to obtain a significant amount of nutrients on the breeding grounds prior to nesting as suggested by Ely (1979) in *Anser albifrons frontalis*.

In order to optimise her foraging activities, it is of value to the goose to spend maximal periods in uninterrupted bouts of feeding. This is seemingly achieved by the behavioural response of the attendant gander which keeps close (generally less than 5 m) to the female; in this protective role, the male bird spends much of his time alert. In solitary pairs, the gander spends most of his time alert, while in flocks, the protective burden is shared between more birds to the advantage of all. In groups, the gander shows no significant difference in the time spent alert when compared to the females, but there is no corresponding decrease in the time spent feeding by the female geese.

Unlike many arctic nesting geese, the solitary-nesting Greenland White-fronted Goose shows little territoral behaviour on the nesting areas, so there is reduced necessity for the condition of the gander to be maximised since his influence on nesting success is less than in colonially nesting geese (see Ryder 1975a, Owen and Wells 1979). However, the gander still provides an important protective function at the nest site against other males (Mineau and Cooke 1979) and against predation so it is clearly of importance to optimise fitness during the pre-nesting phase.

The formation of flocks of feeding animals has been explained in the past in response to three different factors: (i) the uneveness in food resource in time or space (e.g. Turner 1965, Krebs 1974, Thomson *et al.* 1974); (ii) predation, a flock providing potential shelter from attack to an individual (Williams 1966, Hamilton 1971); or (iii) sharing the vigilant role between many individuals to the benefit of all (Dimond and Lazarus 1974, Powell 1974, Abramson 1979). In the pre-nesting social feeding of the Greenland White-front, it is likely that all three factors are acting on the foraging geese. At the time of arrival, there is little food available to pre-nesting White-fronts restricted to the roots, stem and other overwintering material in the few substrates freed from the thaw. Chapin *et al.* (1975) found Arctic grasses and Cyperaceans held the highest concentrations of nutrients in the perennating organs immediately before the onset of spring growth. Similar results are given by Dennis *et al.* (1978) and Whitten and Cameron (1980) who also show that the below-ground live standing crop is at its highest preceding spring production. The bulbils of *Triglochin palustre* are buried in open mud, and during early May, there are no visual clues for the feeding geese to locate this important food item; thus it would seem that flocking at food-rich sites would attract further arriving birds as well as enhancing chances of feeding success on the muddy flats. By contrast, the other important food items are *Puccinellia deschampsioides* (which retains above ground litter and is hence easily located) and *Hippuris vulgaris* which gives individual pairs a measure of predator protection whilst browsing on open water. During the observations both Gyr Falcon and Arctic Fox were noted attempting to prey on the geese, and doubtless these two species represent a considerable danger to the geese on arrival at the breeding areas (see Section D3).



D3 PREDATORS AND PREDATION

A. P. Fowles

Abstract

Of seven located nests, four were unsuccessful and ultimately predated, Arctic Fox were implicated at two or three of these, Ravens at one or two. Glaucous Gulls and Iceland Gulls present showed little likelihood of being serious predators and skuas were totally absent from the study area. Both Arctic Fox and Gyr Falcon were seen attacking White-fronted Geese, but neither successfully. It is thought the geese are only under serious threat from Arctic Fox, but the increase in the numbers of Ravens in this area is discussed as well as the role of man in the recent decline of the geese.

In west Greenland, the Greenland White-front has many potential predators, yet in Eqalungmiut Nunât very few direct attacks were observed and the geese here are probably under serious threat only from Arctic Foxes. Of four nests located that subsequently failed (section D4) foxes were considered to be the cause of two, possibly three, of these whilst it was thought that a Raven robbed the fourth.

EGG PREDATION

The Arctic Fox is a circumpolar predator of tundra-nesting geese, recorded as taking eggs or young from most species (Ogilvie 1978), including White-fronts (Ely 1979). It is perhaps the most important predator of the Greenland White-front.

On 3 June, the nest bowl of Base Camp 2 nest (BC2: section D4) had been ripped up and scattered up to 80 cm around the nest. Moss in the bowl had been dug up and there were two Fox scats in the nest, the typical signs of Arctic Fox predation (Meltofte *et al.* 1980, Ely 1979). However, the remaining egg of a clutch of six had a 3 cm diameter hole puched in its side, characteristic of Raven predation (Rearden 1951). It is uncertain which predator was initially responsible but it is most likely that the Raven began the predation after the desertion of the female during a snow-storm and the Fox later completed the destruction of the nest. On 30 May a white phase Arctic Fox had been seen heading south down Observation Hill in the general direction of the nest and on 31 May fresh Fox tracks led through the snow across Upper Marsh towards the nest.

Nest BC3, containing a clutch of six eggs, was most probably predated between 30 May and 1 June. Again the nest bowl was destroyed and one smashed egg remained. It is likely that the geese had deserted this nest, as well as BC2, during the snow-storm experienced between 31 May and 1 June. The nest at Pass of Jennings Dunes was found empty on 4 July and while it is possible that the single egg hatched successfully, there were no remaining egg-shell fragments to confirm this. The nest bowl showed no sign of damage.

Ely (1979) described the defence of a nest by a female White-front against an Arctic Fox which managed to take one egg; (Meltofte *et al.* (1980) describe a successful nest defence by Pink-footed Geese against Arctic Fox, and it is considered that once incubation has begun, the geese are able to drive Foxes away and predation is successful only when the adults are absent or before the clutch is complete). The degree of fox predation observed was 43% of nests found, compared to 5.3% of 74 White-front nests in the Yukon-Kushokwim Delta (Ely 1979) and 58% of Pink-feet nests in north-east Greenland (Meltofte *et al.* 1980).

Ravens are noted egg-thieves, but theft is invariably undertaken during adult absence from the nest, and thus they are inconspicuous predators. Hammond and Forward (1956) concluded that avian predators locate the nests of waterfowl by observing the movements of the female on the rare occasions when she leaves the nest. Ogilvie (1978) considers that covering eggs conceals them from predatory birds when the adults are absent during the egg-laying period, and although a covering of down is inconspicuous, egg-shape is more important as a search image. At BC1 (section D6) the female left the eggs uncovered during at least four recesses, and if this is typical then Ravens have considerable opportunity to predate eggs during the incubation.

Ravens were probably involved in two out of the three or four predated nests located. A single egg at the Imajuitsoq nest disappeared between 15.30 hours on 19 May and 14.40 hours on 20 May. Although the predation cannot definitely be attributed to Ravens, the presence of an occupied Raven eyrie only 300 m away, at which two adults were busily searching for food for their young, would seem to implicate the species. The predation of the nest BC2 by Ravens is discussed above.

Three other potential predators of White-fronted Goose eggs are resident in the upper stretches of Nagssugtôq. Although a colony of some 30 pairs of Glaucous Gulls was situated at the south-western corner of Eqalungmiut Nunât, adults were observed in Goose Valley only three times (section E22) and were never seen to interfere with nesting geese. A study of Pink-footed Goose predation in north-east Greenland (Meltofte *et al.* 1980) recorded no interference from the abundant Glaucous Gulls, yet they were the chief predators of Canada Geese on the Yukon-Kushokwim (Mickelson 1975). Ely (1979) in the same region, however, did not believe that they had predated any of the 75 nests of Pacific White-front he located during 1977 and 1978.

Both Arctic and Pomarine Skuas are recorded as breeding at the head of Nagssugtôq (Salomonsen 1974) but none was seen during the study period. Skuas are regarded as opportunistic predators and their dependence on goose eggs and young is related to the supply of other food. Inglis (1977) observed Arctic Skuas as the most successful predators of the Pink-footed Goose colony at Thjorsarver and no doubt they exploit the wealth of opportunities available in such a large colony.

A White-fronted Goose nest at Mudderbugten, Disko Island, found in 1975 was placed only 60 m from the nest of a pair of Arctic Skuas. Whenever the geese returned to the nest after flushing there was much aggression with the Skuas, and once "severe fighting". The Skuas frequently landed close to the goose nest while the female was incubating. There were only two eggs found on 19 June and it is possible that the small clutch size may have been due to the Skuas. Ely (1979) found that Arctic Skuas destroyed 20% of all located White-front nests on the Yukon-Kuskokwim Delta during his study. However 14.7% (11) nests had already been flooded, allowing Skuas access to nests that might otherwise have been successful.

ADULT AND GOSLING PREDATION

Only Arctic Foxes and Gyrfalcons were observed making direct attacks on White-fronts, all of which were unsuccessful. Nine attempted attacks by Arctic Foxes were observed, six occurring in May when there was much goose activity in the lowlands where Foxes concentrated before dispersing to higher altitudes later in the month (section F3). Typically, the Fox would run towards a flock of feeding geese and stalk them from about 50 m. The geese generally became aware of its presence 20 - 30 m distant, all the birds adopting an extreme head up posture (Figure D6.2) but soon relaxing and resuming feeding even if the Fox continued to approach. The distance at which the Fox became a direct threat varied, but in most cases it was about 10 m over water and a little more over land. On closer approach the geese would either swim to deeper water or fly back 3 or 4 m to keep the Fox at a safe distance. This general pattern of events was recorded on six occasions. In another case a pair of feeding geese flew off on noticing the Fox running towards them, 150 m distant.

In the two remaining cases the geese threatened the Fox from their position offshore. During the early hours of 21 May an Arctic Fox appeared on the west bank of Lakesmeet and ran quietly across the ice towards 15 geese roosting on the stream; however the birds remained on the unfrozen stretch of water honking at it. Five minutes later it crossed on to an island in the river, whereupon the geese swam directly towards it in a tight band calling loudly. The predator then ran off down the ice of west Eqalungmiut tasia towards another Fox which had appeared earlier about a kilometre from Lakesmeet. The geese here probably did not have enough room on the stream to take to the wing and there was insufficient unfrozen water to allow them to move to a safe distance from the Fox. The group threatening behaviour is thus probably an extreme defensive reaction.

The only occasion on which a Fox approached goslings produced a similar flocking behaviour. Five families were feeding at the edge of Axewater when suddenly all stood extreme head up and ran into the water. A white Fox appeared on the ridge above the lake and ran to where the geese had been feeding. The flock threatened the Fox from their position 10 m offshore whilst it continued along the water's edge. Once the Fox had left the area the geese returned immediately to their feeding.

On 9 June eight geese took off from Upper Marsh and flew to the adjacent slopes of Needle Cairn Heights. A minute later they were all seen to be standing with heads highly alert and lunging with flapping wings in the direction of a pale Fox. The Fox ran off up the hill and shortly afterwards the geese took off and flew back down to the marsh. It is probable that the flock had flown to the slopes just to mob the Fox.

The common feature of all these incidents is that once the geese had become aware of the presence of the Fox it abandoned the attack. It would appear that in order to be successful, the Fox must take the geese completely by surprise. For their part, once the geese had seen the Fox the initial extreme alertness soon lapsed and some even went back to feeding as it came closer. Owen (1973) noted that European White-fronts on their wintering grounds will keep ground predators under observation but will rarely flush.

Although each of the above observations describes attempted attacks which were unsuccessful, the Arctic Fox is quite capable of catching Greenland White-fronted Geese and there were three records of this in Eqalungmiut Nunât. Two kills from the current season were located: on 28 May a pile of White-front feathers was found near west Eqalungmiut tasia and on 3 July the feathers of an adult were found near the northern part of the region near a lake which contained a flock of moulting geese. As with Ptarmigan kills, there were no carcass remains and each was attributable to Fox predation by the distinctive bitten-off ends of the tail and flight feathers. In early May the skull and several neck vertebrae of a female goose were found close to an old nest in Goose Valley (Figure D1.6); the tip of the beak had been bitten off. Ely (1979) found a Pacific White-front's nest on the Yukon-Kuskokwim Delta at which the larger Red Fox had killed the incubating female and removed all the eggs.

In north-east Greenland the Gyrfalcon has been recorded as taking Barnacle goslings (Fletcher and Webby 1977) and hence it is extremely probable that White-fronts occasionally fall prey to the falcons in west Greenland. However, a study of prey preferences at Myvatn, Iceland (Bengston 1971) has shown that "Ptarmigan, when abundant, are the preferred prey even in areas containing excellent habitat for waterfowl" and thus it is unlikely that predation by Gyrfalcons is a major cause of goose mortality.

On 11 May a white-phase falcon flew very low across Kûk Marshes and disturbed a flock of eight feeding White-fronts. The geese appeared not to see the falcon until it was upon them; they leapt into the air and landed again almost immediately. It was thought that the falcon could very easily have struck one of the geese, and 20 minutes later it returned and flushed the flock once more without attempting to kill. It is possible that the adult geese were not attacked because they are too big to carry. Pullianen (1975) estimated that Gryfalcons could carry loads of up to 1800 g whilst nearly all fledged Greenland White-fronts weigh over 2000 g. However, inland from Sisimiut a Gyrfalcon was once seen stooping three times on a White-front on the ground. Each time the goose beat the falcon off with its wings (Preben Grossmann pers. comm.).

Two potential predators of gosling or adult White-fronts elicited a behavioural response consistent with threat. Twice an adult White-tailed Eagle flew over geese feeding on marshes. The geese flushed immediately and flew off, calling vociferously with high-pitched yelping cries. The Eagle, however, paid them no attention and continued on its way. At 10.40 hours on 6 June an adult Eagle was spotted flying along the ridge to the west of Base Camp. It was trailing a large amount of vegetation in its talons and appeared to be flying slowly but purposefully in the direction of its eyrie. It was preceded by two pairs of geese that were calling loudly and frequently. This seemed to be more of a mobbing or distraction display by the geese than an attack by the Eagle which seemed unconcerned by their presence.

The following day a similar encounter was observed as an Eagle flew towards its eyrie from the Cornerstone. On this occasion only one pair of geese flew in front of it, yelping, while it was mobbed more conventionally by a Raven. Although the Greenland White-front has not been recorded as a prey species for the White-tailed Eagle, the raptor is doubtless capable of taking such large prey and it is known that birds form between 4.6 and 5.6% of its summer diet (Wille 1978, 1979).

Observations of the reactionsof breeding geese to Ravens are discussed in section D7, but in addition, there were two occasions when adult geese strongly reacted to their presence. On 28 May the gander of the study pair (section D6) was followed in the air over Upper Marsh by two Ravens. It appears that he deliberately led them away from the general area of the nest and flew down to George Eliot where they continued to follow him for about 15 minutes, until he landed on the marsh. On 24 May five geese on Kûk Marshes flushed in panic when a Raven flew past at a distance of 50 m. This response is inexplicable. Inglis (1977) recorded that, in Iceland "Ravens usually elicit little response from the geese they fly over" and Meltofte *et al.* (1980) observed no interference with Pink-footed Geese by Ravens.

Three species which are potential predators of White-fronted goslings were not observed to interfere with the geese in Eqalungmiut Nunât. Great Black-backed Gulls (section E23) and Snowy Owls (section E25) are casual visitors to the region and can thus be regarded as only incidental predators. Peregrine Falcons arrive in west Greenland around the egg-laying period of the geese. Their breeding cycle is timed such that the eyasses hatch when passerine nestlings are fledged in the first week of July. The adults are thus required to increase their hunting activity at a time when White-front goslings are vulnerable to attack. Peregrines are considered to be capable of catching prey of up to 1800 g (Cramp and Simmons 1979; pp 361-378), enabling them to catch almost full grown goslings. However, there were no observations of Peregrines interferring with goose families and we can assume that the high density of Lapland Buntings (section E34) ensures that they provide the major part of the falcons' diet. None of the goose families under observation was noted to lose any goslings during the summer.

OTHER DISTURBANCES

Human pressure on the Greenland White-front have, in the past, probably been heavy but local on the breeding grounds and recent conservation measures have been designed to reduce this considerably. Previously the Greenlanders collected eggs, mainly from the nests close to coastal settlements, and also rounded up goslings for fattening. It is now illegal to indulge in either of these practices although, as Ruttledge and Ogilvie (1979) point out, enforcement is extremely difficult in such a vast, sparsely populated country.

Breeding pairs are now completely protected, but the current hunting legislation allows geese to be shot from flocks consisting of more than six birds at any time. This enables hunters to shoot at flocks of non-breeders and families of more than five goslings throughout the summer. The dates of the open season when all geese can be shot vary annually, but in recent years they have been such as to allow shooting on both migrations.

Contrary to the belief of Ruttledge and Ogilvie (1979) the White-fronts are shot during their spring migration in Greenland. At Sisimiut where they arrive in the first week of May, an estimated total of 150 - 190 have been shot in the four seasons 1977 - 1980 (Preben Grossmann pers. comm.), whilst at Søndre Strømfjord Air Base about 60 geese are shot each spring (Steen Malmquist pers. comm.). However, there was no known shooting of White-fronts in Eqalungmiut Nunât during 1979, indeed, the Greenlandic hunting party found the idea of shooting geese quite ludicrous when Caribou were so plentiful (section C20). It appears that different settlements have traditional quarry species and the White-front is shot mainly by hunters in the north of the Caribou's range. The settlement of Ikamiut near Sydostbugten, Disko Bugt is the most southerly from which we have been able to ascertain that numbers of geese are traditionally being shot for food. The midden at Kûk Marshes (section F4) contained bones from at least four White-fronts but these were sub-fossils and date from many years previously.

Whereas direct losses from hunting may be decreasing in Greenland it is likely that the goose population is experiencing increased losses from disturbance. Hannibal Fencker (pers. comm.) reports that at Sarqaqdalen, Nuggsuaq, an area once considered to have held a high density of breeding geese, there has been a recent significant decline. He attributes this to increased disturbance from helicopters as west Greenland undergoes a boom in tourism and general improvement of air communications. Helicopters and low-flying planes are "extremely disturbing" to European White-fronts on the wintering grounds (Owen 1973) and low-flying aircraft undoubtedly cause great disturbance amongst the small wintering flock of Greenland White-fronts on the Dyfi Estuary, Wales (see section A2). Helicopters were a regular sight in Eqalungmiut Nunât with one or two passing daily from Søndre Strømfjord Air Base to Âusiât throughout May and June. In early July, however, there was a marked increase in helicopter traffic which lasted until the completion of the study in mid-August. It is difficult to know what effect this has on the geese, but nesting birds were observed to be extremely alert whenever helicopters passed over (section D7).

Owen (1978) has commented on the low-level of production of the Greenland White-fronted Goose and considers that the high average brood size means that the limitation is on the number of geese successfully breeding rather than on their success rate. "The most likely reasons seem to be a limitation on suitable breeding sites, possibly coupled with egg-collecting in Greenland." While this may be true on the coast, inland, where egg-collecting does not occur, it seems that the predation rate is high and there appear to be many suitable sites unoccupied.

It is tempting to draw parallels between the gradual decline of the Greenland White-front population and the noticeable increase of breeding Ravens in continental west Greenland. Steen Malmquist (pers. comm.) is in no doubt that there has been a significant increase in the number of Ravens breeding in this region over the last twenty years, which may be due to supplementary feeding at the Søndre Strømfjord Air Base rubbish dump reducing winter mortality. The Raven is undoubtedly a successful predator of goose eggs, particularly in the early nesting stages, and the distribution of Raven sightings in Eqalungmiut Nunât (section E28) was closely linked with the distribution of breeding geese. It is also most probable that the Raven has the greatest success with inexperienced nesters and hence those successfully breeding will be older birds with a large clutch size. This would result in the large brood sizes noted in winter (Owen 1978). Whilst the increase in the Raven population should not be taken as the sole factor contributing to the White-front decline (see also section D15), the link between the population trends of the two species should be an important component of any future study of the breeding biology of the geese.



D4 NESTS AND NEST SITE SELECTION

D. A. Stroud

Abstract

Nests were found in a wide range of habitats, but all were close to lowland or mid-altitude (<300 m) marshes particularly those containing Eriophorum angustifolium. Such marshes appear to be of great importance for the feeding of geese during incubation and there was no shortage of them, but although three nests were found near one marsh only one of these was ultimately successful. Some nests appear to be traditional, and distinct layers could be made out in their construction, probably indicating material from previous years. Nests were made from dead vegetation available in the immediate vicinity and lined with grass and down, and were placed in positions that would give the incubating female good all-round views of the surrounding terrain.

INTRODUCTION

In his study of the breeding biology of the geese on the Nûgssuaq Peninsula, Fencker (1950) found that the nests were situated on the tops of small hills or gently sloping hillsides. They were always in the vicinity of a lake or 'marshy' valley, but not on lake shores or in 'moist' valleys. The nests were made of leaves or dried grass with down lining, and placed on small tussocks of 'heather' or grass. Fencker thought that an important factor influencing nest site selection was the need for good all-round views so that approaching predators could easily be seen.

RESULTS

We found placings similar to those suggested by Fencker, but in a much wider range of habitats. The main nest site details are shown in Table D4.1 and Figure D1.6. Seven occupied nests were found between 19 May and 24 June. One nest from a previous season was also found. Most of the occupied nests were found by flushing the incubating female, although one nest, at Rimwater Marsh, was discovered when the sitting female was seen with a telescope at a distance of half a kilometre. The Moraine Nest was found by accident when the female was absent, although two hours later she was sitting.

TABLE D4.1. Details of Goose nests found in Eqalungmiut Nunât, 1979.

SITE	LOCATION	VEGETATION	APPROX. DIST. FROM OPEN WATER	APPROX. ALTITUDE
False Eyrie Crag	Heath-herb slope	*Calamagrostis*-herb slope	400 m+	300 m
Ímajuitsoq	Ledge on steep north facing slope	*Empetrum*-moss mat and grass	50 m	100 m
Base Camp 1	Edge of marsh	Marsh/grass-herb	40 m	250 m
Base Camp 2	Grass slope	*Salix* in grass-herb slope	300 m	250 m
Base Camp 3	Hummock on grass slope	Grass-herb mat	50 m	250 m
Pass of Jennings Dunes	Peninsula in lake	Grass-*Carex*-*Salix*	2.6 m	50 m
Moraine Nest	Alongside valley sandur	Sand and boulders	20 m	250 m
Rimwater Marsh	Marsh, *Carex rariflora*, *Salix arctophila*, *Eriophorum* spp.	*Empetrum*-*Carex* hummock	0.2 m	450 m

DESCRIPTIONS OF NEST SITES

False Eyrie Crag

This nest, from a previous season, was on the south-facing slopes above George Eliot, scattered over an area by an Arctic Fox. About 10 m away the skull and neck of an adult goose was found with the tip of the bill bitten off suggesting Fox predation.

Ímajuitsoq

The northern side of Ímajuitsoq was near-vertical cliff. At the cliff base was steep vegetated talus and rock-fall extending up the cliffs for about 100 m in places. The 'nest', on a narrow ledge (possibly an old Caribou trail) about 40 m above the lake at the top of this 50-60°slope, was just a scrape in the tussocky turf. There was no down or other constructional material. The slope had more than 90% vegetation cover, mainly *Empetrum nigrum*, moss, Gramineae and the lichen *Peltigera apthosa*.

Pass of Jennings Dunes

The nest was situated near the end of the Pass of Jennings. The lake was on a broad terrace of relic sandur (fluvioglacial sediments) about 20 m above the presently active surface. Jutting into the lake was a 7 m wide peninsula as was present in most lakes in this area. These seemed to be favoured wildfowl nesting sites, and it was on the end of one of them that the goose had nested (Figure D4.1). The stream inflow near the nest resulted in a marshy area just above the lake containing much *Eriophorum angustifolium*. There were extensive growths of *Menyanthes trifoliata* and *Hippuris vulgaris* in the bay enclosed by the peninsula and in July these matted on the surface to produce a green cover. The closest distance to the water was only 2.6 m.

The vegetation around the nest consisted mainly of Gramineae, *Salix glauca* and *Luzula* spp., with *Aulacomnium palustre* dominating the ground layer. The nest commanded a good all round view of the lake, particularly in early June before the 10 cm high willow came into leaf.

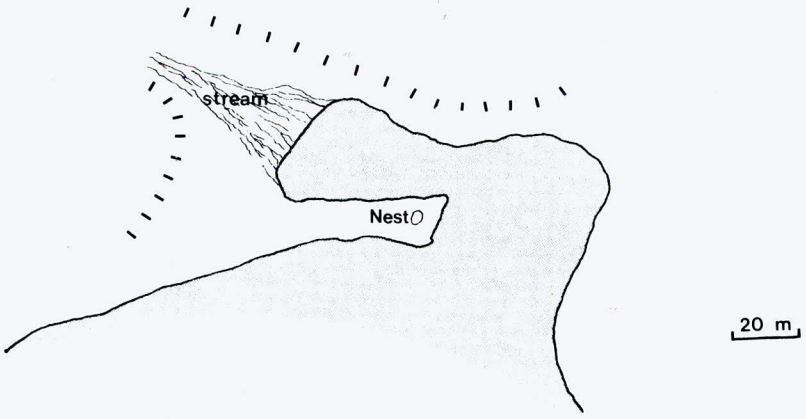


Figure D4.1. Plan of Pass of Jennings Dunes nest site.

Rimwater Marsh

The southern side of Rimwater Marsh was a mosaic of small pools, probably the course of an old stream. The vegetation was very similar to that of Upper Marsh (section 11), dominated by *Salix arctophila*, *Polytrichum* spp., *Carex rariflora*, *Eriophorum angustifolium*, *Luzula confusa* and *Sphagnum squarrosum*. In the very wet areas near the nest hummock there were almost pure stands of *Carex rariflora*. The nest itself was placed in a bowl shaped hollow on the top of a natural hummock, about 20 cm above water level (Figure D4.2).

The vegetation of the hummock was mainly *Polytrichum* spp. and *Salix arctophila* with *Vaccinium*. On the steep (south-facing) side there grew almost pure *Empetrum nigrum*, with an abundance of *Carex rariflora* and a little *Eriophorum angustifolium* and *Luzula* spp. around the edges. Between the two visits of 27 June and 1 July there had been prolonged rain, raising the water level of the marsh and enlarging the pools, but without endangering the nest.

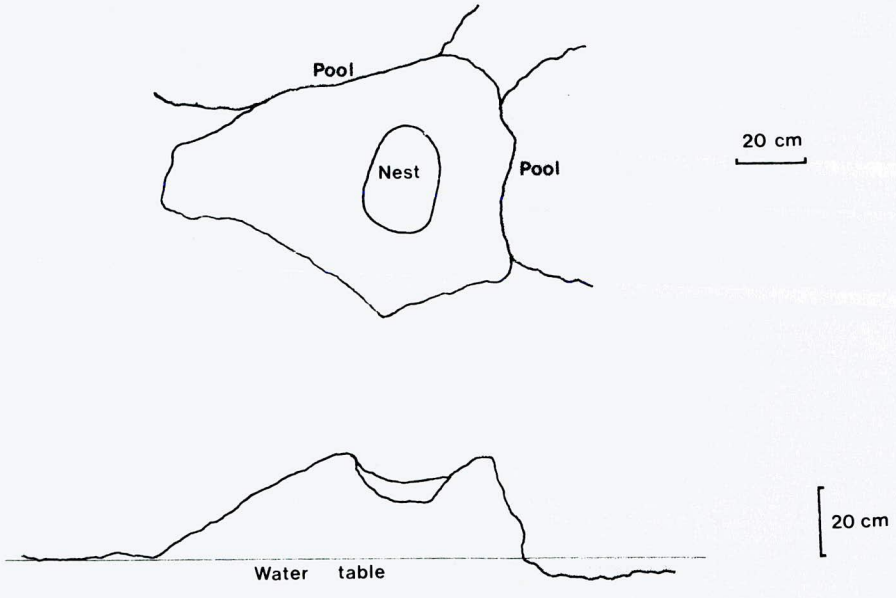


Figure D4.2. Plan of Rimwater Marsh nest site.

Base Camp 1

The nest was at the edge of Upper Marsh in an area of 10 cm high hummocks. During May and June the vegetation consisted almost entirely of dead dried grass, mainly *Calamagrostis purpurescens*, with dead herbs (*Draba glabella* and *Stellaria longipes* particularly) and *Peltigera apthosa* amongst moss. The new season's growth was apparent only after the goose had left the nest. The nest was in a transitional zone between the drier, drained slopes of Observation Hill (grass-herb slope, often with extensive patches of heath), and was so placed as to command a good view over the whole marsh.

Base Camp 2

The nest was placed in a small clump of *Salix glauca* on the west-facing grass-herb slopes below DZ Marsh. The shrub was about 20 cm high, and although not in leaf, may have served to conceal the goose when sitting. The nearest suitable feeding for the male would have been either DZ Marsh or the east end of George Eliot, both about 1 km away. The system draining DZ Marsh was about 400 m away but was swift flowing and contained no *Eriophorum* or other food plants.

Base Camp 3

Between Upper Marsh and the *Salix glauca* thickets on the south-facing slopes below the peak 504 m there were several small moraine deposits. The nest was on the top of a small hummock at the base of one of these. There was no standing water within about 50 m of the nest, although there was a damp mossy patch about 20 m away. Otherwise the surrounding vegetation was grass-herb slope. The edge of the nest had mossy surrounds, and later in the season the hummock had many of the characteristic herbs of such locations (e.g. *Draba glabella, Stellaria longipes, Campanula gieseckiana*) growing on it. However at the time of incubation, the hummock was covered only with moss (mainly *Aulacomnium turgidum*), *Peltigera aphthosa*, *Betula nana* and grass litter. The marsh was about 1 km west of Upper Marsh, where the male possibly fed during the time the nest was occupied.

Moraine Nest

This nest was situated in an unusual area, on a small sub-terrace below a main moraine terrace alongside a valley sandur. The sandy flat ground was strewn with boulders (20 - 100 cm diameter) and there was sparse vegetation (20% cover) of *Betula nana* and *Vaccinium uliginosum* with a little grass. However most of the area around the nest was bare sand. The nest was about 4 m above water level and 20 m from the edge. Despite likely fluctuations in level there would have been no risk of flooding.

There was no suitable feeding marsh for the male on the same side of the river as the nest for at least 1 km. The water near the nest could not be crossed by us, and it is possible that the male was feeding at a nearer site on the other side. Pairs of both Gyrfalcon and Peregrine were breeding near the nest. A high cliff perch regularly used by white phase Gyrfalcons of both sexes overlooked the goose's nest, being only about 200 m away on the face of a 100 m cliff. The degree to which any protection accrued to the geese from the presence of the falcons deterring other predators is uncertain; an Arctic Fox was seen at least as close to the Gyrfalcon eyrie as was the goose's nest without eliciting any response from the Gyrfalcons. Elsewhere Ravens nested on a cliff about 100 m from a Gyrfalcon eyrie but no interaction between the two species was seen during several hours of observation over four days. At a distance of 700 m from the Peregrine eyrie, the goose's nest would lie at the extreme periphery of Cade's (1960) "less vigorously defended" territorial zone, or would be outside it altogether. However, whilst the proximity of the goose's nest to these raptors is probably coincidental, the habitat and location were atypical, both according to Fencker's (1950) observations and to other nests we found.

CONSTRUCTION OF NESTS

All nests, except that at Ímajuitsoq, were of a similar construction. The body of the nest was made of dead vegetation available in the immediate vicinity, in most cases dried grass litter of the previous season, this being by far the most important nest material. However occasionally other material was used as well, for instance *Salix glauca* twigs at the Pass of Jennings Dunes nest. Nests were added to by the female during incubation and by hatching there was an obvious green circle about 30 cm radius around most nests in grassland, caused by the female plucking dead grass from the immediate area around the nest (as far as she could stretch) so exposing the new season's growth underneath. Nests were lined with down, which also was added to during incubation, the amount varying between nests.

Close inspection of some nests (Table D4.2) revealed several layers of nest materials, indicating that they had been used in previous years. In some cases the layers were conspicuous, particularly the rotten down separating them. In other cases, and towards the base of the nest, it became more difficult to distinguish the material of different years.

TABLE D4.2. Construction of nests.

NEST	LAYERS PRESENT IN NEST	CUP DEPTH (cm)	CUP WIDTH (cm)
Ímajuitsoq	No	2.0	20
Pass of Jennings	Yes (3+)	5.3	13.2
Rimwater Marsh	Yes	6.0	21 x 20
Base Camp 1	Yes	-	-
Base Camp 2	?	2.7	c.12
Base Camp 3	Yes	-	-
Moraine nest	?	6.0	30

DISCUSSION

Fencker's (1950) emphasis of the importance of nest sites with good all-round views to guard against predators was supported; but this consideration only affects the local siting of a nest, and does not determine the habitat in which it is placed.

The most important factor seems to be the presence of a nearby marsh containing particularly *Eriophorum* spp., on which the female, and more importantly the male, can feed during incubation. Until late June and July the only such thawed marshes tended to be in the lowland areas below about 250 m, but there were possibly others at higher altitude where, due to the local topography the thaw was sufficiently advanced. The maximum acceptable distance of a nest from a feeding area could not be estimated because only two pairs were studied in detail. However the males of Base Camp 2 and Base Camp 3 were likely to have fed on Upper Marsh (Figure D1.6) about 1 km away, whereas at the Moraine nest the distance may have been greater.

The spacing of nests is also affected by the need to be near marsh vegetation since the marshes are usually well spaced and are not continuous over large areas. So few nests were found that calculations of minimum distances from other nests is not really meaningful, however this factor may have some impact on nest site selection. A further discussion of aspects of nest site selection relating to the behaviour of the geese is to be found in section D6. Ely (1979) found that the Pacific White-fronted Goose showed no habitat preference, and nested in "upland" and "lowland" areas in proportion to their availability. However those terms as used in his study are in no way comparable to those used in this report.

The Greenland White-fronts nesting inland face few of the threats with which Pacific White-fronts nesting on the Yukon-Kushokwim Delta have to contend (i.e. flooding due to exceptional tides, large numbers of skuas as avian predators, and Red Foxes and Wolves as mammalian predators). Thus some of the pressures on nest site selection will be different or of lesser importance. However flooding due to spring thaw is obviously important because of nests usually being raised above the surrounding water table either on a hummock (as at Rimwater Marsh) or well away from the main water table channels (as at Base Camp 1). Only at Pass of Jennings Dunes did there appear to be any risk of flooding, but this may have been more apparent than real due to the drainage of the lake in question. Unlike Ely (1979) we found little evidence to show that Greenland White-fronts chose nest sites with substantial vegetation cover; this may reflect fewer avian and terrestrial predators.

In response to Arctic Fox predation the Greenland White-front shows concealed breeding of the type described by Larson (1960). This involves nesting in relatively open areas but having protective plumage colouration and behavioural adaptations such as sitting very tight in the presence of a predator.

In general our findings agree with the statement of Newton (1977) that arctic geese usually nest "in habitats which differ from, but are adjacent to, good feeding areas".

Nests found were constructed in similar fashion to those reported elsewhere (Ely 1979; Mickleson 1975). The nest site at Imajuitsoq corresponds to nests found in Alaska "which had just been initiated (i.e. contained one egg and no down or contour feathers); in each case the vegetation had been parted and trampled to bare earth with proximal plants built up around this scrape. Except for the presence of an egg in these scrapes, they would not have been recognisable as nests." Ely (*loc. cit.*).



D5 BREEDING BIOLOGY OF THE GREENLAND WHITE-FRONTED GOOSE

D. A. Stroud

Abstract

Clutch initiation was observed over the period 19-24 June with a peak in the middle of this period. The incubation period of one nest was 25 days. Of seven active nests found, two hatched successfully, three failed due to predation and/or desertion, and the outcome of the remaining two was not determined. Hatching dates at the successful nests were 22 June and 27 June. The clutch size of two nests was one egg, while five nests each contained six eggs (overall mean = 4.57 ± 0.918). There was no obvious shortage of nest sites, or other physical factors limiting breeding numbers or success of nesting White-fronts. Data on egg sizes and weights are presented.

INTRODUCTION

The only published details of the breeding biology of the Greenland White-fronted Goose are those made by Hannibal Fencker (1950) in Sarqaqdalen on the Nâgssuaq Peninsula; 70°06'N, 57°08'W. Fencker found that after arrival of the geese in early May there was a period of feeding before the first eggs were laid between 20 and 28 May. One egg was laid each morning until the clutch of 5 - 7 was complete. During the egg-laying period the geese left the nest during the day, and usually covered the eggs before departure. Incubation started when the clutch was complete and lasted between 22 and 23 days. Immediately after hatching the young were led away from the nest and taken to a lake or nearby valley.

RESULTS

Our findings confirm Fencker's observations to a large extent, but we found a longer incubation period, more in line with those reported from other races of White-fronted Geese. The main details of the seven active nests found in 1979 are given in Table D5.1. Most clutches were initiated in the period 19 - 24 June, approximately 15 days after the first arrivals were seen.

TABLE D5.1. Nest details of Greenland White-fronted Geese, Eqalungmiut Nunât, 1979.

SITE	PROBABLE DATE CLUTCH STARTED	EGGS LAID	DATE OF FAILURE	DATE OF HATCH AND NUMBER
Ímajuitsoq	19 May	1	20 May	0
Base Camp 1	22 May	6		5 (22 June)
Base Camp 2	22 May	6	1 June	0
Base Camp 3	24 May	6	31 May - 3 June	0
Pass of Jennings Dunes	?	1		? (24 June - 4 July?)
Moraine nest	?	6		?
Rimwater Marsh	27 May	6		5 (27 June)
(Axewater chick)	?	1 ?		1 ? (21 June)

Incubation Period

The only nest from which it is possible to estimate the incubation period was Base Camp 1. On May 27 at 16.30 hours five eggs were present, and on May 28 by 13.10 hours six eggs had been laid. During 27 and 28 May the female was observed sitting on the nest, which does not agree with Fencker's observation that the female starts to sit only when the whole clutch has been laid. It is possible that it starts with the penultimate egg (as in many goose species (Ogilvie 1978)) if the clutch is large (Newton 1977). If the incubation period is taken as starting on 27 May, then it lasts 25 days, hatching having taken place in the early hours of 22 June, in comparison with the 22-23 day estimate of Fencker (1950) and Salomonsen (1950a). Other estimates for *A. a. flavirostris* are 27 - 28 days (Cramp and Simmons 1977), 26 - 27 days (Ogilvie 1978); for *A. a. albifrons*, 27 - 28 days (Dementiev and Gladkov 1952); for *A. a. frontalis*, 24 - 28 days (Mickleson 1975), 25 - 27 days (Ely 1979); and for *A. a. gambelli*, 26 - 28 days (Palmer 1976).

Hatching Success

The hatch was witnessed at two nests, Base Camp 1 and Rimwater Marsh. At both of these, six eggs were laid of which only five hatched. The first gosling at Base Camp 1 was seen in the early hours of 22 June and by 10.00 hours all five had emerged. The Axewater chick was likewise seen early on 22 June and had probably hatched the day before. The nest at Rimwater Marsh was visited at 14.00 hours on 27 June when two of the eggs were chipping. The nest at the Pass of Jennings Dunes had a single egg which was present on 24 June but there was no sign of egg-shell, gosling, or adults on 4 July. The success of the nest is not known. The Moraine nest was not revisited. The nests of Base Camp 2 and Base Camp 3 together with Ímajuitsoq were either deserted or predated and are discussed in section D3.

TABLE D5.2. Egg morphometrics of Greenland White-fronted Geese in Eqalungmiut Nunât, 1979.

DATE	NEST	WEIGHT (g)	LENGTH (mm)	BREADTH (mm)	CLUTCH	HATCHED
19 May	Ímajuitsoq	-	-	-	1	0
28 May	Base Camp 1	108	75.65	50.70	6	5
		114	76.00	51.35		
		115	77.70	51.90		
		116	78.00	51.80		
		116	76.00	53.95		
		122	80.30	52.50		
28 May	Base Camp 2	101	75.50	48.70	6	0
		102	73.70	50.30		
		102	73.20	49.90		
		103	75.50	50.40		
		111	76.50	51.60		
		(122)	80.40	52.45		
30 May	Base Camp 3	106	-	-	6	0
		120	-	-		
		121	-	-		
		126	-	-		
		127	-	-		
		128	-	-		
16 June	Moraine nest	-	-	-	6	?
18 June	Pass of Jennings Dunes	(101)	71.35	50.70	1	?
18 June	"	96				
24 June	"	93				
26 June	Rimwater Marsh	(121)	77.60	53.00	6	5
		(134)	79.40	55.20		
		(156)	80.00	59.20		
		(131)	80.50	54.20		
		(140)	81.30	55.60		
		(133)	81.65	54.15		
	MEAN	119.04	77.38	52.50	4.57	
	STANDARD ERROR	2.73	0.669	0.564	0.918	

Calculated egg weights shown in round brackets - see text.

Egg Measurements

Measurements from eggs are shown in Table D5.2 and plotted in Figure D5.1. Fresh egg weights have been calculated from those eggs weighed late in incubation (Pass of Jennings Dunes and Rimwater Marsh) using the formulae Weight (g) = $K_w.LB^2$ (Hoyt 1979), where K_w = weight coefficient, and L and B are length and breadth (in cm). The weight coefficient of 0.556 was used, as also by Ely (1979). There is a significant difference between the weights of this sample and the weights of 100 eggs from captive birds of this race laid at Slimbridge ($\bar{x}$ = 123.7; SE = 0.668; t_{116} = 22.597; $P < 0.05$; J. Kear pers. comm.). This may be because captive birds are receiving a more nutritious diet than wild geese, or alternatively the captive sample may be biased towards eggs from older birds since mature geese are known to lay heavier eggs in some species (Brakhage 1965). This relationship between egg weight is suggested for this race by the wide range of total clutch weights (clutchs of six: 641, 691, 728 and 815 g).

The mean clutch size of 4.57 compares with 4.53 of 77 broods over four years for *A. a. frontalis* (Mickleson 1975) and 4.7 of 67 broods over two years (Ely 1979). However the Ímajuitsoq nest was predated before clutch completion, whilst the Pass of Jennings Dunes nest may have been partially predated before it was found; thus a mode of six eggs per nest is probably a more meaningful measure of production.

Cramp and Simmons (1977) state that there are no significant differences between the eggs of the races *flavirostris* and *albifrons*. Other egg measurements are given in Table D5.3.

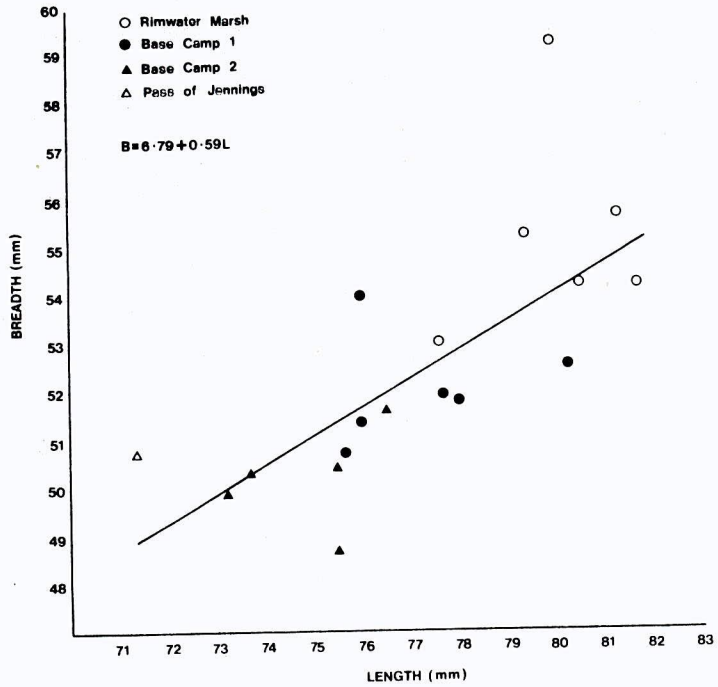


Figure D5.1. Egg measurements of Greenland White-fronted Geese.

TABLE D5.3. Comparative egg morphometrics of White-fronted Geese.

RACE	WEIGHT (g) MEAN	WEIGHT (g) RANGE	LENGTH (mm) MEAN	LENGTH (mm) RANGE	BREADTH (mm) MEAN	BREADTH (mm) RANGE	SAMPLE SIZE
A.a.albifrons							
Schönwetter (1967)			79	72-89	53	47-59	120
Kear (a)	114	97-126					51
Alpheraky (1905)	110	100-125					20
Alpheraky (1905)			81	76-88	54	49-58	24
A.a.frontalis							
Ely (1979)	127.8 ± 2.65		80.1	71-87	53.5	49-58	313
A.a.flavirostris							
Schiøler (1925)			79.5		52.3		17
Kear (pers. comm.)	123.7	108-136.5					100
This study	119.0	101-156					25
			77.4	71-82	52.5	49-59	19

Kear (a) quoted in Cramp and Simmons (1977)

Factors limiting numbers nesting

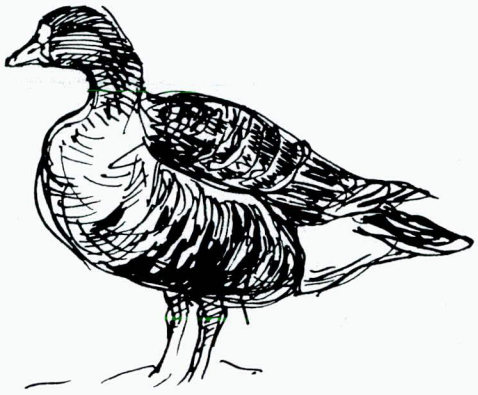
Owen (1978) discussing the population dynamics of Greenland White-fronts shows that the population has a very low productivity. Whilst the brood sizes are usually high an exceptionally low proportion of mature adults breeds in any year, probably less than 20%. The average proportion of young in the autumn population is17.8% and the mean brood size 3.3. "This represents a recruitment of some 2 650 birds per year, and an average of 810 successful breeding pairs, out of a population taken as 15 000" (Ruttledge and Ogilvie 1979). In wildfowl collections, Greenland White-fronts successfully lay in their second summer, but it is unlikely that they breed until their third or fourth summer in the wild bearing in mind the above and previous studies on *A. a. frontalis* (especially Ely 1979). Thus the inference is that there is either some social factor limiting the number of successful breeding pairs, or a lack of suitable nest sites.

The geese nest close to feeding marshes, and it seems that this is the main requirement of nest site selection. Whilst the birds are not highly territorial no marsh was found with more than one successful nest and it is probable that each nest is located near its own marsh. However there were many marshes which seemed suitable which did not have nesting geese nearby, even though some of these had even had geese present before nesting began. Thus, in Eqalungmiut Nunât at least, lack of suitable nesting areas would not seem to be a cause of low productivity. We have no information to suggest whether or not social factors may influence the proportion of mature adults breeding.

Another possibility is that the low productivity is caused by a high predation rate. This question is considered in more detail in section D3, but it should be noted that it is difficult to draw many conclusions from our predation observations when it is not known how much affect we were having in influencing predators. Nonetheless, of the seven nests found, three were predated, two hatched successfully, and the fate of the remaining two was undetermined.

Boyd (1966) found a highly significant negative correlation between July rainfall (i.e. immediately post-hatching) near the breeding areas of *A. a. albifrons* and mean brood size the following winter. He attributed this to the newly hatched young being highly susceptable to chilling. Although these results have not been found in other, more direct, investigations of gosling mortality (see Owen 1980; p. 170), it is interesting that in west Greenland July has the highest monthly rainfall of the year (Danske Meterologisk Institut 1978a, 1978b) and in 1979 Eqalungmiut Nunât had a prolonged spell of sleet, snow and rain throughout early July (section J1). This may affect goslings in the way that Boyd envisages, although the effect will be to reduce the mean brood size rather than the proportion of adults breeding, the major cause of the low productivity in this population.

Other aspects of White-front breeding biology are presented and discussed in section D6 and the summer strategy of the geese is discussed in section D15 together with a consideration of other factors possibly limiting the population.



D6

BREEDING BEHAVIOUR OF THE GREENLAND WHITE-FRONTED GOOSE

D. A. Stroud

Abstract

A behavioural study during the incubation and immediately post-hatching period of two Greenland White-front nests is reported totalling nearly 500 hours of continuous observation. At the time of clutch completion the male stood a few metres from the nest but then later moved away and spent most of the rest of incubation feeding on a nearby marsh. At hatching he moved back closer again. Both sexes show strong diurnal activity cycles, being most alert at that time of day when there are most predators active. The significance of these cycles is discussed with reference to other arctic diurnal cycles. The male showed a significant increase in time spent vigilant over the incubation period which affected the time apportioned to other activities such as grazing. The female left the nest roughly once a day at a constant time (of low predator abundance) and for a constant period; however, the frequency of these recesses increased throughout incubation. At the time of hatch both sexes markedly changed their behavioural patterns, the male becoming much more attentive which allowed the female to spend longer feeding. The significance of this change-over and the presence of an immature goose associated with one nesting pair is discussed. The results of the study are compared with previous work undertaken on the colonially nesting Pink-footed Goose, and some of the factors responsible for determining the solitary breeding dispersal of arctic geese are discussed in the light of the results.

INTRODUCTION

There has been no detailed study of the breeding behaviour of the White-fronted Goose although Fencker (1950), Salomonsen (1950a) and Mickleson (1975) all make passing reference in their works. More recently Ely (1979) has discussed many aspects of White-front behaviour as they relate to breeding, although this work is primarily concerned with the relationships between spring phenology, nesting chronology and productivity of the nesting Pacific White-fronts. Knowledge of White-front breeding behaviour prior to the latter study is summarised in Cramp and Simmons (1977: p. 407). When planning the expedition it was felt that a quantitative study of the behaviour of incubating geese would be of value especially if a comparison could be made with the breeding behaviour of the Pink-footed Goose (Inglis 1977, Lazarus and Inglis 1978). (In order to avoid repetitious references to the work of Inglis on the Icelandic Pink-footed Goose, for the rest of this section all details of the breeding behaviour of this species are taken from Inglis (1977) unless otherwise stated).

As a generalisation there seem to be three nesting strategies adopted by arctic geese. The first is that of colonial or high density nesting shown by many species (including Pink-footed Goose, Snow Goose, Ross's Goose, Barnacle Goose and Brent Goose). There seem to be many reasons for adopting this strategy but the main ones are either a reduction in predation, or topographic (e.g., at Thjórsárver in Iceland, ice-cap drainage creates an oasis in the central Icelandic desert, providing large feeding grounds for goose families after hatching). Although a colony of geese, or other birds, may tend to attract predators, the relative predation rate for any pair in a colony is less than it would be if they nested solitarily. The second strategy, which is probably a special case of the first, is that shown by the Red-breasted Goose. This goose nests commensally near to nests of the Peregrine where it seems to gain protection from other predators by the territoriality of the falcon. The Peregrine keeps Arctic Foxes and other predators away from its own nest, and although the Red-breasted Geese run a slight risk from the Peregrines this is evidently more than outweighed by the advantages. Here, nesting geese gain protection from predation by association with another species rather than with more individuals of the same species in a colony (Krechmar and Leonovitch 1967). The final breeding strategy is that of dispersed or solitary breeding. This is shown to various degrees by White-fronted Goose, Bean Goose, Lesser White-fronted Goose, Emperor Goose and some races of Canada Goose. In this strategy defence against predators is achieved both by camouflaged plumage and by nests being widely separated, such that if a predator finds one nest this does not increase the chance of finding another. Association with other pairs is risky since it enhances the chances of the nest being located.

It is obvious that there will be differences in the behaviour of colonial and solitary nesting geese. Colonial nesters defend a territory immediately around the nest from which the geese derive most of their food during the incubation period (see Ryder 1975; Inglis 1976; Mineau and Cooke 1979; Owen and Wells 1979 for theories concerning the evolution of territory size in colonial geese). Solitary breeders do not seem to have the same 'necessity' for a defended feeding territory so their behaviour towards other geese is different. Response to predators will probably also differ; there is no advantage to a goose in the middle of a colony in trying to hide on the approach of danger, whereas this is probably a good strategy for a dispersed nester as it reduces the chance of detection. We might therefore expect the reactions of the two geese to a predator a similar distance away to differ. By comparing the behaviour of the Greenland White-front (a solitary nester) with that of the Pink-footed Goose (a colonial nester) we hoped to identify some of these differences and see how they contributed to the success of each breeding strategy.

STUDY AREA

Site choice

Breeding pairs of Greenland White-fronts were widely separated (section D4) and found predominantly near small marshes, particularly those containing *Eriophorum angustifolium*. The distances between these meant that intensive observations could be made at only one nest site. For logistic reasons it was decided to study a pair near Base Camp, although this was less than ideal because of disturbance from the camp affecting the behaviour of the geese. However, by placing the hide here it could be manned without the need for a separate camp. Time-lapse cameras at other nests could be attended to on day-walks (section L9), and other observations made whenever possible.

Site description

The site studied - Upper Marsh - is shown in Figure D6.1. On three sides the marsh was surrounded with heath-herb slopes dominated by *Calamagrostis purpurescens*. These merged with a wetter community along the edge of the marsh, and it was in this transitional vegetation that the nest was situated. In the central regions of the marsh there was a mixture of cyperaceans and grass with pools of frozen water. There were several small moraines here surrounded by *Salix glauca* but with typical dry barren vegetation on top dominated by *Dryas integrifolia* and crustose lichens. At the west end of the marsh was an extensive area of *Salix glauca* carr growing to a height of one metre where the stream flowed across the drier moraines.

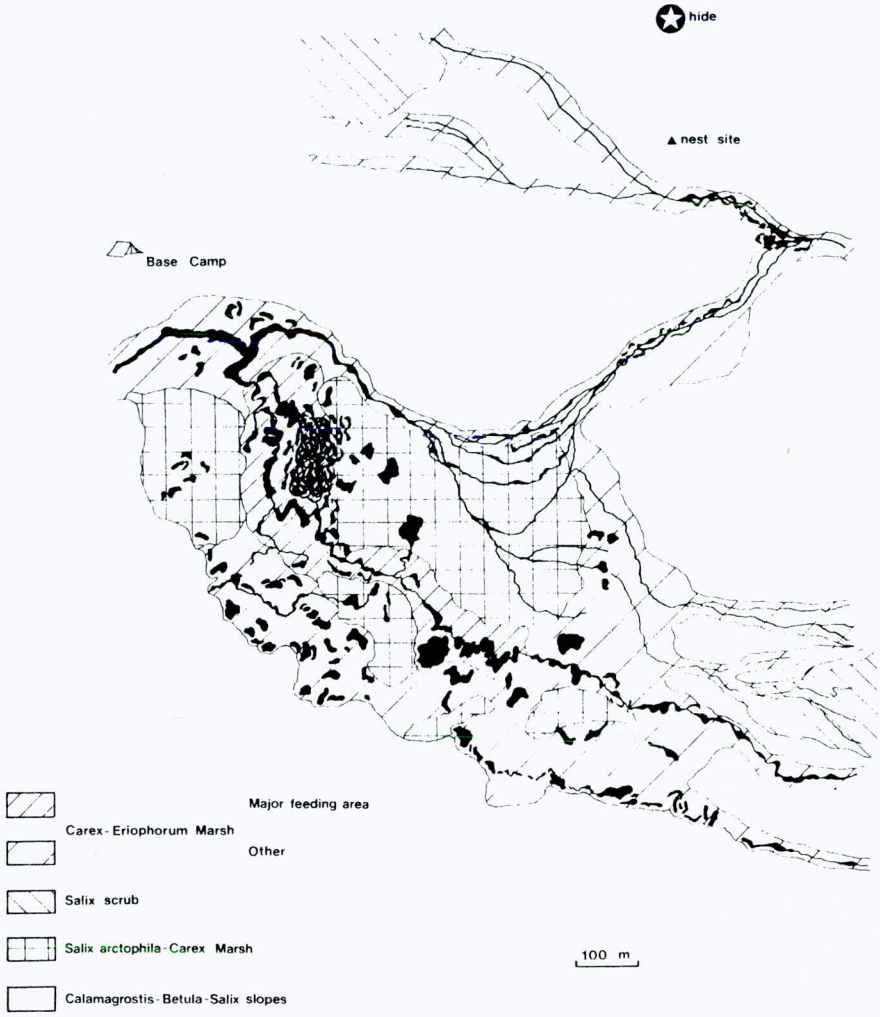


Figure D6.1. Upper Marsh study area showing vegetation types as apparent at the time of incubation. Further details on the plant communities of Upper Marsh are to be found in section D8.

The most important area for the geese was along the northern edge where the stream draining down from the plateau lakes flowed. This initially crossed the marsh in several deep channels cutting down into the underlying gravels. It braided as it flowed across the marsh and in several places lost its identity in a number of tiny streams and pools. The expedition name for the area, Thousand Islands, well describes its general appearance. The vegetation along the edges of these smaller streams was extensively grazed and large piles of roost faeces and other droppings were found here. Both *Eriophorum angustifolium* and *E. scheuchzeri* were present as were *Carex* spp., *Salix arctophila*, *Sphagnum squarrosum* and *Hippuris vulgaris*. The results of a vegetation survey of Upper Marsh and observations on seasonal changes are given in section I1. The very wet area of Upper Marsh extended for approximately 50 m on either side of the stream and thus provided an area of roughly 0.1 km^2 of potential grazing (although not all of the same quality).

Another nest, observations on which are also presented here, was located on Rimwater Marsh. The vegetation was similar to Upper Marsh but with a greater abundance of *Carex rariflora*. The nest was placed on the top of a hummock in the wettest part of the marsh, and was thus surrounded by suitable feeding.

PROCEDURE

Method of observation

Observations were made from a six foot cubic wooden hide situated 173 m from the nest (Figure D6.1). The construction of the hide is described in detail in section L7. Observations were made with a range of telescopes (usually x30 - x60) supplemented with x8 and x10 binoculars. Two telescopes were used, one trained on the nest and the other on the wandering male so that observations of both geese could be made almost simultaneously. Records were kept in logbooks, although a tape-recorder or dictaphone for when there was much activity would have been useful. Observations were made in five-hour shifts, four people being responsible for each four-day period. However, for most of the time there were five on shift duty giving a more comfortable ratio for those observing. Approach to the hide was possible without being seen from the nest. The use of time-lapse cameras is discussed in section L9.

Classification of position and behaviour

The methods used were based on Inglis (1977). Every five minutes the marsh was scanned, and the behaviour and position of the geese in relation to the nest, the Base Camp and a central moraine were recorded. The distance between these was estimated with surprising accuracy as later measurements showed. It was not possible, as had been hoped, to lay out a measured grid of stakes on the marsh since the nest was discovered only after the incubation had begun.

The behaviour of the geese was recorded as activities and postures. Activities were mainly locomotory states, and included nest building, swimming, sitting, incubating (if sitting on nest), walking, running, floating, flying and standing. Most postures were related to the position of the head and neck. The simplest of these were head on ground (defensive), head on back, head low, head up, and extreme head up (Figure D6.2). These represent an increasing level of alertness (Inglis 1977). Other postures included: graze, preen, drink, flank drink, threat, nest adjusting, egg rolling, down plucking and wing flapping. Activities and postures were recorded instantaneously (Altmann 1974) and independently of behaviour in the previous five minutes. The behaviour of the geese between scans was noted if significant.

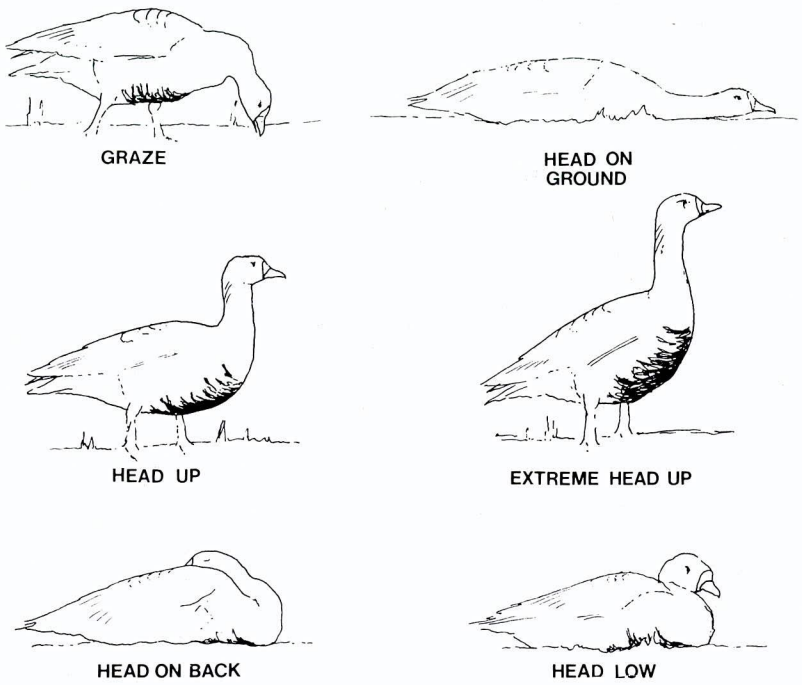


Figure D6.2. Some of the more frequent behavioural postures of White-fronted Geese (after Inglis 1977).

In retrospect, although most of the posture and activity categories were clear, a few were ambiguous. These included grazing which comprised a variety of postures and also varied according to the habitat in which the grazing took place. The pause between ingestions may have meant that grazing was under-recorded. Thus the proportion of scans when grazing was noted (e.g. Figure D6.19) was considerably less than the amount of time spent 'feeding'. The separation of head up from extreme head up was sometimes difficult since the two often merged into each other. Inglis found that extreme head up postures were associated with an upward tilt of the body axis, an extended and rigidly straight neck, and an upward angle to the beak; head up postures usually lacked two of these three features (pers. comm.). In Greenland we used just the angle of the beak to separate the postures, thus the separation was not as accurate as it might have been.

Chronology

The female was flushed from the Upper Marsh nest containing five eggs on 27 May. During the following 24 hours the nest area was kept under observation from Base Camp (and occasionally from Observation Hill), The hide was installed above the nest on the afternoon of 4 June and continuous observation commenced that evening. The nest was observed until midnight on 12 June when the hide blew away in a gale. Observations on the nest recommenced 24 hours later, although the male had been watched since noon from Base Camp. The watch finished on the evening of 22 June when the family, hatched that morning, was lost from sight as they walked away from Upper Marsh. The nest and geese were observed for 400 hours.

Observations were also made at Rimwater Marsh during the later stages of incubation and hatch. The methods used were the same as at Upper Marsh, but observations were made from the shelter of a hilltop boulder 1 km from the nest over the period 26 - 29 June.

RESULTS

Unless otherwise stated, all results and figures refer to the Upper Marsh pair of geese.

Disturbance from Base Camp

This was kept to a minimum throughout the study and scans which are known to have been affected by human disturbance have been excluded from the analysis. However, when the mean hourly distance of the male from Base Camp (the probable source of disturbance) is plotted (Figure D6.3), there is a distinct movement away from the camp in the afternoon (when disturbance would have been greatest). Thus it is possible that in some aspects the behaviour of the study pair was altered by our presence. Subjectively, the geese seemed to take little notice of us and there were many places on the marsh where the male would have been out of sight of the Camp. The presence of the male feeding less than 30 m from the Camp one afternoon suggests that his movement on the marsh may have been due to other factors, however bias from this source must unfortunately remain an unknown quantity.

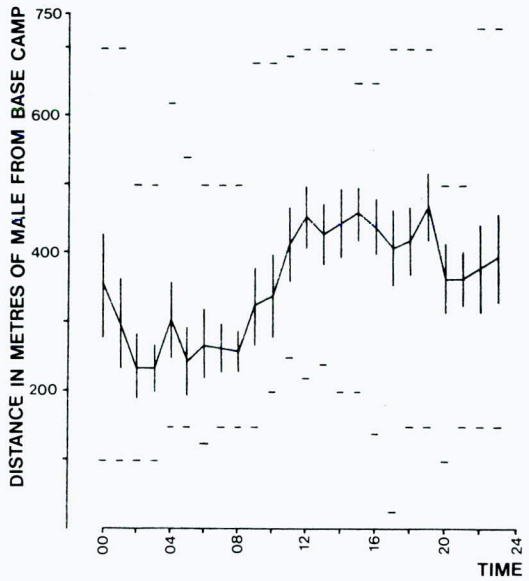


Figure D6.3. Changes in the distance of the male from Base Camp during the day. Mean distances from the camp at each half-hourly interval are shown with bars indicating standard error of mean, and the range of distances recorded at that time of day. Data from the period 5 to 21 June. The mean sample size at each half-hourly point is 10.2 ± 1.8.

Attendance of other geese on Upper Marsh

At times up to seven other geese were present on Upper Marsh with the male during the incubation period (Figures D6.4 and D6.6). As with the male, their attendance fits no obvious pattern, but tended to be more frequent between the hours of 02.00 and 10.00, and early in the incubation.

A male with distinctive belly bars (called the 'Step' male) was a frequent visitor to the marsh. It is thought that his mate was nesting nearby, although no nest was found. On 6 June he had been present in the evening for some hours before flying off and returning with his mate a few minutes later. This was at the time of day when the resident female most frequently left the nest to feed and the behaviour of the Step female was very similar to that of the Upper Marsh female during her feeding recesses. It is also interesting to note that one of the few aggressive encounters between the Step male and the resident male occurred during a visit of the Step female. Later in June the Step female was present on the marsh with her mate for some hours and it is presumed that the nesting attempt failed sometime between 6 and 9 June.

The presence of other geese on the marsh was largely tolerated by the resident bird and few aggressive encounters were witnessed. He would feed amongst them and occasionally fly with them to roost on the nearby hillside. However the geese usually came no closer to the nest than the river, at least 300 m away. The breeding pair reacted to the presence of strange geese in the immediate vicinity of the nest as if they were predators and showed more concern than if Ravens were flying at a similar distance. On three occasions when geese flew within 100 m of the nest the female rapidly adopted the extreme concealment position, head on ground (see section D7), and she was extremely wary when relaxing from this position. On two other occasions she lowered her head to her breast and remained motionless until the intruders were out of sight.

Attendance of male on Upper Marsh

Throughout the incubation period the male spent most of the time on Upper Marsh, but occasionally he was not visible. Undoubtedly this was sometimes either due to being in one of the blindspots of the marsh, but quite frequently he was seen flying away from or returning to the marsh after a genuine absence. The attendance patterns were highly variable. On 16 June for example he was seen on the marsh for 21 hours continuously, in contrast to a total of 4.5 hours on the preceeding day (Figure D6.4). His longest known absence was 13 hours between 14 and 15 June; however some of this period was during a snow storm and thus he may have been out of sight on the marsh. There is no diurnal pattern to his attendance (Figure D6.5). The male was present less frequently at about 11.00 hours and more frequently between 14.00 and 16.00 hours, but this is not a significant deviation from the mean ($t_{[47]} = 2.006$, $P = 0.05\%$).

Whenever the male was seen on the marsh he was usually within 20 m of running water near the stream on the northern side of the marsh, the only exceptions to this being when he was close to the nest, when he would stand in *Eriophorum* and tussock grass, or near to one of the muddy pools close to the nest; he rarely fed.

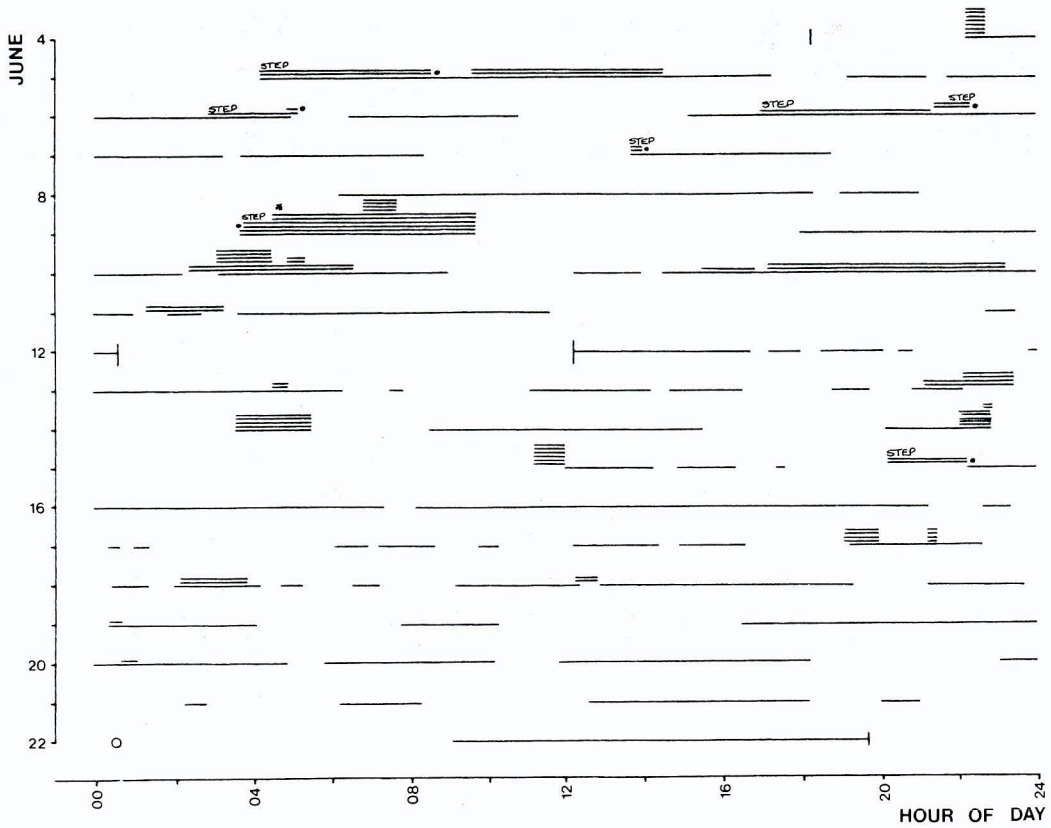


Figure D6.4. Attendance of the nesting male and other geese on Upper Marsh. Parallel lines indicate the number of other geese on the marsh (see also Figure D6.6). • indicates the female accompanying the Step male (see text). In plotting the attendance of the breeding male it has been assumed that he was present on the marsh if he was out of sight of the hide for less than 30 minutes, unless he was seen to take off or return. * indicates that all the geese were roosting on the nearby hillside 700 m from the marsh. ○ indicates the time of hatching.

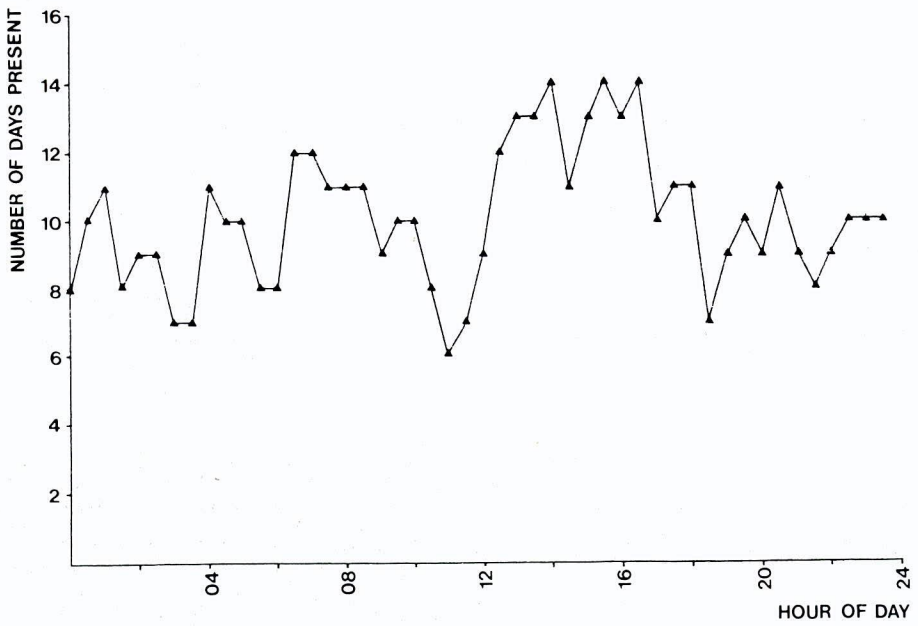


Figure D6.5. Number of days attendance on Upper Marsh by the breeding male 'sampled' at each half-hourly interval.



Figure D6.6. Presence of non-breeding geese on Upper Marsh during the incubation period shown in goose-hours per day.

The male also attempted to conceal himself on three occasions when he was visible to the observer, even adopting the head on ground posture 450 m away from the ground when a strange goose flew very close to the nest.

On 20 June an immature White-front flew back to the nest with the breeding pair after one of the female's recesses. The gander was obviously chasing the immature in the air whilst the female flew straight to the nest. All three birds landed within 30 m of the nest and the female walked straight to it and sat in a head up posture. The male rushed at the immature which was 6 m distant from him, and the latter moved away by another 7 m. Both the gander and the immature then sat head-up for one minute before the immature got up and walked away out of sight. The male walked straight to the nest, circled it once, and returned to his previous position near the nest. Twelve minutes later he took off silently and flew back to resume feeding on the far side of the marsh.

Departures of female from nest

The almost daily departure of the female from the nest, or recess (Skutch 1962), was regular in both timing and duration (Figure D6.7). On average recesses lasted 24 minutes and the majority occurred between 19.00 and 01.00 hours. The period between recesses varied from as much as 67 hours to as little as four hours. Between 4 and 11 June they occurred once every two days, but after 13 June she left the nest daily. On 20 June there were two recesses but after this she did not leave the nest until the chicks had hatched on 22 June.

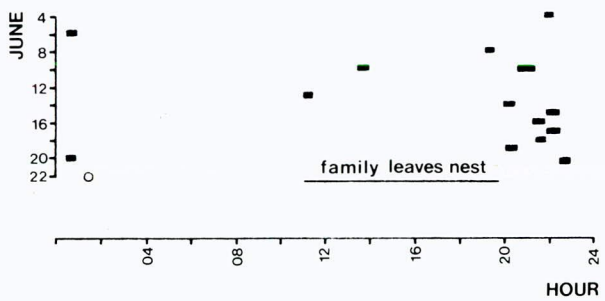


Figure D6.7. Timing and length of recesses of female during incubation. No observations were made on 12 June.

The sitting female first stood and then flew straight off the nest calling, sometimes covering the eggs with down before leaving. Once in the air she would be quickly joined by the male who had usually been either feeding or roosting nearby on the marsh. The calling of the female always elicited a very quick response from the male who joined her within seconds, then together they would fly to the wet areas near the river where the female would graze for about ten minutes or so, moving quickly through the vegetation. The male, very alert and not feeding himself, would follow. On several occasions the female showed a snapping behaviour to her left and right, not taking her head above body level, possibly eating insects (section D8).

After feeding she would wash and preen for a few minutes before flying back to the nest, with her mate, calling. Often before reaching the nest they would stop first in a marshy area near the nest for a further brief feed and preen, then the female would fly straight to the nest and sit down immediately. The male remained standing in an extreme head up posture within 20 m of the nest for about 10 - 15 minutes before flying silently back to the river. After the female had sat down she adjusted the nest about her and often stood briefly to roll the eggs. On her return from the last recess she was most restless and spent over 20 minutes adjusting the nest, rolling the eggs and preening before finally settling down.

There was a marked increase in the time she spent off the nest as the incubation progressed (Figures D6.8 and D6.9). The percentage of the day spent by the female off the nest in the 14 days before hatch (0.015%) is much less than the time spent feeding by the Pink-footed Goose in the same period (mean = c. 3.77%).

During her recesses the female often drank from pools and the stream; however water from these sources was augmented by collecting droplets from her flanks during rainy conditions. This was evidently an important source as often she would be flank drinking for up to half an hour or more.

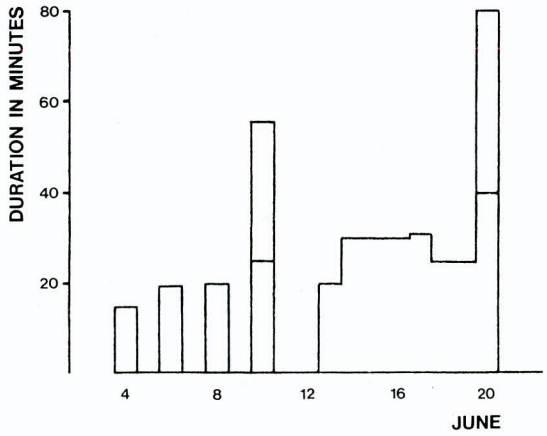


Figure D6.8. Time spent off the nest by the female each day. No observations were made on 12 June. The female left the nest twice on 10 & 20 June. Mean duration of each period off the nest = 24 ± 6 minutes, range 15 to 35 minutes.

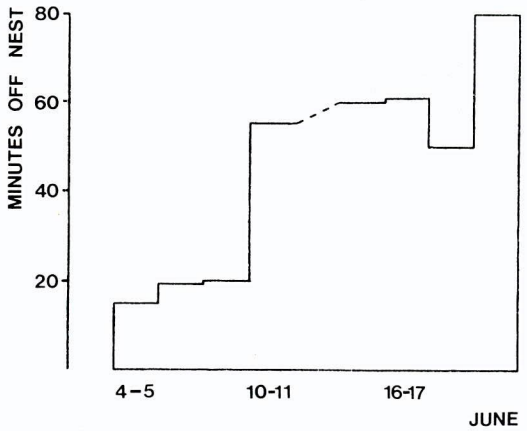


Figure D6.9. Time spent by female away from nest presented as time per 48 hour period to show the increase in time spent feeding.

Changes in behaviour during incubation: data presentation

Graphs of both long-term and diurnal behavioural changes have as the ordinate the mean number of scans per day and per hour respectively in that activity or posture. Since the methods used gave objective samples of behaviour, these approximate to the percentage time spent in that activity or posture (i.e., 12 scans in an hour in any activity is represented as 100% of time spent). The vertical line above and below the mean is ± the standard error of the mean. In the calculation of diurnal cycles the hourly data for each day of the observation period have been summed and the means and standard error presented. Those hours when the bird was out of sight for more than 10 minutes (two scans) have been excluded from the totals, as have data for the female for 36 hours prior to hatching and for the male from four hours before hatching, since as is shown later their behaviour changes significantly in this period. These exclusions result in a variable size for the summed hourly data. The graphs of long-term changes in behaviour are the percentage of those scans of the days during which the goose was visible ($\bar{x}$ = 152 ± 46 for male), and are thus directly comparable to the data presented by Inglis (1977).

Gross time budgets for male and female

The incubating female spent the vast bulk of her time in one of two postures, head on back or head low (48.72% and 41.49% of the time respectively, n = 4,731 scans). As can be seen from Figure D6.10 other postures made small contributions to the total, 2.26% of the time was spent with the head up and then in decreasing order of frequency time was spent flank drinking, nest adjusting, grazing, preening, egg-rolling, head on ground, flying, down plucking, head forward, extreme head up, and wing flapping. The male had a more varied time budget as shown in Figure D6.10. Grazing took up nearly a quarter of the time, although as earlier suggested this may be an underestimate of the actual amount of time spent feeding. Most of the time was spent with head up and then in order of decreasing importance grazing, head on back, extreme head up, head low and preening. Since the proportion of time allocated to different behaviour changed for the male over the incubation period, gross totals have less significance than overall trends (below).

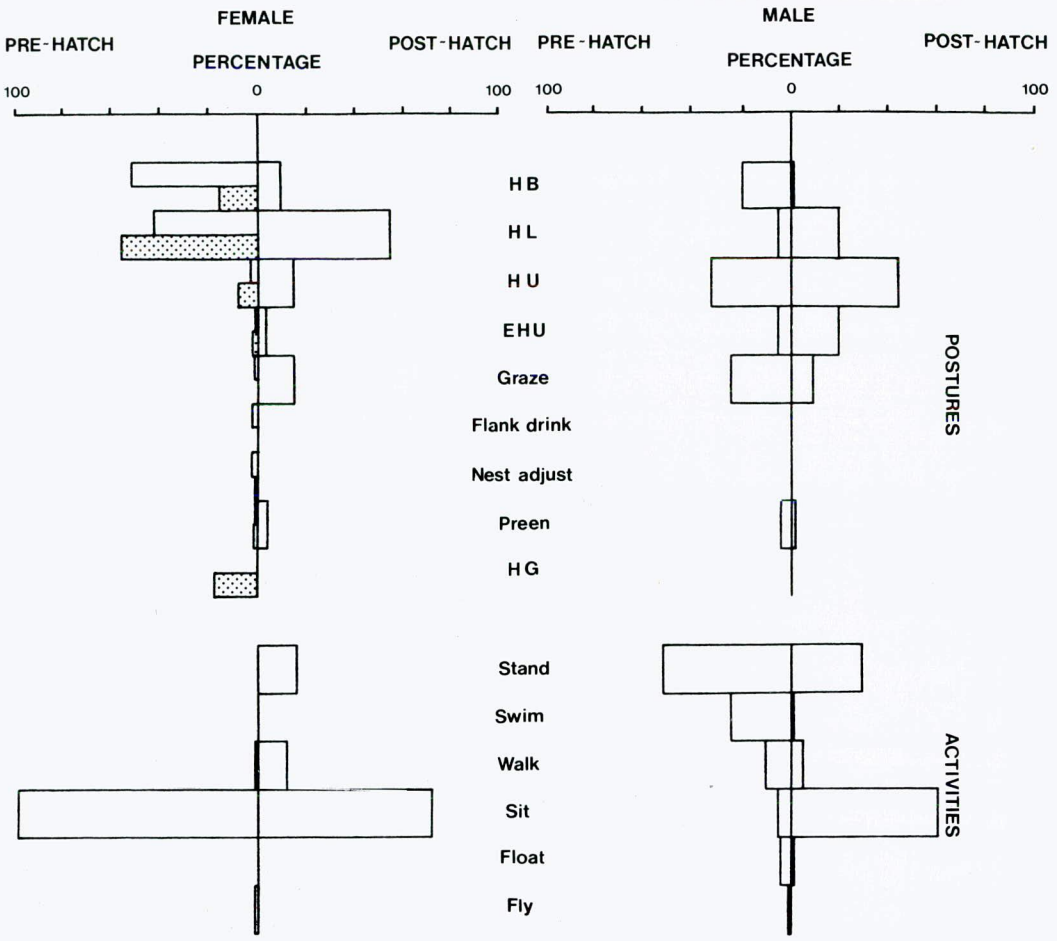


Figure D6.10. Gross time budgets of male and female White-fronts during incubation and after hatching. Left hand half of figure presents data for female and right hand half for male. Upper half of figure shows time budgets for various postures, lower half are activities. Each block is divided into two parts; the columns on the left are the percentage time spent before hatching whilst columns on the right are percentage time spent after hatching for the same activity. The time budgets for the female postures before hatching have been divided into time spent in the presence of predators (shaded columns) and time spent when no predators were present (open columns).

Distance of male from nest

At the time of clutch completion (27 May) the male spent many hours only 2 m from the nest. Later he spent most of his days feeding by the river 350 m away but occasionally spent time near the nest (Figures D6.11 and D6.12). He was 100 m from the nest on the eve of the hatch, but since he had been closer for longer periods in the middle of the incubation, this proximity may not have been caused by the imminence of the hatch. The most frequented feeding area was between 300 and 500 m from the nest; closer than this there was little suitable grazing so the male would be either at the river or at the nest, rarely between the two. This is the cause of the 'spiky' nature of Figure D6.12. The few observations made at Rimwater Marsh show that here too the male was close to the nest about the time of hatching (Figure D6.13). However since the nest was surrounded by suitable grazing there would have been no great need for the gander ever to have gone far from it (if this indeed influences proximity - see discussion).

Alertness

Figure D6.14 shows a steady increase in the proportion of time the male spent with head up - indicating increasing alertness. No such clear trend emerges from the time spent extreme head up. This is possibly due to the problem of separation of extreme head up from head up experienced by some observers. The female whilst spending more time head up in the later stages of incubation became very much more alert after the eggs hatched (Figure D6.15). For the female, the extreme head up posture was restricted to the period after hatching (except for one scan) (Figure D6.10).

Roosting

The amount of time spent by the male roosting (head on back - Figure D6.16) shows no clear trend but was greatly reduced after the chicks had hatched (Figure D6.10). The day before the hatch the female spent hardly any time asleep (Figure D6.17) but most of the day with her head low (Figure D6.18). The first chick was seen at 00.38 hours on 22 June, but whilst it is possible that some of the eggs may have hatched earlier the onset of the behavioural change precedes this observation by 30 hours, probably indicating that the female was aware of the forthcoming hatch. There is often a timelag after the first crack in the egg-shell before the chicks emerge (Ogilvie 1978).

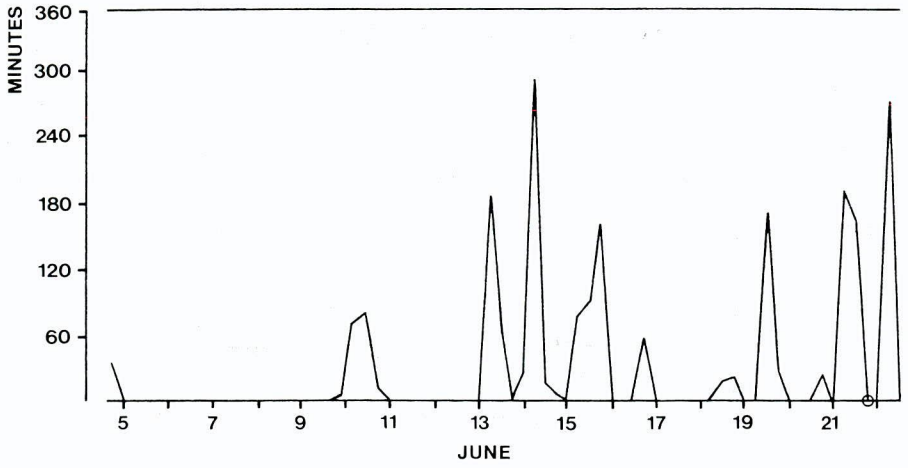


Figure D6.11. Distance of the male from the nest during the incubation period, expressed as the number of minutes in each six hours (03.00 - 09.00, 09.00 - 15.00, 15.00 - 21.00, 21.00 - 03.00) when the male was less than 150 m from the nest. First point is 21.00 - 03.00 on 4 June. o indicates hatch of eggs.

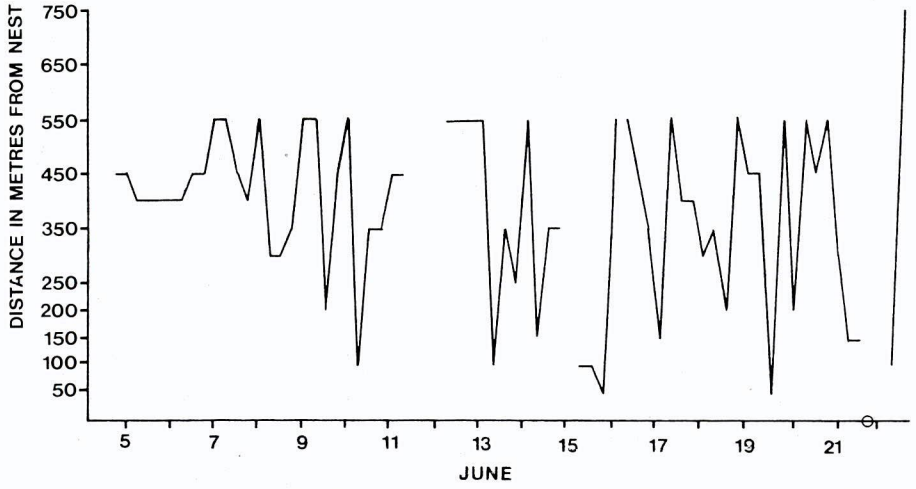


Figure D6.12. Distance of the male from the nest during the incubation period, expressed as the modal distance in each six hour period (as Figure D6.11).

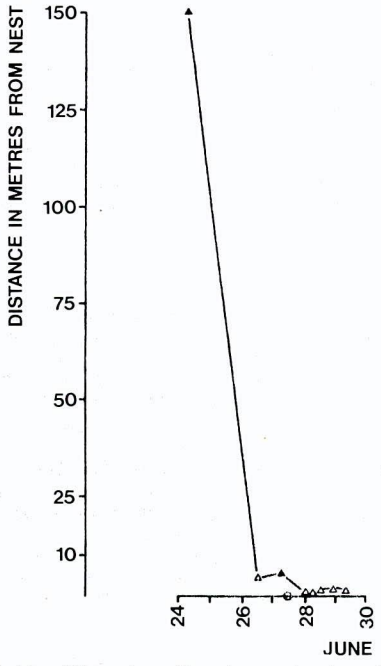


Figure D6.13. Distance of male of the Rimwater Marsh nest site from the nest in the final stages of incubation and immediate post-hatch period, expressed as the modal distance in each six hour period (see Figure D6.11).

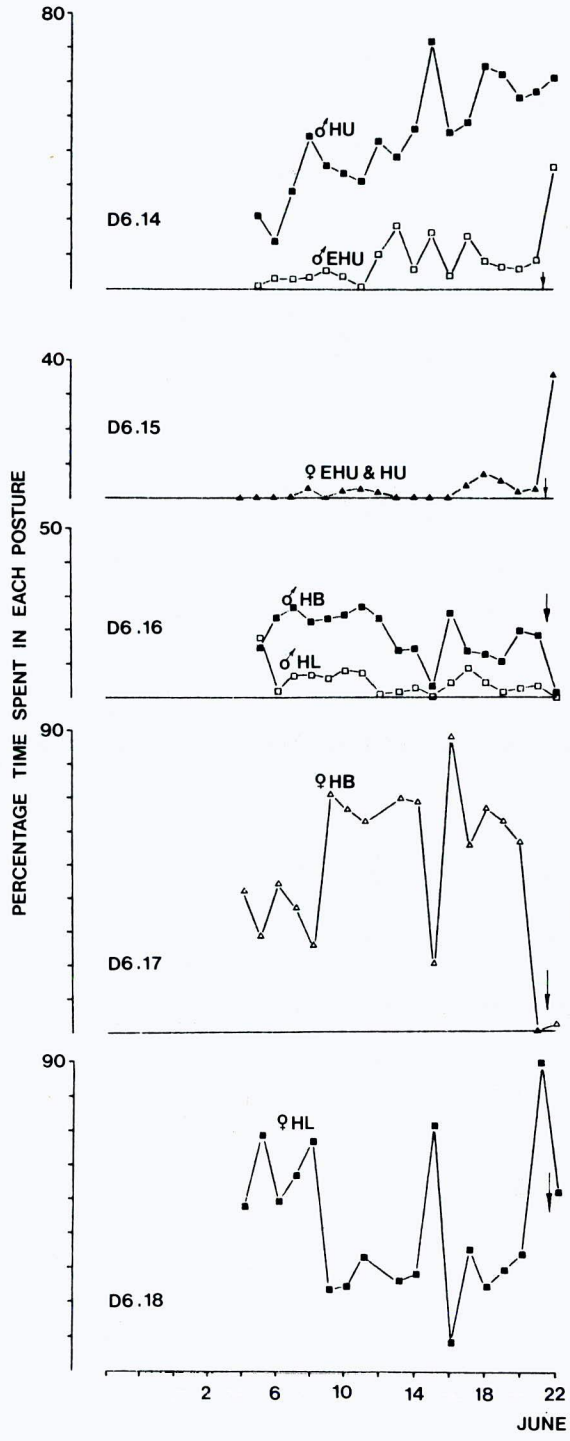


Figure D6.14. Long term behavioural changes: percentage time spent each day by male with head up and extreme head up (arrow indicates hatch).

Figure D6.15. Long term behaviour changes: percentage time spent each day by female with head up and extreme head up combined (arrow indicates hatch).

Figure D6.16. Long term behavioural changes: percentage time spent each day by male with head on back or head low (arrow indicates hatch).

Figure D6.17. Long term behavioural changes: percentage time spent by the female with head on back (arrow indicates hatch).

Figure D6.18. Long term behavioural changes: percentage time spent each day by the female with head low (arrow indicates hatch).

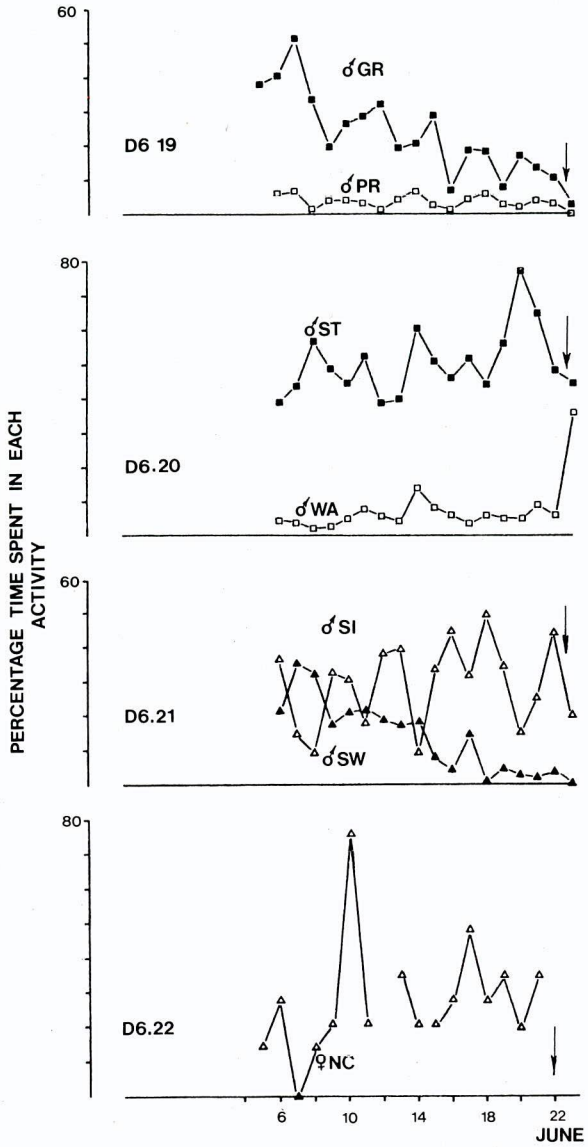


Figure D6.19. Long term behavioural changes: percentage time spent by the male grazing and preening (arrow indicates hatch).

Figure D6.20. Long term behavioural changes: percentage time spent by the male walking and standing (arrow indicates hatch).

Figure D6.21. Long term behavioural changes: percentage time spent by the male sitting and swimming combined with floating (arrow indicates hatch).

Figure D6.22. Long term behavioural changes: percentage time spent by the female in various 'nest care' postures, recorded separately as nest adjusting, egg rolling, and down plucking and combined (arrow indicates hatch).

Feeding

Feeding by the male shows a decline during incubation (Figure D6.19) which is probably a direct result of the increase in time spent alert. Male Pink-footed Geese also show an increase in proportion of time spent head up and extreme head up in the later stage of incubation (Inglis 1977: Figure 8) but an increase in time spent feeding until about three days before hatch (Inglis 1977: Figure 12).

Male activities

Other activities and postures of the male remain more or less constant over incubation: preen (Figure D6.19); head low (Figure D6.16); standing and walking (Figure D6.20); sitting (Figure D6.21); although the combined activities of floating and swimming (Figure D6.21) show a significant decline over the period of observation. This is probably due to the emergence of vegetation above water level, and thus a lessening of dependence on aquatic plants for food. It is also reflected in a dietary change at about this period as shown by faecal analysis (section D8).

Other female postures

The female spent a little time in postures relating to nest care i.e., down plucking, egg rolling and nest adjusting. These were usually quickly over and thus may have been under-recorded by the method used. Down plucking may have been slightly more common at the beginning of incubation but with a maximum of one scan a day recorded, it is difficult to interpret. Nest adjusting and egg rolling were recorded more frequently, and possibly increased slightly towards the later stages of incubation (Figure D6.22).

Diurnal changes in behaviour during incubation

Female

Figures D6.23 and D6.24 show a clear and significant diurnal rhythm in the behaviour of the female. Between the hours 23.00 to 07.55 she spent most of her time with her head on back (i.e., sleeping or resting); after 08.00 hours there was an increase in the time spent with her head low. (It should be noted however, that whilst she usually slept with head on back, she was sometimes observed sleeping with head low. Likewise, the male was often seen literally 'nodding-off' with head low or head up. On a few occasions he was seen to have his eyes shut in head up postures for quite long periods of time). The high frequency of head low was maintained until about 18.00 hours when there was a slow lapse into the sleep period over the following four hours. Other postures were only common in two periods; between 07.00 and 15.00 she left the nest on two occasions and was seen flank drinking, and caring for the nest (above). Between 20.00 and 01.00 she most frequently left the nest to feed and on return adjusted the nest. There is no significant difference in the diurnal cycle of female behaviour in the two 'halves' of incubation, 4 - 11 June and 13 - 20 June.

The time of maximum head on back (Figure D6.23) came shortly after the most common time of recess (Figure D6.7). In order to see if the female always slept after feeding and if this rather than the solar cycle might be the cause of her diurnal cycle, the proportion of time spent head on back has been calculated using her return to the nest after feeding as the start of the period (Figure D6.25). It can be seen that she did sleep more after returning to the nest, time spent asleep falling to a minimum 14 - 19 hours after the last feed. Whilst there is an obvious relationship, the variability is such that it is unlikely to be the cause of the diurnal cycle, rather being a result of it and the regular timing of the feeds.

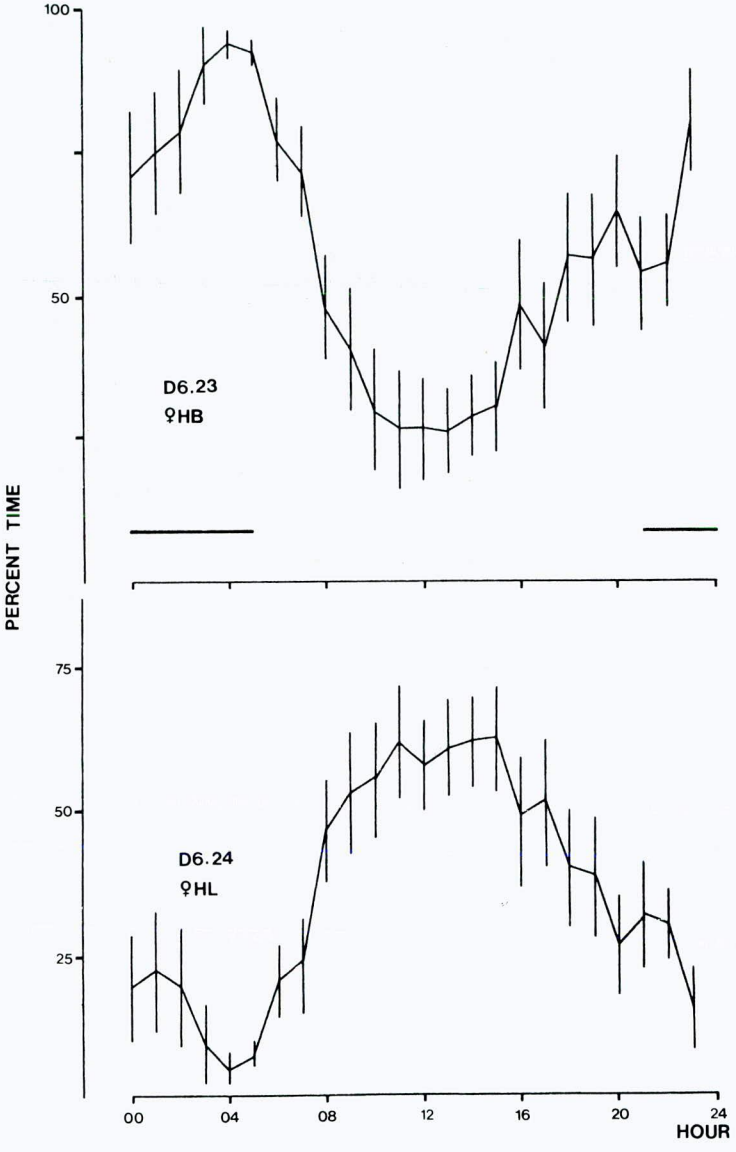


Figure D6.23. Diurnal behavioural changes: proportion of each hour spent by the female with head on back. Mean values from the period 4 to 21 June with vertical bar indicating standard error of mean. Horizontal bar at base of figure indicates the period during which the nest was in the shadow of nearby hills (dark period).

Figure D6.24. Diurnal behavioural changes: proportion of each hour spent by the female with head low. Mean values from the period 4 - 20 June with vertical bar indicating standard error of mean.

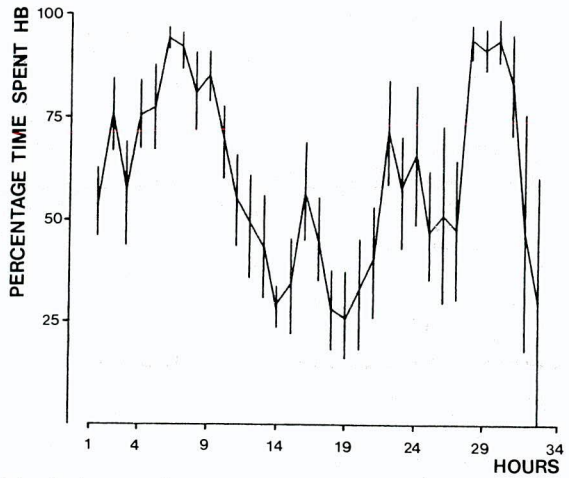


Figure D6.25. Relationship between the timing of the female's recess and sleep time. Horizontal axis is the number of hours since feeding whilst the vertical axis is the proportion of time spent head on back each hour (see text for full details). Means shown ± standard error of mean.

Male

The diurnal changes in the behaviour of the male are less obvious (Figures D6.26 - D6.29). There is a peak of grazing between 22.00 and 05.00, then between 06.00 and 18.00 a high proportion of the time was spent either head up or extreme head up. Roosting (head on back) occurred throughout the day, but fell to a minimum between 16.00 and 19.00. Since Figures D6.28 and D6.29 are different, it is evident that much time was spent sleeping when standing and also that time was spent sitting whilst awake. Preening was recorded infrequently and there is no significant diurnal change in its frequency for either sex; it usually occurred after a spell of feeding and before roosting.

Since in the early post-arrival period the sexes shared vigilant behaviour (section D2) it might also have been expected in the nesting period. However the times of day in which the male (head up - Figure D6.27) and female (head low - Figure D6.24) are alert are roughly the same, significantly correlated with each other and with the time of day at which predators were most commonly seen or heard (Figure D6.30).

Despite being a degree above the Arctic Circle (67°36'N), the nest was not in continuous sunlight. Throughout June and July the sun remained above the horizon but on Upper Marsh the nest and feeding area fell into the shadow of the hills in the north as the sun moved round in the evening. On June 16 - 17 it was noted that the nest was in the shadow of Needle Cairn Heights for 7.5 hours from 21.00 to 04.31 hours. The mean hourly temperature (Figure D6.31) varied over the day. This cycle correlates at $P < 0.001\%$ (Spearman Rank Correlation) with male and female behaviour as shown in Figure D6.32.

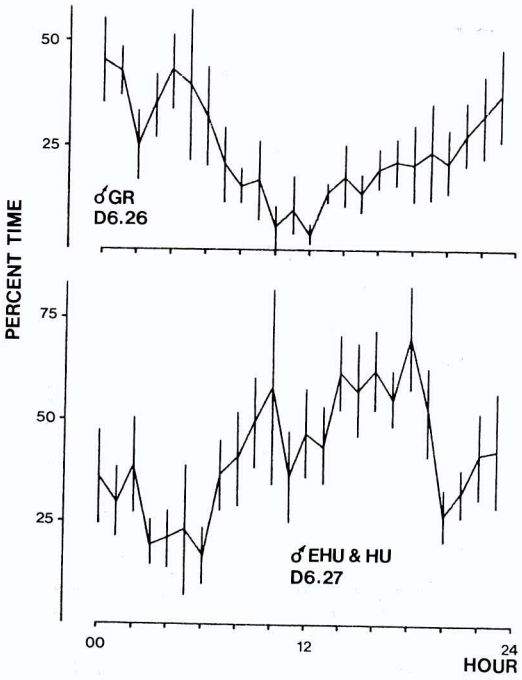


Figure D6.26. Diurnal behavioural changes: proportion of time spent each hour by the male grazing. Mean values from the period 4 - 21 June shown ± standard error.

Figure D6.27. Diurnal behavioural changes: proportion of time spent each hour by the male in head up and extreme head up postures. Mean values from the period 4 - 21 June shown ± standard error.

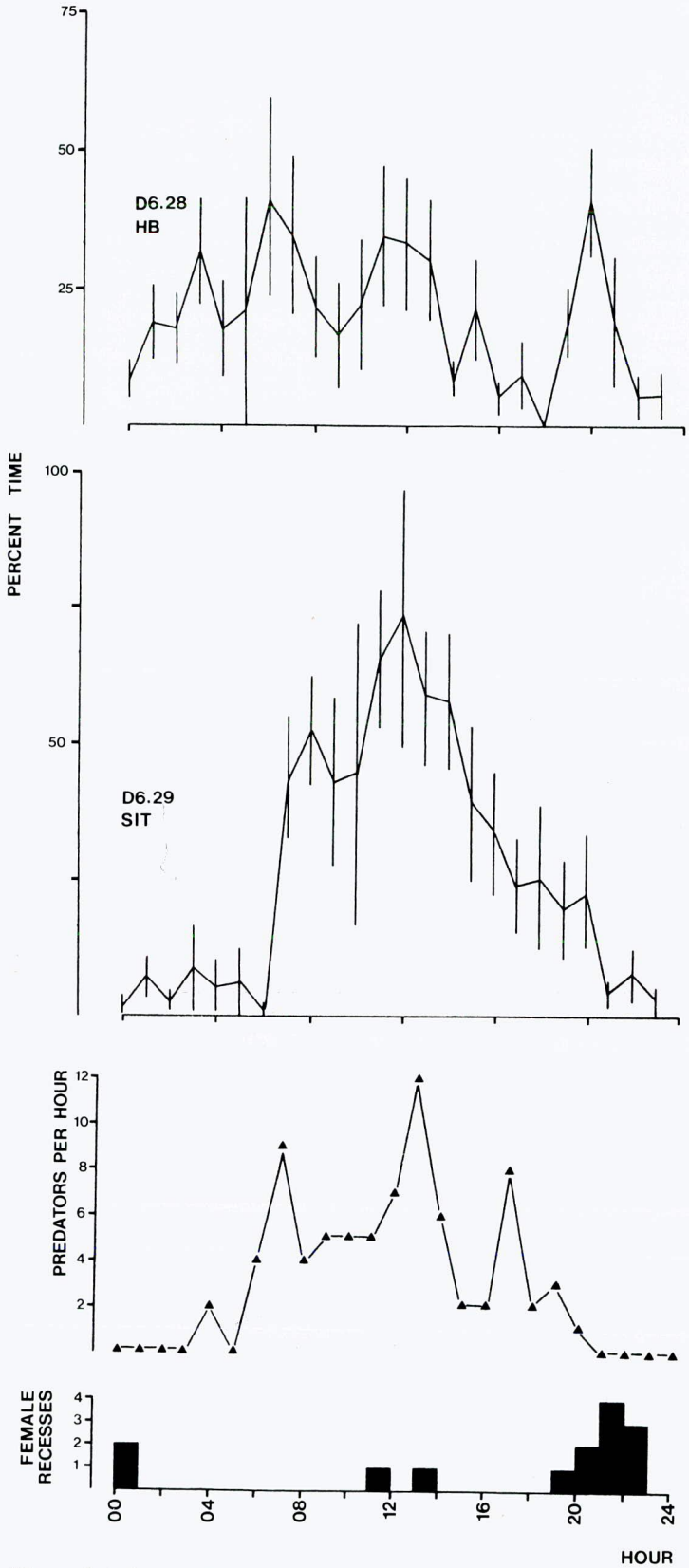


Figure D6.28. Diurnal behavioural changes: proportion of time spent each hour by the male with head on back. Mean values shown ± standard error.

Figure D6.29. Diurnal behavioural changes: proportion of time spent each hour by the male sitting. Mean values shown ± standard error.

Figure D6.30. Relationship between the hourly abundance of predators (Raven, Arctic Fox and Gyrfalcon) over or near the study nest, and the timing of departures from the nest to feed by the female. Total number of predator sightings = 77.

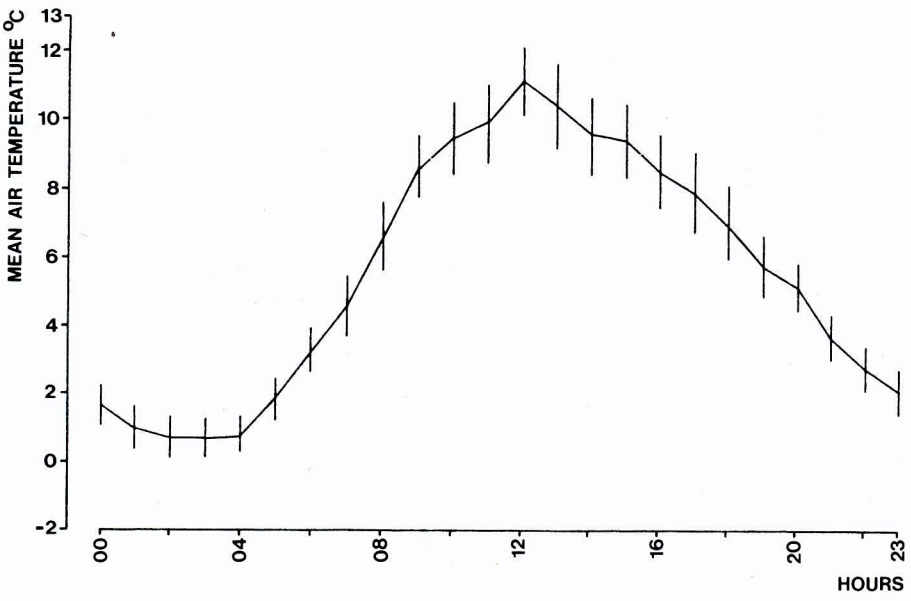


Figure D6.31. Mean hourly temperatures recorded at the hide (4 to 22 June), mean shown ± standard error.

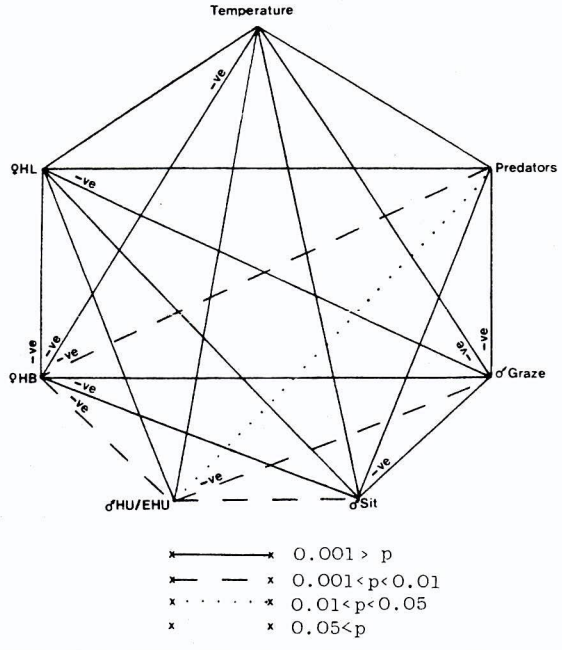


Figure D6.32. Correlations of diurnal behavioural changes. The correlations between five categories of behaviour, predator abundance and temperature (Figures D6.23, D6.24, D6.26, D6.27, D6.29, D6.30, D6.31). A line joining two of the categories shows that there is a statistical correlation between them (Spearman Rank Correlation) and the level of significance is indicated by the type of line. Negative correlations are indicated as appropriate, all others are positive correlations.

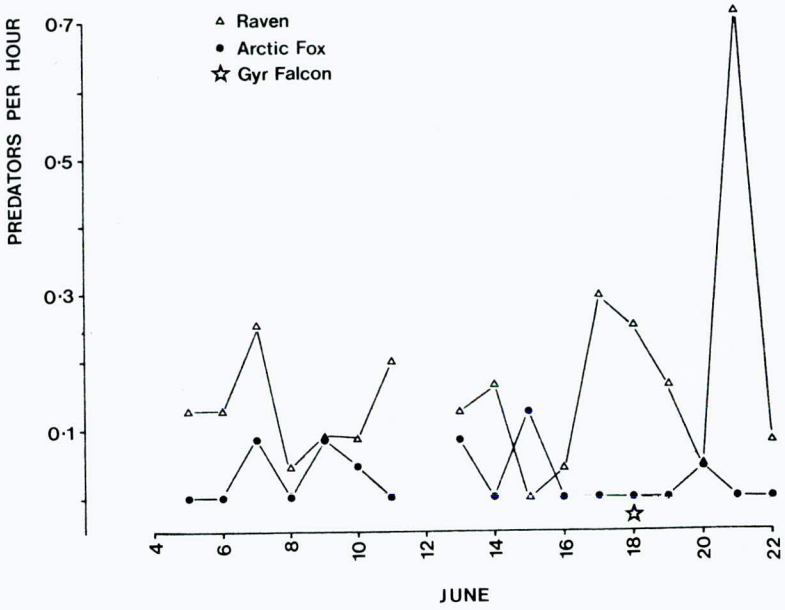


Figure D6.33. Daily totals of predators seen over or near the study nest (4 to 22 June). △ indicates Ravens, ● indicate Arctic Foxes, and ☆ indicate Gyrfalcons. Expressed as numbers of predators per hour.

Departure from the nest after hatching

The first gosling was seen at 00.38 hours on the 22 June (not necessarily the time of hatching) and by 09.00 all five chicks had emerged. In the next hour there was a lot of gosling activity, with frequent excursions although always within reach of the female. A Raven croaked in the distance, causing the male to move closer to the nest and both birds looked about. At 10.38 the female stood up and moved away from the nest, returning briefly apparently to eat from it. Although it could not be discerned what she was eating it was likely to be either eggshells or the unhatched egg since no trace of this could be found later and it had not been eaten by Ravens in the interim. Similar behaviour was seen on Rimwater Marsh after hatching, and the egg membranes and yolky remains are probably an important energy supplement for the female goose before she can graze sufficiently to build up her food reserves again. Pink-footed Geese sometimes eat egg fragments when arriving at old nest sites in spring. Then, however, the supplement of calcium is important in the formation of new eggshells (Gardarsson 1976).

Finally at 11.02 the geese left the nest for the last time, although their departure was disrupted by four Caribou running through the nest area. Both adults crouched and sheltered the young under their wings. Throughout the rest of the day the family walked across Upper Marsh and up the slopes of Needle Cairn Heights in the direction of Llyn Anne. They were lost from sight at 19.45 by which time they had covered about 1 km and ascended about 200 m in height. Fresh roost droppings and down found at Llyn Anne the next day suggests they spent the night there before climbing over the ridge (another 50 m) to the lake Charlie where they were seen on June 24. (Their further movements are given in section D1, and ringing information is given in section D10).

During the walk the parents were always within 1 m of the chicks and the most common groupings are shown in Figure D6.34. This is a 'line abreast' formation very similar to that adopted by Pink-footed Geese when leading young (Nyholm 1965: Figure 22). The female more frequently led the family than the male who was usually positioned to the side of and slightly behind most of the goslings; however the arrangement of the family whilst walking changed constantly.



Figure D6.34. Some common marching sequences of newly hatched Greenland White-front chicks.

At Rimwater Marsh two eggs were seen chipping at 14.30 hours on 27 June and by the early hours of the following day two goslings were visible. Later that day all five were seen. They were brooded in the nest over the 'night' of 28/29 June before being led away towards higher lakes on the morning of 29 June. Thus it appears that, like the Pink-footed Goose, the eggs of the Greenland White-fronted Goose all hatch within 24 hours, and that whether or not they are brooded in the nest over their first night possibly depends on the time of day at which they hatch.

Changes in behaviour after hatching

Gross time budgets have been calculated for both sexes (Figure D6.10): pre-hatch values consist of data from Upper Marsh only, whilst post-hatch values refer to aggregated data from both Upper and Rimwater Marshes. At both nests the hatch was witnessed. At Upper Marsh the family was watched for 19 hours subsequently whilst at Rimwater Marsh the family stayed at the nest for a longer period and was observed for 26 hours.

The female showed a marked and significant decrease in time spent sleeping and resting (head on back) and an increase in all vigilant postures (head low, head up and extreme head up). She also started to eat intensively, spending about 26 times as long grazing as previously. Preening took up a greater proportion of her time, but the only other activity recorded was nest adjusting when brooding young.

The male after hatch assumed a more vigilant role within the family, releasing the female to spend longer feeding. He spent more time alert and markedly less time in non-alert states (grazing, preening and head on back). Activities do not have the same significance as postures but the gander spent longer sitting near the nest and less time in all other activities.

Association of immature goose at Rimwater Marsh

At Rimwater Marsh the nesting pair was accompanied by an immature bird of possibly the previous year's brood. It was seen throughout the late incubation and post-hatch period and there is no reason to suppose that it was not present near the nest throughout incubation. It usually stood between 2 and 20 m from the nest but most frequently was seen about 7 m away. Once the breeding male was observed to chase the immature bird away to about 20 m after it had been gradually getting closer. Although chased off on this occasion from a distance of 6 m it had been much closer many times previously. It seemed that to some extent the male and the immature bird were sharing vigilant behaviour. Table D6.1 is a contingency table of various combinations of posture shown by the two birds. The overall behaviour of the male differs significantly from that of the immature bird (χ^2; $P<0.001$). The male spent more time alert and less time in non-vigilant states (14.38% of the time as compared with 50.83%). It is difficult to test for any 'linkage' or sharing of vigilant behaviour without a control. Also to an extent alert behaviour is 'infectious'. This is supported by the fact that of all the combinations of head up with other postures by both birds, the most frequent combination was when the other bird was head up also. For the breeding male the next most frequent combination of head up was when the immature was non-alert. The immature bird generally spent more time non-alert (grazing, preening and roosting) and less time alert than the male, Without a larger sample size of post-hatching geese it is not really possible to show that the behaviour of the breeding male was significantly altered by the presence of the immature bird.

TABLE D6.1. Contingency table showing combined frequencies of different postures of breeding male and immature in the immediate post-hatching period at Rimwater Marsh. Each value shows the proportion of total time in various combinations of behaviour by male and non-breeding immature. Thus during 6.35% of the time, both the male and immature had their heads low. Horizontal totals give the allocation of time to different postures by the male, vertical totals give the allocation of time to various postures by the immature. Total sample size is 472 scans.

		BREEDING MALE				
		Head Low	Head Up	Extreme Head Up	Other*	TOTAL
IMMATURE	Head Low	6.35%	5.29%	1.05%	0.84%	13.53%
	Head Up	4.23%	13.98%	6.77%	5.08%	30.06%
	Extreme Head up	0.84%	2.54%	1.48%	0.63%	5.49%
	Other*	18.43%	12.92%	11.65%	7.83%	50.83%
	TOTAL	29.85%	34.73%	20.95%	14.38%	

* 'Other' category includes the non-vigilant states of head on back, grazing, and preening.

DISCUSSION

Recesses

The time spent incubating each day (99.985%) is much greater than in both the Pacific White-front (97.3% reported by Ely 1979) and the Pink-footed Goose (96.23%). However, these overall figures conceal the marked increase in time spent off the nest in the later stages of incubation (Figure D6.9). The recess serves two main functions; feeding and preening. Whilst the incubation is largely carried out on the reserves of food accumulated over the winter (Ogilvie 1978; Ryder 1970) these become increasingly depleted. The greater time spent feeding late in incubation is consistent with greater need as the reserves are used up. Also as Inglis (1977) points out, the risk of chilling of the eggs becomes less later in the incubation period, both because of an increase in the air temperature (Figure D6.35) and because the developing embryos become less dependent on extraneous heat sources. The recess also gives the female time to preen and maintain and waterproof the feathers to withstand long periods of motionless sitting in adverse weather.

It was surprising that the female did not cover the eggs with down on some of her departures. Whilst she was away the male did not stand guard at the nest as occurs in some species of geese (Ogilvie 1978), and uncovered eggs would seem to be at some risk from aerial predators. This risk is reduced by the recesses being at the time of least predator activity (Figure D6.30). The female left the nest at a remarkably constant time each day (Figure D6.7), both in the early period (4 - 11 June) when she left the nest once every two days, and later when she was leaving daily. Ely (1979) found that the Pacific White-front left slightly earlier; 44 of 51 departures observed were between 12.00 and 22.00; however his study area was at a lower latitude ($61^{\circ}26'$N cf $67^{\circ}36'$N). Brakhage (1965) reported that the Giant Canada Goose (*B. c. maximus*) left the nest during the first and last two hours of day light; similar

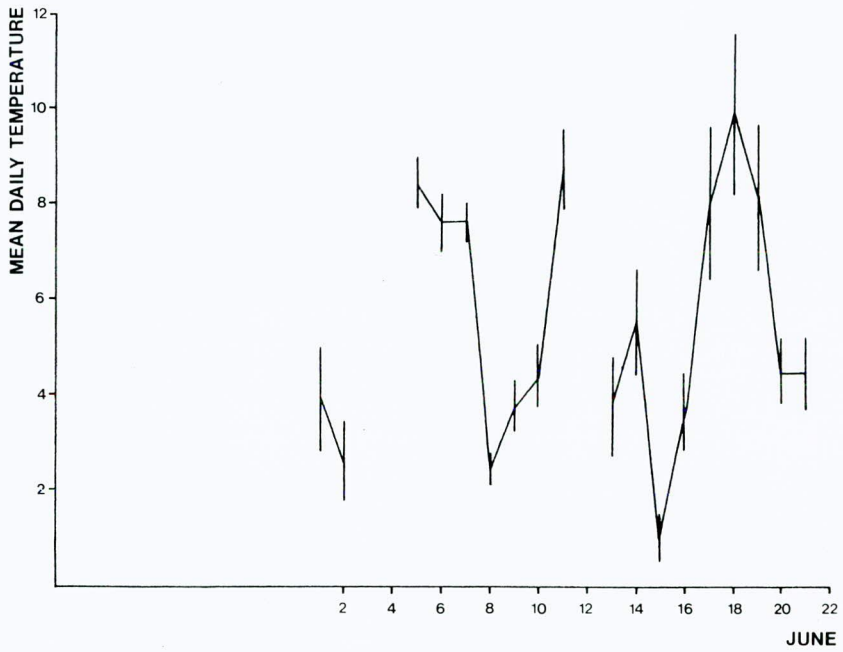


Figure D6.35. Mean daily temperature over the incubation period, means ± standard error.

timing to that of the Greenland White-front. It is also possible to speculate that there is a daily cycle of assimilation efficiency, like so many of the other bodily functions (Fisher and Bartlett 1957; Halberg 1969). The goose has only a short period in which to feed and it may be that this is timed so that food is eaten just before the period when it can be assimilated most efficiently. Few droppings were found near either nest site and none in the nest itself.

The female White-front (both *flavirostris* and *frontalis*) spends a shorter proportion of the day off the nest than the female Pink-footed Goose. This may be because the female Pink-foot never feeds far from the nest and if a predator approaches the nearby nesting geese will provide sufficient alarm to allow her to get back in time. The White-front does not have the protective function of a colony to warn her of the approach of predators and so has to restrict feeding to one bout each day at a time when fewest predators are active.

Diurnal cycles

As can be seen from Figure D6.32 there are many correlations with fluctuations in temperature and predator abundance resulting from the diurnal behaviour cycle of both sexes. A problem of causality presents itself because many of these correlations are probably not functionally significant but merely due to the behaviour of both sexes responding in similar fashion to a few 'controlling' factors.

The study of diurnal rhythms in the continuous daylight of the arctic summer has for long held the interest of physiologists, ecologists and ornithologists (see, for example: Armstrong 1954; Askbirk & Franzmann 1978, 1979; Brown 1963; Cullen 1954; Karplus 1952; Krull 1976a, 1976b; Marshall 1936; Peiponen 1970). Unfortunately this study was not planned with diurnal cycles in mind so that few environmental variables were monitored (e.g. light intensity, altitude of the sun, 'colour temperature' or spectral composition, humidity, etc.). However it is possible to suggest a causal sequence important in this situation.

At the proximate level it is possible that the geese are responding to environmental cues such as variations in temperature, light intensity or colour temperature when changing behaviour. There may be an endogenous component of the rhythms separate from the environmentally induced component (Aschoff 1960) but it is impossible to separate the two under these circumstances. Either temperature (Figure D6.31) or light intensity is likely to be the most important environmental cue but in the absence of illuminance measurements it is not possible to assess the significance of the changes in temperature. (Under the conditions of the study, light readings taken at the hide would have been different from those at the nest since it fell into shadow at different times; a remote sensor near the nest would have been needed).

At the ultimate level the geese probably respond to the activity of predators, being more alert when there is greater chance of attack from either Arctic Fox or Raven. The determination of levels of Fox activity does not seem to have received much attention in arctic field studies but the following ideas may be worthy of further investigation.

Greenwood (1978) and others have shown that there is diurnal variation in the activity of tundra invertebrates, the numbers of most invertebrate groups caught in pitfall traps (especially Diptera) being greater during the day (08.00 - 20.00) than those caught at night (20.00 - 08.00). This in turn will no doubt influence passerine foraging behaviour and activity, and certainly Snow Buntings and Wheatears have an inactive period, the former between 03.00 - 08.00 and the latter between 24.00 - 04.30 (Asbirk and Franzmann 1978, 1979). These periods may not be exactly the same in west Greenland since the studies quoted above were from the high arctic.

If the frequency of Fox calls is an accurate reflection of their activity, then from counts made over 24 hour periods they also seem to be less active in the early hours of the day (see section F3 and Figure D6.30). It seems likely that the vigilant behaviour of both sexes of the goose (female head low, male head up and extreme head up) is so timed as to be greatest when there is greatest risk of predation. Other behaviour 'fills in' when the birds are not alert, i.e., female head on back, male grazing. The peak of sitting during the day is largely due to this activity being associated more frequently with vigilance than feeding.

There were no diurnal rhythms found in nesting Pink-footed Geese between 05.00 and 23.00 hours, although observations that were made outside that time suggest that the females were invariably on their nests. This difference may be due to the protective function of the colony acting in a manner analogous to a flock and removing any great need for individual geese to be alert at particular times of the day, because even with random timing there will be at least a few birds which will see an approaching predator. The study area was at a lower latitude (64°35'N) and thus darker at night than Greenland.

This hypothesis is an ecological extension of the ideas of Aschoff (1964) on the survival value of diurnal rhythms . More recently Daan and Tinbergen (1979) have presented evidence of an analogous situation whereby the daily timing of the departure of Guillemot chicks from their cliff nests is determined by the abundance of predators, 'a daily rhythm of risk'. Evidently changes in predation risk are of great importance in the timing of arctic animal behaviour and should clearly be further investigated to determine if the response of animals to predator abundance is direct, or if, as suggested here, although predation risk is the ultimate cause, the proximate response is to regular environmental changes.

Prop *et al.* (1978) found that nesting Barnacle Geese in high-arctic Svalbard (77°N) showed a distinct diurnal rhythmicity in the timing of their feeding bouts. Males left the nesting island to feed on the nearby mainland most frequently at night (18.00 - 03.00 hours) whilst the female fed more often in the day (09.00 - 17.00 hours). They attribute the timing of the females' feeding to two factors; the smaller energetic cost of rewarming the eggs on return, and the higher concentrations of carbohydrate available in typical arctic forage plants in daylight hours (Wilson 1954). Both these factors are valid in low arctic Eqalungmiut Nunât, and the fact that the female White-front chooses a later time of day to feed may show that the benefits are outweighed by the greater predation risk to a solitary nesting goose.

Distance of male from nest

The Pink-footed Geese at Thjórsárver have a mean inter-nest distance of 15.4 m (range 7.0 - 27.2 m). Too few White-front nests were found in Greenland to make meaningful calculations of this measure but it would seem to be at least 1 km; however Ely (1979) found that for the Pacific White-front the mean inter-nest distance was about 170 m. This great difference in dispersal affects breeding behaviour.

During the completion of the clutch (27/28 May) the male was very near the nest for about a day. This is longer than at any other time and may well have been a defence against intraspecific nest parasitism, as reported for the Pacific White-front by Ely (1979: p 47) and for other species by Mineau and Cooke(1979a, 1979b)and Owen and Wells (1979).

The male spent most of the day away from the nest after clutch completion (Figure D6.12), whereas the Pink-foot spends the bulk of the incubation nearer the nest. At the time of clutch completion the male Pink-footed Goose spends about three-quarters of the day 3 - 7 m from the nest; later he usually wandered further and by mid-incubation most time was spent 10 - 16 m from the nest. At the time of hatch the male moves back usually to within 3 m of the nest (Inglis pers. comm.). There is not such a clear cut trend in the positioning of the male White-front although at both nests watched by us the males were close to the nest at hatching (Figures D6.11 and D6.13). Ely (1979) also found that the distance of the gander from the incubating female decreased from early to late incubation in 12 of 17 nests at which the male was consistently attentive. The presence of the male serves two possible functions: as protection against disturbance of the female by other geese and to guard against predators.

There was only one occasion when the Upper Marsh nest was visited by another goose and it flew off after threats by the male. At Rimwater Marsh a few hours before hatching, three immature geese were seen less than 4 m from the nest; however despite there being no overt aggression the male was always careful to position himself between them and his family. Inglis (1976) points out that it is difficult to envisage any evolutionary advantage to the geese in harrassment of colonially nesting geese, other than perhaps rape (Mineau and Cooke 1979) or the eating of eggs. In the context of solitary breeders it is even harder to suppose that there would be any reason to harrass the female, and in almost 500 hours of observation we did not witness any intraspecific harrassment or interspecific attacks on the female. Thus, for the Greenland White-fronts at least, the only important advantage of the male being close to the nest after egg-laying would seem to be tc guard against predators.

The predator pressure on the Greenland White-fronted Goose is less than that on the Pink-footed Goose (Figure D6.33 and Table D6.2). Colonies not only protect individuals from predation but they also attract predators from a wide area. An alternative strategy of solitary nesting combined with cryptic colouration is used by the Greenland White-front. The female is highly camouflaged against a background of dead and dried grasses and sedges, and when Raven calls were heard she often placed her head low on the ground reducing hersilhouette. Two geese attempting to 'hide' in this way would be more conspicuous than one.

TABLE D6.2. Relative predator abundance near White-front nests (this study) and Pink-footed Goose nests (Inglis 1977). Mean number of predators seen or heard per hour (over the last 19 days of incubation in each case).

	Eqalungmiut Nunât	Thjorsarver
Arctic Fox	0.0286	0.0023
Raven	0.1690	0.0162
Greater Black-backed Gull	-	0.6220
Arctic Skua	-	0.3050
Gyrfalcon	0.0023	-
Mean number of potential predators in region of nest per day: (An indication of relative predator pressure).	4.8120	5.6730

Solitary breeding in the Greenland White-fronted Goose

The advantages of colonial nesting as a strategy for arctic geese have been investigated by Ryder (1969, 1971, 1975) for Snow and Ross's Geese, by Inglis (1976, 1977) and Lazarus and Inglis (1978) for the Pink-footed Goose, whilst the breeding strategies of all arctic nesting geese have been reviewed by Newton (1977) and Ogilvie (1978). However there is little ethological literature concerned with the determinants of solitary nesting as an alternative reproductive strategy. It has been noted that some geese breed colonially or semi-colonially in one area and solitarily in another. There are several reports of White-fronts nesting with some degree of gregariousness (e.g., Gabrielson and Lincoln 1959; Dall in Nelson 1887 - both referred to in Ely 1979; Snyder 1957). Table D6.3 shows that the breeding density varies considerably in different areas even given that only the assessments of Ely and Mickleson are likely to be accurate. All this implies that breeding density is affected by local factors (e.g. predator density, habitat availability or topography) and that aspects of breeding behaviour also vary between different parts of the range.

TABLE D6.3. Nesting densities of White-fronted Geese from different areas.

SUBSPECIES	DENSITY OF PAIRS km^{-2}	STUDY AREA km^{-2}	SITE	REFERENCE
A. a. frontalis	0.4	51800	Alaska	Dzubin *et al.* (1964)
	2.0	10.4	Yukon-Kuskokwim Delta, Alaska	Mickelson (1975)
	3.0	9.8	Y - K Delta, Alaska 1977	Ely (1979)
	4.7	9.8	Y - K Delta, Alaska 1978	Ely (1979)
	5.7	?	Old Crow Flats, Alaska	Dzubin *et al.* (1964)
	14.0	1.3	Y - K Delta, Alaska	Mickelson (1975)
	23 - 30	?	Point Barrow, Alaska	Dzubin *et al.* (1964)
A. a. flavirostris	"not colonial"		Greenland	Fencker (1950)
	<0.5	10.0	Eqalungmiut Nunât	This study

In Eqalungmiut Nunât, there was no evidence of any form of aggregation or semi-colonial organisation amongst nesting geese (sections D4 and D5). The smallest inter-nest distance was 1170 m, much more than the same measure for Pacific White-fronts (see above; Mickleson 1975; Ely 1979). The reasons for such solitary breeding probably include the patchiness of the feeding areas and predation. In Alaska the nesting habitat utilised is often the dominant vegetation over vast areas of tundra (e.g., the Yukon - Kuskokwim Delta: Ely 1979; Dzubin, Miller and Schildman 1964); however in Greenland the marshes and wetlands (section I1) are not continuous but occur in discrete units. These are released as the thaw progresses altitudinally, and thus food resources are both temporally and spatially patchy.

Upon arrival the geese feed together, often in large flocks. This is a consequence of only a few sites being available for feeding at this time, and also because flock feeding confers an advantage in allowing individual geese to feed for longer periods than if in separated pairs (section D2). As the thaw progresses, the birds move to other sites and prospect for nests near marshy areas. Some aggregation between three geese on Upper Marsh was noted on 12 May about the time when early prospecting for nests would have started. However observations at other nest sites were not sufficient to be able to tell if aggregation between pairs establishing themselves at a site was common. Salomonsen (1950a) states that "each pair has its own territory. Territorial fights sometimes take place; two ganders meet on the lake, and uttering strong trumpeting notes they strike each other heavy blows with their wings until one of them withdraws". He does not say when this fighting takes place; that which we observed early on was not as severe as this, consisting only of threat postures and a lunge with neck outstretched.

Once the pair are established and the clutch laid the male spends most of the incubation period on a marsh feeding within sight of the nearby nest. Rather than standing guard at the nest he spends his time feeding on the best available grazing. Incubation involves a considerable drain on the energy reserves of the female which she is unable to recoup without frequent departures from the nest. After hatching the male is largely responsible for the protection of the family (section D9) allowing the female to regain weight. Thus it is important that the male should be in the best possible condition prior to this period. It was surprising therefore to find that he was tolerating the presence of other geese on the marsh since these would seem to have been reducing the available food supply. It may be that the marsh was of such a size that the offtake to other geese was so small as to have had no appreciable effect on the total amount of food. Alternatively they could have been tolerated because of their wandering nature.

They were non-breeding birds and thus free to move between feeding areas as the thaw released more throughout June. The breeding male, however, is probably restricted to one marsh. The impact of non-breeders on any one site because of the transient nature of their competition poses no long-term threat to the food supply of the breeding male. This is illustrated by Figure D6.6 showing that by the end of the incubation other geese were rarely visiting the marsh to feed having already moved to higher altitudes. The male may also tolerate non-breeders for the same reasons as are probably responsibe for flocking in early May (section D2).

It is interesting to note that the few aggressive encounters seen between the geese on the marsh were between the male of the successful nest and another suspected breeding pair. After the probable failure of this latter pair, aggression between the males was much reduced. This may indicate that tolerance of other geese on a feeding site may not extend to other breeding males and, as suggested above, this may be due to the long term nature of such competition.

Changes in behaviour after hatching

The dramatic and significant changes in behaviour of both sexes is in accord with theoretical considerations of partitioning of parental investment. Lazarus and Inglis (1978) analysed the behavioural costs of parental care of Pink-footed Geese at a later stage after hatching when the goose families had left the nest site and were freely ranging over Thjórsárver. During this time (from when the goslings averaged 26 days old to their autumnal departure) it was found that parents did not differ in the amount of time spent in any activity and the only postural differences were that females spent a greater amount of time, on longer bouts, grazing, and that males spent longer in extreme head up postures than did the female (males, $\bar{x}$ = 19.82%, females, $\bar{x}$ = 5.17%).

The time of hatch is a change-over period in the behaviour of a pair of nesting geese. During incubation the female feeds little and undertakes the burden of incubation alone. After the hatch the male assumes the dominant role within the family, maintaining a high state of vigilance and allowing the female to feed-up and recover much of her lost weight prior to migration. This is well demonstrated in the pre- and post-hatch time allocation to grazing and preening by both sexes (Figure D6.36). Although both show an increased proportion of time vigilant (i.e. decreased head on back, increased head up and extreme head up), the male spends much more time alert than his mate, at the expense of other postures.

Lazarus and Inglis found that vigilance of parents declines as the young grow. Presumably time spent alert is greatest during the immediate post-hatch period, the period of maximum risk to the goslings. They then have least resistance to stress and are most vulnerable to attack, thus the need to monitor the position of the goslings and maintain a look-out for predators is greatest.

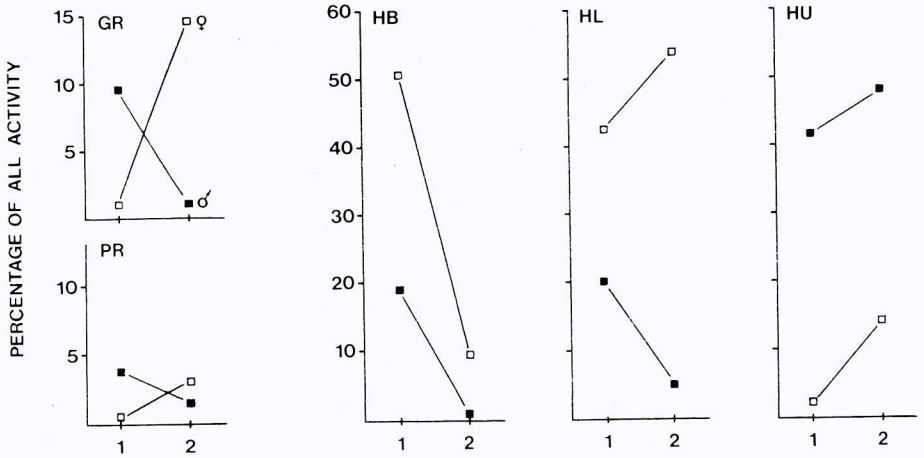


Figure D6.36. Comparisons of time-allocation to different postures before and after hatching for male and female. Lines join values for each sex before(0) and after(1) hatching of eggs.

ACKNOWLEDGEMENTS

This study could not have taken place without the dedicated observations of John Bell, John Floyd, Adrian Fowles, Tony Fox, William Higgs, Alison Higgs and Jesper Madsen, who not only carried the hide up and down hills through blizzards in search of nests, but subsequently spent long, cold and uncomfortable days in it. The most interesting incidents were quickly over and often the tedium of watching a sleeping goose for hours on end was great. This account is a measure of their perseverance. Tony Fox and Jesper Madsen also helped with the observation at Rimwater Marsh - a task calling for frequent applications of 10% Diethyltoluamide !

Thanks are also due in no small measure to Mr. A Jennings and Mr. S Halls who designed and built the hide before the expedition. Without it conditions would have been even colder and more uncomfortable than they were. The Royal Geographical Society provided meteorological instruments and Mr. Archie White designed and built a timer unit and the electronics for the time-lapse cameras (described more fully in section L9). Dr. I R Inglis provided much help and support throughout the planning of the study, willingly answering many detailed letters and providing us with the benefit of his experience.

All members of the study and Dr. W Sinclair read the account in draft and gave useful criticism and I am indebted to Tony Fox for limitless good advice and ideas when inspiration began to fail.

D7 BEHAVIOURAL RESPONSES OF BREEDING GREENLAND WHITE-FRONTED GEESE TO THE PROXIMITY OF PREDATORS

A. P. Fowles

Abstract

The response of the female goose to predators during incubation varied with the distance of the predator from the nest. She assumed concealment behaviour which reduced her silhouette on the close approach of predators, whilst adopting alert postures if they were > 200 m distant from the nest. The response of the male did not vary with the distance from the nest of the predator, and this is explained by the need of the male to be aware of predators at all times and by his having no need for personal concealment. The breeding pair tolerated other geese on the feeding marsh, but showed concealment behaviour if they flew over the nest. After hatching the male took a more active role in the protection of the family from predators and responded to more predators than did the female.

INCUBATION

Introduction and methods

During continuous watches of the main study on incubating geese (section D6), observers noted the response of the nesting geese to the presence of predators. The reactions of the gander and incubating goose were recorded, with sequential changes in behaviour noted until the predator moved out of sight of the geese or stopped calling. Seventy instances of predator presence in the vicinity of the nesting marsh were noted, 42 of which involved Arctic Foxes or Ravens calling from the ridges enclosing the marsh to the north and west. No direct predatory attacks were made upon the study nest and only one Raven showed any indication that it had noticed the incubating female. In addition, the female's reactions to five visits made to change the film in the time-lapse cameras (placed 100 m from the nest), and six appearances of other White-fronts near the nest are discussed.

Predator response was recorded opportunistically and the sequence of responses recorded in a standardised format. This included noting the activities and postures of both geese at each stage of the event, proximity of the geese to the nest, calls given by either predator or the geese, approach of the predator including height (if avian), direction and altitude. By recording these variables at short intervals throughout the encounter it was hoped to see the changing response of each participant.

Results

Postural responses: female.

The female either attempted to conceal herself or adopted a vigilant posture in the presence of a predator (Table D7.1). Her attempts at concealment were of two types; the most frequent, the full concealment posture, consisted of extending the head and neck fully until it was outstretched along the ground with the bill and forehead buried deep in the surrounding vegetation (head on ground). She was observed to assume this posture on 21 occasions, coinciding with the greatest predatory threat; the posture being adopted only five times when the predator was more than 200 m away from the nest. The other form of concealment was the assumption of a posture half-way between the head low and head on ground attitudes, when she would lower her head and press her bill amongst her breast feathers and thus reduce her profile, a posture assumed on only three occasions.

The vigilant posture took on three forms: head low, head up and extreme head up as depicted in Figure D6.2. There were 45 cases in which the incubating female either maintained or assumed one of these postures. She assumed a head up or extreme head up posture on only one occasion when predators were within 800 m of the nest, and this can be explained by her greater alertness making her more conspicuous at closer range than a low-profile posture. Thus the head low position predominated and accounted for 39 of the records of vigilance. The female was only twice seen in an extreme head up posture throughout incubation, and the low frequency of this posture no doubt corresponds to the need for her to remain as inconspicuous as possible.

It appears that the female considers herself under threat of discovery only if a predator is within 200 m of the nest (Table D7.2), although on one occasion she fully concealed herself when a Raven called over 1 km away. Arctic Foxes rarely elicited any response from the female, no response occurring in 11 of the 12 recorded cases of Foxes barking from the ridges around the marsh. However on 10 June at 09.53 hours she responded to a barking Fox by adopting an alert (head up) posture. It seems likely that Arctic Foxes pose no threat to nesting geese at such great distances and this agrees with the apparent disregard White-fronts have for Arctic Foxes in general (section D3).

Despite the awareness of the female throughout the study to the presence of predators, on one occasion she was seemingly oblivious to their proximity. At 13.17 hours on 16 June a Raven flew directly over the nest at a height of 50 m, calling volubly. The female was vigorously egg-rolling at the time and continued this activity as the predator passed over; it appeared that she was too pre-occupied with the task in hand to be aware of any threat. Although the Raven seemed to notice the nest it carried on its way without altering either speed or direction.

Postural responses: male.

The vigilance of the male is discussed in section D6 and the role of the male in protecting the incubating female is well known in arctic nesting geese (Ogilvie 1978). At the study nest it was difficult to ascertain the full nature of his reactions as on many occasions of predator presence he was not visible to the observer. However, of the 50 cases when his reaction was noted, he either maintained or assumed a vigilant posture (head up or extreme head up) in 35 of these (70%). There was only one case out of 20 when he did not assume a vigilant posture on changing behaviour, and this was when he put his head on the ground for an unknown reason. It is apparent that a concealment posture, as shown by the female, is of little value and thus the gander becomes alert whenever he is aware of threat (Table D7.3).

The gander does not appear to respond differently to predators in relation to their distance from the nest (Table D7.4). He was vigilant for 12 of the 18 occasions (66.6%) when a predator was more than 200 m away from the nest. Since his alertness was unlikely to draw attention to the nest, placed as he was several hundred metres away, this no doubt reflects his need to be aware of the activities of the predator at all times. It is interesting however, that the male never flew up to mob Ravens crossing the marsh, but was always content to watch them on their way. Since even close passage to the nest (above) did not result in any direct attacks, mobbing would seem to have little value, and indeed, he conserves energy by avoiding a confrontation.

TABLE D7.1. Postures assumed or maintained by the female on the appearance of a predator (Raven, Arctic Fox and Gyrfalcon). Vertical column shows posture before appearance of predator, whilst horizontal column shows posture of female after the predator had appeared or called. Values are the proportion of instances of predator encounters in which particular combinations of assumption or maintainance were noted. Vertical totals indicate the time-budget of the female after predator appearance, whilst horizontal totals show the time-budget of the female before predator appearance (see also Figure D6.10). Sample size = 73 observations.

	RESPONSE						
Original posture	No change	Head on ground	Head on breast	Head low	Head up	Extreme head up	TOTAL
Head on back	15.1%	5.5%		11.0%			31.2%
Head low	39.7%	9.6%	4.1%		4.1%		57.5%
Head up	2.7%	1.4%		2.7%		1.4%	8.2%
Egg-rolling	1.4%						1.4%
Preening	1.4%						1.4%
TOTAL	60.3%	16.4%	4.1%	13.7%	4.1%	1.4%	

TABLE D7.2. Postures assumed or maintained by the female during the appearance of a predator at selected distances from the nest.

	Distance of predator from nest			
Posture	0 - 100 m	100 - 200 m	200 - 700 m	>700 m
Head on back			1	10
Head low	2	6	6	25
Head on breast	1	1		1
Head on ground	1	6	3	2
Head up		1		4
Extreme head up				1
Preening/egg-rolling	1			1
TOTAL	5	14	10	44

TABLE D7.3. Postures assumed or maintained by the male on the appearance of a predator before hatching. Sample size = 50 observations. Conventions as Table D7.1.

	RESPONSE				
Original posture	No change	Head on ground	Head up	Extreme head up	TOTAL
Head on back	10.0%		8.0%	6.0%	24.0%
Head low	4.0%		2.0%		6.0%
Head up	32.0%	2.0%		14.0%	48.0%
Grazing	12.0%		4.0%	4.0%	20.0%
Preening	2.0%				2.0%
TOTAL	60.0%	2.0%	14.0%	24.0%	

The gander, unlike the female, responded to the calls of Arctic Foxes and in three of the four cases observed after Foxes had barked from the surrounding hills, he adopted an extreme head up posture.

The male showed increased alertness as incubation progressed (Figure D6.14) and he was alert (head up or extreme head up) during all 17 predator observations from mid-day on 18 June until hatching four days later, compared to 18 (55%) vigilant postures recorded in 35 observations prior to 18 June.

Responses of nesting White-fronts to other geese in the proximity of the nest.

Generally the gander tolerated other geese on Upper Marsh and the only aggressive encounters witnessed were with another male suspected of breeding nearby; the implications of this tolerance are discussed in section D6. However, these observations relate to geese feeding on the west edge of the marsh, over 300 m from the nest. The breeding pair reacted to the presence of strange geese in the immediate vicinity of the nest as if they were predators, and showed more concern than if Ravens were flying at a similar distance. These reactions are described and discussed in section D6.

Responses of nesting geese to man.

Each of the five visits made to the nest to change the film in the time-lapse camera elicited the same response from the nesting female. As the recorder approached the camera placed 100 m from the nest, she assumed a head on ground posture described above. She maintained this position for between 9 and 19 minutes, regaining her rest position (head low) only when the recorder was out of sight.

This response has been observed in both Pacific White-fronts (Ely 1979) and Pink-footed Geese (Meltofte *et al.* 1980), and in the case of White-fronted Geese it is thought that the aim of such behaviour is to conceal the bright colouring of the bill and forehead. Certainly, the resultant flattened and camouflaged profile of the bird is extremely difficult to distinguish against the background of dead grasses.

The female sat tight during incubation and flushed only at distances of between 5 to 20 m, leaping into the air to fly off, calling. The female at the Rimwater Marsh nest responded differently when the eggs were chipping; as the observer approached she crawled for 20 m away from the nest before finally flying off.

At none of the nests discovered in Eqalungmiut Nunât did the female defaecate over the eggs when suddenly flushed from the nest (9 instances). This habit is well-established for many species of waterfowl (Hammond and Forward 1956).

The male's responses were observed on three occasions when visits were made to the nest. The first (13 June) occurred when he was sitting 80 m from the nest and he lowered his head to a head low posture. On 16 June he was 400 m from the nest and from a head on back posture in a sitting position he assumed a head up posture. On the third occasion (immediately prior to, or during, hatching) he was standing extreme head up 100 m from the nest and maintained this position, not attempting to conceal himself, which is consistent with his general increased alertness during this period.

POST-INCUBATION

Introduction

The parental care of the goslings immediately after hatching was observed at two nests; Upper Marsh for 18 hours; and Rimwater Marsh for 24 hours (section D6). During the Rimwater observations there were 20 instances of predatory threat before the goslings left the nest for the vicinity of the upland lakes. Rimwater Marsh was contained within a narrow valley running approximately north-south. Ravens were frequently observed flying from the eastern ridge, which rose steeply behind the nest, over the marsh. This activity accounts for 16 of the cases of predatory threat, the remaining four instances being due to Arctic Foxes barking at some distance from the surrounding ridges. Two observations from the Upper Marsh nest are included with the data from Rimwater Marsh since they are of Ravens flying over the nest when the goslings were nearly hatched. Three instances of Caribou in the vicinity of the nest are also discussed.

Postural responses: female.

The concealment postures (head on ground and head on breast) that dominated the female's responses during incubation (above) were not observed at either nest following hatching despite Ravens flying directly overhead on several occasions. Predation by Ravens is more of a threat during the egg-stage than when the goslings have hatched (Ogilvie 1978). Under natural conditions it is unlikely that the goslings are ever left alone and the parents will vigorously defend their young against all predators apart from man.

While the young were still in the nest the female fed nearby, up to 10 m distant, and on two occasions (a Fox barking from the slopes above and a Raven calling overhead), the male and female quickly returned to the nest and closed around the goslings in an extreme head up posture. Whilst the male took a more active role in the care of the family (Figure D6.10), the female was still vigilant and a third of her assumed or maintained postures during the presence of a predator were alert (head up or extreme head up) (Table D7.5).

Postural responses: male.

When the goslings hatched the male joined the female at the nest where he spent most of his time alert. At Rimwater Marsh he positioned himself within one metre of the nest for almost the whole period before the family left for the plateau lakes. Vigilance appeared to be shared with an immature goose that was tolerated in the nest vicinity (Table D6.1) but the gander almost invariably assumed an alert posture when a predator was nearby, regardless of the presence of the immature (17 out of 21 instances: 81%).

After hatching the gander took over the vigilant role in the family allowing the female to feed intensively. This is reflected in the fact that the female was never observed in an alert posture when predators were nearby without the male also being alert, whilst the male was alert on 11 such occasions without the female responding.

TABLE D7.4. Postures assumed or maintained by the male during the appearance of a predator at selected distances from the nest before hatching.

	Distance of predator from nest			
Posture	0 - 100 m	100 - 200 m	200 - 700 m	>700 m
Head on back	1	1		3
Head low		1		1
Head up	2	4	3	14
Extreme head up		6	1	5
Head on ground			1	
Grazing	1	1		4
Preening	1			1
TOTAL	5	13	5	28

TABLE D7.5. Postures assumed or maintained by the female in the presence of a predator after the hatch. Sample size = 22 observations; conventions as Table D7.1.

	RESPONSE			
	No change	Head up	Extreme head up	TOTAL
Original posture				
Nest-adjusting	4.5%			4.5%
Grazing		4.5%	9.1%	13.6%
Head on back	18.2%			18.2%
Head low	45.5%		4.5%	50.0%
Head up	4.5%		9.1%	13.6%
TOTAL	72.7%	4.5%	22.7%	

TABLE D7.6. Postures assumed or maintained by the male during the presence of predators after the hatch. Sample size = 21 observations; conventions as Table D7.1.

	RESPONSE			
	No change	Head up	Extreme head up	TOTAL
Original posture				
Grazing	4.8%	4.8%	9.5%	19.1%
Head on back	4.8%			4.8%
Head low	9.5%	9.5%		19.0%
Head up	28.6%		14.3%	42.9%
Extreme head up	14.3%			14.3%
TOTAL	61.9%	14.3%	23.8%	

Response to Caribou near the nest.

An additional form of disturbance was experienced when Caribou crossed the nesting area. At Upper Marsh four Caribou were watched as they ran close past the newly hatched family. Both parents sat in a head up position until the danger was past and the goslings ran under the female's wings for protection. During the other instance the gander defended the Rimwater Marsh nest from an inquisitive Caribou. A single stag came on to the marsh and appeared to notice the geese at the nest, approaching within 10 m whereupon the gander ran at it in a lunging manner with wings half open, and attempted to peck at it. The Caribou jumped back but again advanced only to be met with another lunge from the gander. After four more attacks from the gander the stag finally moved off. The female, meanwhile, was sitting on the nest watching (head up) while the goslings sheltered beneath her. It is most probable in this case that the Caribou was merely curious; however it must be borne in mind that Caribou do occasionally take animal food, feeding on Lemmings during explosion years (Freuchen and Salomonsen 1958). Henning Thing (pers. comm.) has also observed a male White-front near Søndre Strømfjord Air Base driving a Caribou from the nest by beating at it with its wings.

PARENTAL CARE OF THE GOSLINGS ON THE UPLAND LAKES

Once the goslings moved up on to the plateau the separate families tended to band together in loose flocks where protection was probably increased through shared vigilance in the flock (section D9).

A pair with a single gosling less than five days old was watched feeding on the shores of Delta. Both of the adults were sitting grazing when a Raven swooped low over them at a height of 30 m. The Raven then descended to a height of 10 m and both parents stood in an extreme head up posture. They advanced in a forward-threat posture (Boyd 1953) towards the Raven with their wings open and the Raven flew to a rock on the slope 20 m above the geese. The gosling ran beneath the female while the male slowly advanced towards the Raven, which flew off when the gander was 15 m away. A similar response was observed between Pink-footed Geese and Great Black-backed Gulls at Thjórsárver, Iceland (Inglis 1977).



D8 THE SUMMER DIET OF THE GREENLAND WHITE-FRONTED GOOSE

J. Madsen & A. D. Fox

Abstract

Eriophorum spp. were selected during almost all stages and are the most important food item in Greenland. The altitudinal movement of the geese is apparently linked to nutritional status of emergent plant species. The geese generally select subterranean plant organs initially, following the thaw, eventually browsing on Cyperaceans and grass species late in the season. Differences in gosling diet from that of the parents was noted and the significance discussed.

INTRODUCTION

The diet of the Greenland White-fronted Goose during the breeding season has not previously been studied in detail. Fencker (1950) described the geese as feeding on *Empetrum* and 'dead grasses' on their arrival at Sarqaqdalen in Disko Bugt when snow cover was complete, feeding later on *Equisetum* and a variety of grasses after the thaw.

In this study, the food composition of the geese was assessed by identification of epidermal fragments of ingested food species in the goose faeces, a technique widely applied in waterfowl feeding studies, especially in geese (e.g. Ranwell and Downing 1959, Owen 1973), including Greenland White-fronts on the wintering grounds in Wales (Pollard and Walters-Davies 1968). Geese have an extremely rapid passage of food through the alimentary canal (0.75-1.5 hours, Owen 1975), with little nutritive uptake (Ebbinge *et al.* 1975). Little or no cellulose digestion takes place (Mattocks 1971), leaving the epidermis of food plants undigested and thus readily identifiable microscopically in faecal material.

This section summarises the analyses of the food composition and gives a short description of feeding techniques of the geese. The seasonal change in habitat usage is discussed in relation to the progress of the season and food demands.

METHODS

Goose droppings were collected from the arrival of the geese to the fledging of young (i.e. early May to mid-August). At all sampling sites, the geese are known to have remained in the vicinity for at least one day, ensuring that droppings did not contain ingested food from other sites. During the post-incubation period, gosling droppings were sampled separately for as long as they were distinguishable by their smaller size. Gosling droppings were collected from sites where a family had been observed feeding, and adult droppings collected simultaneously for comparison of food material. At most sites, 50-200 faecal pellets were collected in each sample, but at eight sites (localities 1b, 5-10 and 16, Table D8.3) fewer samples were taken (c. 20 droppings from each). Faecal material was preserved in 4% formaldehyde solution for later examination; analysis followed the quantitative technique outlined by Owen (1975). Reference specimens of plants believed to be potential food of the geese were collected at sampling localities and also preserved in 4% formaldehyde.

RESULTS

Faecal analysis was relatively easy because the plant communities of the feeding areas were of rather uniform composition, dominated by *Eriophorum angustifolium* and *Carex rariflora*. 115 1 x 1 m quadrats were sampled for vegetation from eleven goose feeding sites (from which faecal samples were also collected) and the data analysed on the basis of species presence/absence using Normal Association Analysis (after Lambert and Williams 1966), the results of which are given in Figure D8.1 and Tables D8.1a and D8.1b and D8.2. All sites were wetland sites, showing the common presence of *Eriophorum* and *Carex rariflora* (Table D8.1b). The diet of the geese proved highly specific at all times; throughout the sampling period, only 10 species exceeded a frequency of 10% in a single sample (Table D8.3). The two species of *Eriophorum* (*angustifolium* and *scheuchzeri*) were not always distinguishable in the analysis, so are referred to as *Eriophorum spp.* throughout although the two species were generally discretely distributed.

Between the pre-nesting and fledging phases in the breeding season, the geese moved between plant communities selecting different food items and exhibiting marked seasonal variation in the dietary composition. The change in utilisation of the six most common food items is shown in Figure D8.3 and discussed below.

Pre-nesting

On arrival in early May, the geese were confined to Kûk Marshes, the only area of open water away from running streams at this time. During early May, the shallow water pools and uppermost soil horizons underwent rapid thaw due to the warmth of the sun, permitting the geese to feed on the vegetation and underground storage organs from the previous year's growth. None of the land plants was in a significantly active stage of growth on the arrival of the geese and only *Hippuris vulgaris* had developed fresh shoots.

Geese stripped the vegetation from the edges of pools attempting to feed on the underground storage organs and roots, while the probing of bare mud was commonly observed, presumably foraging for *Triglochin palustre*. Geese were also seen standing in shallow pools and on the wetter mudbanks violently trampling the mud to expose subterranean vegetative parts, often to a depth of 10-15 cm.

Samples of droppings were taken from two areas of the marshes, with differing results (Table D8.3, localities 1a and 1b). In one sample, *Puccinellia deschampsioides* was most frequent, and in the other *Triglochin palustre*. In both cases, underground organs (rhizomes and tubers respectively) predominated, the difference in the two samples presumably reflecting the difference in abundance of the two species on the marsh complex. *Hippuris vulgaris* was taken in pools where the geese were frequently watched up-ending and pulling entire *Hippuris* shoots clear of the water, selecting the submerged parts and leaving the upper stems floating on the surface.

Extremely high grit content was noted in faecal material at this time, due to the ingestion of soil with the underground food items, this was absent in later samples.

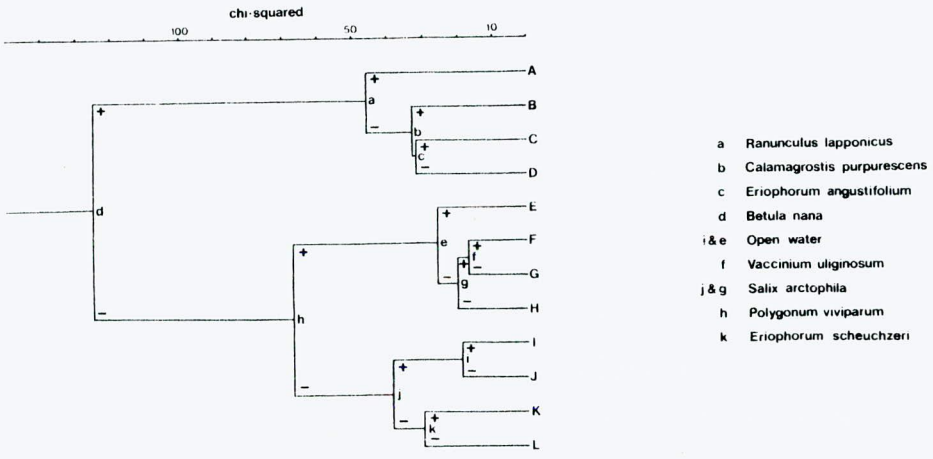


Figure D8.1. Association analysis of feeding marshes, based on normal association analysis.

TABLE D8.1a Species frequency within associations from Normal Association Analysis of quadrats taken from feeding marsh communities.

ASSOCIATION LETTER		A	B	C	D	E	F	G	H	I	J	K	L
Number of Quadrats		6	4	9	5	3	9	13	1	7	28	7	23
Betula nana	24	0.25	0.17	0.37	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calamagrostis purpurescens	10	0.20	0.40	0.00	0.00	0.00	0.10	0.20	0.00	0.00	0.00	0.00	0.10
Carex bigelowii	22	0.00	0.05	0.14	0.14	0.00	0.05	0.00	0.00	0.09	0.05	0.05	0.45
Carex canescens	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Carex rariflora	84	0.05	0.00	0.10	0.01	0.04	0.08	0.14	0.00	0.07	0.29	0.02	0.20
Empetrum nigrum	12	0.33	0.00	0.00	0.08	0.00	0.08	0.00	0.08	0.08	0.00	0.00	0.33
Equisetum variegatum	23	0.00	0.13	0.13	0.09	0.00	0.09	0.09	0.00	0.13	0.09	0.00	0.26
Eriophorum angustifolium	95	0.02	0.04	0.09	0.00	0.03	0.05	0.14	0.00	0.07	0.29	0.04	0.21
Eriophorum scheuchzeri	16	0.00	0.00	0.00	0.00	0.12	0.06	0.00	0.00	0.12	0.25	0.44	0.00
Hippuris vulgaris	9	0.00	0.00	0.00	0.00	0.11	0.11	0.00	0.00	0.11	0.11	0.33	0.22
Ledum palustre	2	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Luzula confusa	1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Luzula groenlandica	2	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Pedicularis labradoricus	1	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poa arctica	7	0.14	0.29	0.14	0.29	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Poa glauca	1	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poa sp	6	0.00	0.00	0.17	0.00	0.00	0.00	0.33	0.17	0.17	0.00	0.00	0.17
Polygonum viviparum	36	0.03	0.11	0.14	0.00	0.08	0.25	0.36	0.03	0.00	0.00	0.00	0.00
Pyrola grandiflora	1	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ranunculus hyperboreus	4	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.25
Ranunculus lapponicus	12	0.50	0.00	0.00	0.00	0.00	0.25	0.08	0.00	0.00	0.00	0.00	0.17
Salix arctophila	68	0.00	0.03	0.09	0.01	0.03	0.13	0.19	0.00	0.10	0.41	0.00	0.00
Salix glauca	12	0.00	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.17	0.08	0.00	0.42
Stellaria longipes	14	0.07	0.21	0.00	0.29	0.00	0.07	0.00	0.07	0.00	0.14	0.00	0.14
Vaccinium uliginosum	48	0.08	0.08	0.12	0.06	0.02	0.19	0.00	0.02	0.04	0.25	0.00	0.12
Vaccinium vitis-ideae	10	0.50	0.00	0.10	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Bare ground	28	0.04	0.00	0.11	0.04	0.00	0.07	0.18	0.04	0.00	0.39	0.04	0.11
Open water	22	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.32	0.00	0.23	0.32
Luzula multiflora	13	0.08	0.00	0.00	0.00	0.23	0.00	0.31	0.08	0.00	0.15	0.00	0.15
Saxifraga stellaris	1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salix herbacea	4	0.00	0.00	0.00	0.00	0.25	0.25	0.50	0.00	0.00	0.00	0.00	0.00
NUMBER OF SPECIES RECORDS		41	35	58	28	22	54	69	7	43	116	24	92
NUMBER OF SPECIES		16	13	14	14	10	16	11	7	14	12	8	18
MEAN NO. SPECIES PER QUADRAT		6.8	8.7	6.4	5.6	7.3	6.0	5.3	7.0	6.1	4.1	3.4	4.0

TABLE D8.1b Species frequency between associations from Normal Association Analysis of quadrats taken from feeding marsh communities.

ASSOCIATION LETTER		A	B	C	D	E	F	G	H	I	J	K	L
Number of Quadrats		6	4	9	5	3	9	13	1	7	28	7	23
Betula nana	24	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calamagrostis purpurescens	10	0.33	1.00	0.00	0.00	0.00	0.11	0.15	0.00	0.00	0.00	0.00	0.04
Carex bigelowii	22	0.00	0.25	0.33	0.60	0.00	0.11	0.00	0.00	0.29	0.04	0.14	0.43
Carex canescens	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00
Carex rariflora	84	0.67	0.00	0.89	0.20	1.00	0.78	0.92	0.00	0.86	0.86	0.29	0.74
Empetrum nigrum	12	0.67	0.00	0.00	0.20	0.00	0.11	0,00	1.00	0.14	0.00	0.00	0.17
Equisetum variegatum	23	0.00	0.75	0.33	0.40	0.00	0.22	0.15	0.00	0.43	0.07	0.00	0.26
Eriophorum angustifolium	95	0.33	1.00	1.00	0.00	1.00	0.56	1.00	0.00	1.00	1.00	0.57	0.87
Eriophorum scheuchzeri	16	0.00	0.00	0.00	0.00	0.67	0.11	0.00	0.00	0.29	0.14	1.00	0.00
Hippuris vulgaris	9	0.00	0.00	0.00	0.00	0.33	0.11	0.00	0.00	0.14	0.04	0.43	0.09
Ledum palustre	2	0.17	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Luzula confusa	1	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Luzula groenlandica	2	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Pedicularis labradoricus	1	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poa arctica	7	0.17	0.50	0.11	0.40	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Poa glauca	1	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poa sp	6	0.00	0.00	0.11	0.00	0.00	0.00	0.15	1.00	0.14	0.00	0.00	0.04
Polygonum viviparum	36	0.17	1.00	0.56	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
Pyrola grandiflora	1	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ranunculus hyperboreus	4	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.14	0.04
Ranunculus lapponicus	12	1.00	0.00	0.00	0.00	0.00	0.33	0.08	0.00	0.00	0.00	0.00	0.09
Salix arctophila	68	0.00	0.50	0.67	0.20	0.67	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Salix glauca	12	0.00	0.50	0.22	0.00	0.00	0.00	0.00	0.00	0.29	0.04	0.00	0.22
Stellaria longipes	14	0.17	0.75	0.00	0.80	0.00	0.11	0.00	1.00	0.00	0.07	0.00	0.09
Vaccinium uliginosum	48	0.67	1.00	0.67	0.60	0.33	1.00	0.00	1.00	0.29	0.43	0.00	0.26
Vaccinium vitis-ideae	10	0.83	0.00	0.11	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Bare ground	28	0.17	0.00	0.33	0.20	0.00	0.22	0.38	1.00	0.00	0.39	0.14	0.13
Open water	22	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.71	0.30
Luzula multiflora	13	0.17	0.00	0.00	0.00	1.00	0.00	0.31	1.00	0.00	0.07	0.00	0.09
Saxifraga stellaris	1	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salix herbacea	4	0.00	0.00	0.00	0.00	0.33	0.11	0.15	0.00	0.00	0.00	0.00	0.00

TABLE D8.2. Distribution of Associations from Normal Association Analysis between goose feeding sites.

Association A - Rimwater Marsh: 20, 21 Lake Line 4: 1, 2, 5, 6

Association B - Upper Marsh: 43, 53, 55, 72

Association C - Upper Marsh: 41, 60, 85, 93, 102, 116 Rimwater Marsh: 8 Fish + 1: 2 Hotel: 2

Association D - Upper Marsh: 30, 89, 113, 114

Association E - Fish + 1: 4, 5 Fish + 2: 2

Association F - Rimwater Marsh: 3, 4, 7 Juliet: 5 Upper Marsh: 42, 131 Mike: 5 Hotel: 3 Fish + 2: 4

Association G - Hotel: 1 Fish + 2: 3, 5 Fish: 4, 6 November: 2, 3, 5, 6 Mike: 1, 6 Upper Marsh: 103 December: 2

Association H - Fish: 2

Association I - Upper Marsh: 121, 127, 117, 132, 107, 84 Fish + 1: 1

Association J - Rimwater Marsh: 12, 13, 16 Upper Marsh: 101, 108, 115, 120, 122, 123, 124, 128, 136, 139 Juliet: 1, 2, 3, 4 Mike: 2, 3, 4 Fish: 3 November: 1 December: 1, 3, 5, 6 Hotel: 4

Association K - Upper Marsh: 118, 119, 129, 140 November: 4 Juliet: 6 Fish: 5

Association L - Upper Marsh: 83, 86, 91, 95, 92, 99, 100, 109, 110, 111, 130, 133, 94 Rimwater Marsh: 17, 22 Fish: 1 Fish + 1: 13, 16 Fish + 2: 1, 6 December: 4 Lake Line 4: 3, 4

TABLE D8.3 Percentage frequency of various food items in faecal analysis from various sites throughout the summer 1979.

LOCALITY	1a	1b	2	3	4	5	6	7	8	9	10	11	12a	12b	13	14a	14b	15a	15b	16	17
DATE	10/5	10/5	15/5	14/6	1/7	5/7	5/7	5/7	5/7	5/7	5/7	7/7	7/7	7/7	11/7	17/7	17/7	25/7	25/7	10/8	12/8
PARENT/GOSLING/ NON-BREEDER	P/NB	P/NB	P/NB	P	P	NB	NB	NB	NB	NB	NB	NB	P	G	NB	P	G	P	G	NB	P/G
SPECIES FREQUENCY (%)																					
BRYOPHYTA																					
Bryophyta sp.	4	–	–	1	–	–	–	1	–	–	–	3	–	3	2	1	–	–	–	–	1
EQUISETACEAE																					
Equisetum sp.	9	–	–	–	–	1	–	–	–	2	–	18	6	50	–	4	14	4	12	–	18
DICOTYLEDONES																					
Hippuris vulgaris	17	–	–	–	–	–	–	–	–	–	–	1	1	2	–	–	5	4	12	–	–
Salix sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Polygonum viviparum	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	1	–	–	–	–	1
Stellaria sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	2	2	–	–	–	–
Dicotyledones sp.	1	–	–	–	–	–	–	–	–	–	–	–	1	3	–	–	–	–	–	–	–
MONOCOTYLEDONES																					
Juncus sp.	–	5	–	–	–	–	–	–	–	–	–	2	–	2	1	–	–	2	–	–	–
Luzula sp.	–	–	3	–	6	–	–	–	–	1	1	3	10	5	2	–	–	–	3	1	–
Eriophorum sp.	6	–	89	94	61	2	6	9	43	7	8	43	13	11	49	12	6	33	30	–	5
Carex rariflora	–	–	–	–	30	92	92	87	66	89	86	16	17	3	38	6	37	14	23	11	3
Carex bigelowii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	48	–
Poa pratensis	–	–	–	–	1	4	–	–	–	–	–	6	43	8	7	66	27	33	13	30	46
Puccinellia deschampsioides	56	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Trisetum spicatum	–	–	–	–	–	–	–	–	–	–	–	7	8	2	1	7	9	10	7	–	25
Calamagrostis purpurescens	–	–	–	–	–	–	1	2	1	–	–	–	–	–	–	–	–	–	–	–	–
Triglochin palustre	5	91	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Monocotyledones sp.	–	3	8	5	–	1	1	1	–	1	5	1	1	1	–	1	–	–	–	10	1

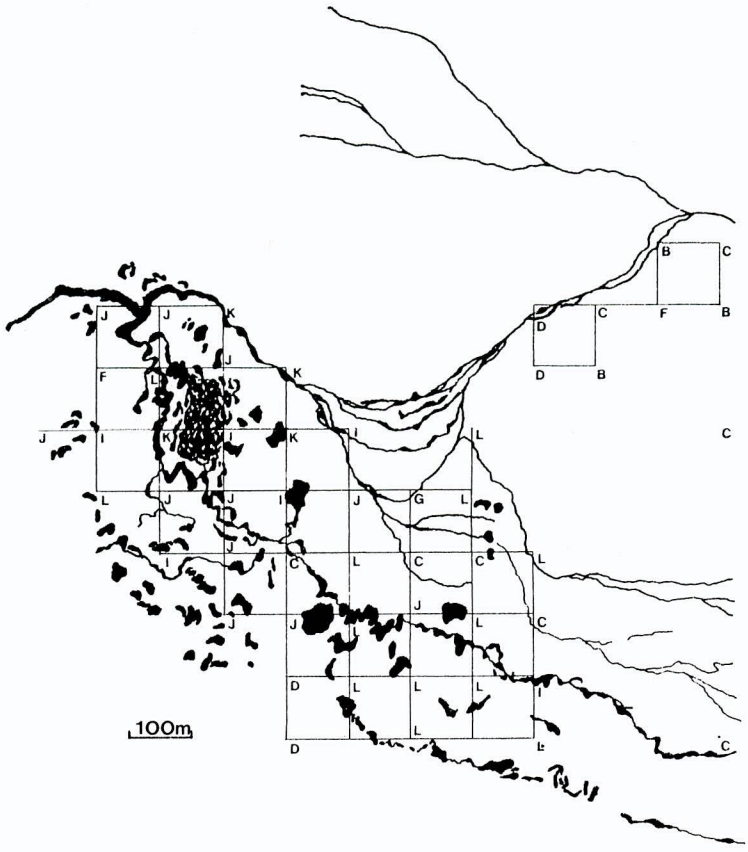


Figure D8.2. Distribution of associations on Upper Marsh, letters indicate associations defined in Figure D8.1.

Incubation

Droppings were collected prior to incubation (sampling from pairs thought to be prospecting for nest sites, Table D8.3, locality 2) and at two nesting sites, Upper Marsh and Rimwater Marsh (Table D8.3, localities 3 and 4) during incubation. At the latter two sites, droppings came largely from the ganders of the nesting pairs, since the occurrence of other geese on the marsh was generally infrequent.

Nest sites were in close proximity to open water or marshes where the nesting birds could feed during incubation. Just prior to and during the first half of incubation, *Eriophorum angustifolium* was almost entirely the food selected from the wetland community (Figure D8.3). At times, the gander watched up-ending on Upper Marsh was feeding on submerged fresh shoots as well as roots and rhizomes of this plant. During the course of incubation, the gander changed to feeding on drier areas where the young shoots of *Eriophorum* emerged later than from wetter areas freed earlier by the thaw. The gander at Rimwater Marsh took rather more *Carex rariflora* , reflecting the greater abundance of this species than on Upper Marsh and possibly the later hatching date at Rimwater Marsh.

On two occasions when the female from the Upper Marsh pair left the nest to feed, the bird was observed feeding on land, running quickly and snapping the air rapidly; while it is interesting to speculate on the likelihood of this being insectivorous feeding no female droppings were ever found.

Post-incubation

During the latter part of incubation amongst breeding pairs, the large non-breeding element of the population moved to higher altitudes to commence feeding about the lake margins of the plateau. Here the geese fed on the water-side marsh vegetation, similar to that used earlier at lower altitudes, but with less *Eriophorum angustifolium*. The dominant feature of the diet was *Carex rariflora*, one of the major elements of the flora, showing again a high level of food specificity (Figure D8.4).

From the time of hatching, almost all geese were found on the plateau feeding along the fringes of the lakes. Geese grazed the fresh shoots and leaves, and no roots were found in the faeces at this time. Generally, the food composition became more varied than before (Table D8.3) with grasses and the above ground parts of Cyperaceans forming a greater part of the diet, with *Poa pratensis* being particularly favoured. This species, with *Carex rariflora*, *Eriophorum spp* and *Equisetum variegatum*, was most frequent in the faeces. *Trisetum spicatum*, a snow-patch grass, showed increasing frequency towards the end of the investigation, marking the movement of the geese to feed on this type of habitat, the site of most delayed plant production about the lake edges.

Table D8.3 shows a high degree of inter-site variation in diet which may be due to differences in the composition of the plant communities, but more likely reflects changes in food preference as the season progressed. Figure D8.5 reveals a difference in the food selection of goslings and parents. *Equisetum variegatum* was greatly preferred by the goslings making up 50% of the food intake in the second sample when they were two weeks old, whereas the parents did not utilise this species any more than might have been taken up accidentally with other food items. The goslings also grazed several dicotyledonous plants noticeably absent in the parents diet such as *Stellaria* and *Polygonum*. By the end of July, the difference in diet between parents and off-spring had become less apparent, with the gosling diet increasingly resembling that of the adults which by mid-July had become more or less constant at all sites.

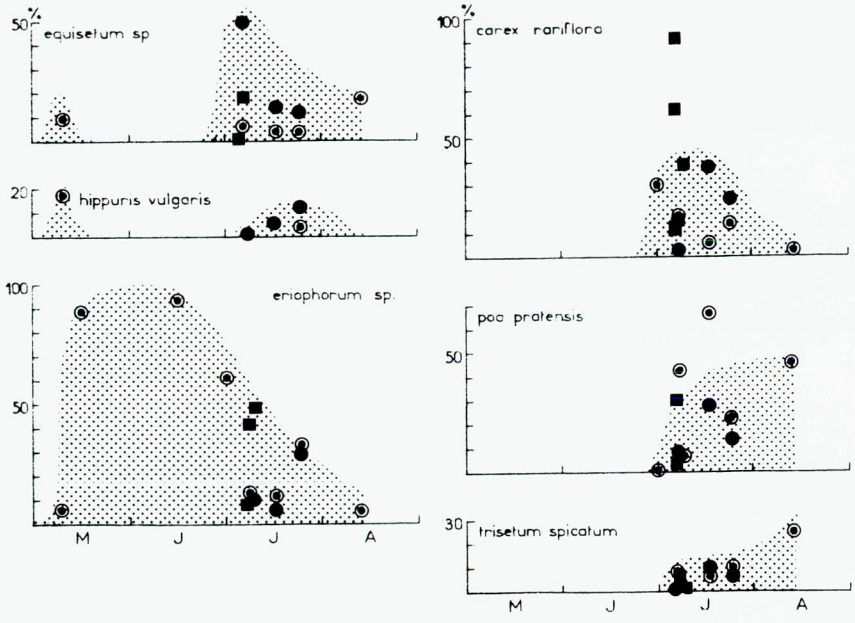


Figure D8.3. Seasonal changes in the utilisation of six major food plants by Greenland White-fronted Geese *(Anser albifrons flavirostris)* during summer 1979. Percentages represent frequency of occurrance in faecal analysis: ● indicate gosling diet, ■ indicate non-breeders diet and ◐ indicate adult diet. Shaded areas indicate generalised usage patterns.



Figure D8.4. (a) Selectivity of breeding ganders during incubation (based on analysis of faecal material and mean percentage plant cover in 10 1 m^2 quadrats from the feeding area on Upper Marsh).

(b) Selectivity of non-breeding geese during June (based on analysis of faecal material and mean percentage plant cover in 10 1 m^2 quadrats from six different sites).

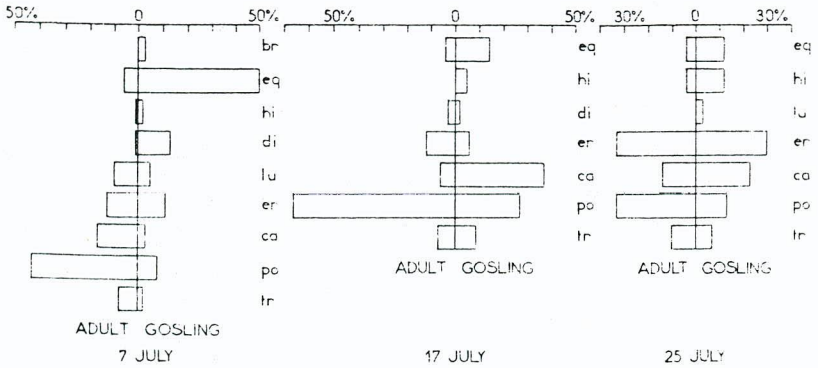


Figure D8.5. Parental and gosling food items during July, percentages represent frequency in faecal analysis. Abbreviations: br = bryophytes eq = *Equisetum* sp., hi = *Hippuris vulgaris*, di = dicotyledons, lu = *Luzula* sp., er = *Eriophorum* spp., ca = *Carex rariflora*, po = *Poa pratensis*, tr = *Trisetum spicatum*.

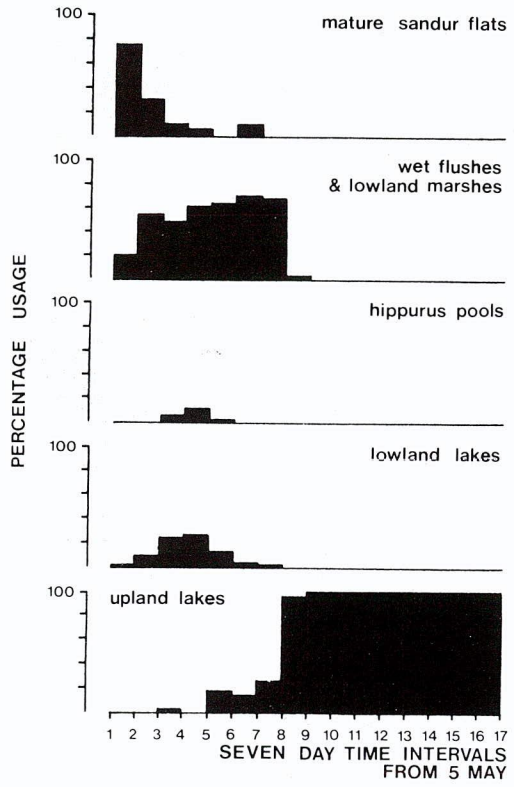


Figure D8.6. Usage of feeding sites by Greenland White-fronted Geese in Eqalungmiut Nunât throughout the summer of 1979.

DISCUSSION

Although the food composition varied throughout the summer season, *Eriophorum spp.*, and *E. angustifolium* in particular, were selected during all stages and must be considered as the single most important food item of the geese on the breeding grounds.

This fact is particularly interesting in the light of the fact that *Eriophorum angustifolium* together with *Rhynchospora alba* and other peatland species, are the traditional food items of the geese on the wintering grounds (Cadman 1953; Pollard and Walters-Davies 1968). However, alteration of habitat and disturbance on the wintering grounds have changed the habits of the geese so that the majority of the population in winter now feeds on farmland (Ruttledge and Ogilvie 1979), abandoning the traditional *Eriophorum* feeding areas except possibly for night-time supplementary feeding at bog roosting sites.

During the breeding season, the geese face several periods of nutritional stress as nesting and moult make demands on their energy reserves, and the goslings require highly nutritious food items to ensure a growth rate sufficient to achieve fledging before the major decline in forage quality. The geese must maximise protein and carbohydrate intake with respect to the handling time involved with different species, and this is apparently achieved by selecting plants with high nutritive content and digestibility (low fibre component) (Owen 1972).

There is some evidence that the movement of the geese during the summer may be explained in terms of the nutritional requirements. The geese move between the pre-nesting, nesting and post-nesting habitats, choosing these plant communities on the basis of optimal nutrient availability. The usage of different habitats with respect to time is shown in Figure D8.6.

During the early part of May, geese were effectively restricted to Kûk Marshes where the forage was difficult to locate (as shown by the high grit content of the faeces). However, prior to active growth, subterranean plant organs such as bulbils, rhizomes, roots and other over-wintering parts are highly nutritious (Dennis *et al.* 1978; Thomas and Prevett 1980) and thus the geese may have obtained significant amounts of food prior to nesting (see Section D2).

From the pre-nesting period to incubation and during hatching to fledging, the geese followed the delay in growth of emergent aquatic and marsh vegetation up an altitudinal gradient from Kûk Marshes to the plateau lakes. This gradient is equivalent to a temperature gradient which results in delayed phytoproduction at successively higher areas. Protein content of monocotyledonous plants is considered to be at its peak just before maximum growth (Harwood 1977), whereas fibre content is lowest at the beginning of the growth phase (Whitten and Cameron 1980). By following the effective growth season of the same plant species, the geese would be in a favourable position to optimise their nutritive intake, always selecting fresh shoots prior to maximum growth as they move along this gradient of production.

The hypothesis is further supported by observations on the plateau where the geese fed initially along the northern (i.e. south-facing) fringes of the upland lakes which thaw first, later moving to the north-facing edges and finally to the snow patches lying typically in deep shade along the southern sides on the plateau waters. Thus even at altitude, the geese are able to follow the phenology of plant growth by selecting between habitats.

Owen (1980) discusses the moult migration in geese in relation to a hypothesis similar to that expounded above and a similar sequential utilisation of feeding sites freed from snow has been found by Prop *et al.* (1978) for Barnacle Geese in Spitzbergen. Owen and Ogilvie (1979) suggested that the northerly moult migration found in many arctic nesting geese might be explained in terms of feeding advantage (i.e. better food quality) during the energetically stressful moult period because of a similar delay of the growing season at higher latitudes. An equivalent situation is to be found in the Lesser White-fronted Goose (Ekman 1922 in Owen 1980), which moves to higher altitudes to moult.

Differences in gosling and adult diet during the first weeks after hatching are also known in Pink-footed Geese in Iceland (Gardarsson and Sigurdsson 1972). In this species too, the goslings switch to the parential diet after a few weeks.

The reasons for the differences in food selection within Greenland White-front families remain obscure. It was noted, however, that *Equisetum* (the major constituent of gosling diet at the very youngest stage) was broken down to a greater degree in the faecal material of the goslings than any other food item. It is interesting to note that at none of the sampling sites was *Equisetum* a major constituent of the vegetation sward, so that even at a very young stage, the goslings are highly selective for forage with high digestibility, even if the nutritional content may be relatively poor.

No information is available on the possibility of sexual differences in food selection as found in Barnacle Geese by Prop *et al.* (1978), but this would clearly be a priority in future projects, along with detailed investigations of quality and quantity of forage available to the geese at different times throughout the summer.

ACKNOWLEDGEMENTS

Simon Laegaard gave specialist advice and provided laboratory facilities - we thank him heartily.

D9

POST HATCHING BEHAVIOUR OF FAMILIES AND NON-BREEDING GREENLAND WHITE-FRONTED GEESE

J. Madsen

Abstract

The behaviour of both families and non-breeding geese during the summer is described. Compared to non-breeders, families grazed more, were more alert, preened less and less often adopted head low/ head on back postures. The time spent by parents in most activities and postures did vary between different size families, although the parents of the biggest broods were more alert than other families. Female parents grazed for significantly longer than males, and both parents grazed for longer than non-breeding adults. The amount of time spent feeding by goslings decreased during the summer, a fact possibly related to dietary change taking place. The spacing of parents and goslings doubled over the observation period, and birds were further apart in large broods when compared with smaller ones. There was no change in spacing patterns by non-breeders over the same time period. The observations are discussed in the light of previous work undertaken on Pink-footed Geese by Lazarus and Inglis (1978).

INTRODUCTION

This section describes the behaviour of Greenland White-fronted Geese from two days after hatching until the fledging of the young. The behaviour of the families immediately post-hatching has been described in section D6.

Much of the inspiration for this work came from the study of Lazarus and Inglis (1978) who described the post-hatching behaviour of Pink-footed Geese in Iceland, and it is the intention here to compare the behaviour of the two species of geese over the same period of the breeding cycle. Lazarus and Inglis included a comprehensive discussion on the costs and benefits of parental care and vigilant behaviour in both parents and non-parental adults. This section examines some of their conclusions regarding vigilance, with a discussion of gregariousness in families and non-breeders as well as observations suggesting alloparental care of young.

STUDY AREA

Observations were concentrated on the plateau lakes Charlie, Delta, Echo, Zulu, Welsh and Axewater. The lakes are partly interconnected by marshes and streams along which the geese walked. At least six families of geese spent the summer in this region, and it was the moulting area of a more labile population of 10 - 20 non-breeders (section D1). Feeding took place along the fringes of the lakes and their connecting marshes, although later, when the geese were able to fly once more, discrete marshes away from the lakes were also utilised.

METHODS

Observations were made between 24 June and 17 August, corresponding with gosling ages of between two and 54 days. Observation periods were evenly distributed throughout the period 08.00 - 21.00 hours. The following behavioural parameters were recorded:

(a) Measures of activities and postures as outlined in section D6. Scans were made recording instantaneous posture and activity (Altmann 1974) of each goose under observation every 2.5 minutes (or 5 minutes if large numbers of geese were being watched). Since these provide an objective sample of behaviour, time-budgets can be estimated from the relative proportions of different postures recorded in each observation period.

(b) Intra-group measures. Distance between members of a group (families or non-breeding pairs) were estimated in metres (0, ½, 1, 2, 3, 4, 5, 10, 15, 20, 30, 40, 50, 100, >100), using goose-lengths as a guide. Parent-gosling distances were recorded as the distance between the parents and the furthest gosling, since this was regarded as the furthest the gosling was allowed to depart from the family group.

(c) Inter-group measures. Distances between families, families and non-breeder groups, and between separate non-breeder groups.

The families were recognised by the unique belly markings of the parents (section D12). The brood sizes of six families watched were one, two, three, four, five and five. However, an immature goose thought to be a yearling associated with the family with two goslings, and as it behaved exactly as a gosling, the brood has been treated in the results as if it contained three young. Another immature goose associated with the family containing four young, although it was not treated as a gosling in the results. The families consisting of seven members came from Rimwater and Upper Marshes, where the adults had been observed during incubation and the hatches witnessed (section D6).

As it was impossible to predict the location of the geese and thus use hides, observations with telescopes (20x to 45x) were made instead from behind boulders after concealed approach to ridges overlooking lakes. If more than two hours uninterrupted observations were made during the day, the results have been used as a representative sample of daily time budgets. With observation periods of less than two hours, results have either been excluded or pooled with other observations made on preceeding or subsequent days. Table D9.1 presents sample sizes from each family and non-breeder group. Observations were not made throughout a 24 hour period as was done for incubation (section D6) and thus it is not known to what extent the behaviour of the family groups shows a diurnal periodicity. The possibility of regular changes in behaviour relating to time of day, as was seen earlier in the season, within the observation limits of 08.00 - 21.00 hours should thus be borne in mind. Mean hatching date was 24 June, however as the observations during the first half of the study period were mostly undertaken on single families the actual age of the goslings has been used, whereas in later observations on many families simultaneously, gosling age is taken as the time since the mean hatching date for all families.

RESULTS

Time budgets in relation to social status

In the period 3 - 17 August information is available on most sizes of family and can be compared with results from non-breeding geese. Five families and a more labile group of 2 - 8 geese were regularly observed near Axewater (sample sizes are given in Table D9.1). As there were some long-term changes in frequency of some behavioural parameters, to obtain meaningful comparisons only data from a relatively short period can be compared.

There are striking differences between the time-budgets of families and non-breeders. The effect of brood size on the activities and postures of parent birds is shown in Figure D9.1. Compared to non-breeders, families grazed more, were more alert, preened less and less often adopted head low/ head-on-back postures. All four differences are highly significant ($P < 0.001$; Chi-squared tests; non-breeder scores compared to parental scores). Only the frequency of the head low posture did not significantly vary with brood size.

Compared to the activities of non-breeders, families walked more and sat less, but the amount of time spent in these activities by families did not vary with different brood sizes. Indeed the time spent in most activities and postures did not vary within the different family classes, however the parents of the biggest broods were more alert than other families ($P < 0.001$; compared to the pooled data of the two smaller family classes), with a corresponding decrease in the time spent grazing ($P<0.001$).

Only a few comparable observations of families with different brood sizes were made in June or July. However on 27 June, when the family with one gosling was observed for a period of three hours, neither male nor female was seen in the extreme head up posture, whereas the adults with broods of five spent on average more than 20% of the time alert during the same period. This points to a relationship between the time spent alert (extreme head up posture) by the parents and their brood size.

Time budgets

The following account is based on observations on the two families with five goslings (Table D9.1), as they were the only families observed throughout the study period. Comparisons are made with non-breeder flocks.

Parents spent on average 35% of the time under observation grazing. Since grazing probably often 'fills in' time when the birds are not alert, and the time spent alert increases with brood size, then presumably those parents with fewer goslings would have spent even more time feeding. Female parents grazed on average for significantly longer than males (mean of females = 42.1%, mean of males = 25.5%, $t = 5.33$, $P < 0.001$). Lazarus and Inglis (1978) showed that Pink-foot ganders compensated for their shorter feeding times by having faster peck rate; although this was not tested in this study, it was noticed that ganders fed faster and more vigorously than the females. Goslings grazed for longer than their parents (mean of goslings = 61.6%; compared to females, $t = 3.46$, $P < 0.001$).

Over the study period, there was no significant change in the proportion of time spent grazing by either the parent birds or the non-breeders (Figure D9.2), although the time spent grazing by the goslings decreased ($r_s = -0.883$, $n = 8$, $P = 0.01$). Non-breeders spent an average 33.1% of their time grazing, significantly less than parental females ($t = 2.19$, $P < 0.025$).

Parents spent an average 15.3% of the time under observation in the extreme head up posture, and males spent more time alert in this posture than their mates (mean of males = 23.7%; mean of females = 6.8%; $t = 4.01$, $P < 0.005$). In both sexes the proportion of time spent in the posture declined over the study period (male $r_s = -0.88$, $n = 9$, $P < 0.01$; female $r_s = -0.85$, $n = 9$, $P < 0.01$), and by the time of fledging, parents spent on average only about 10% of their time alert (Figure D9.3).

The non-breeders were seldom seen in the extreme head up posture, only for an average of 0.4% of the day. When non-breeders joined family flocks they were never seen extreme head up, but in flocks containing only non-breeders usually a single bird stood alert in this posture.

Brooding of the goslings was last seen 14 days after hatching (Figure D9.4), which is similar to data given by Kear (1970). Both sexes devoted equal time to brooding, and during the 14 days brooded for an average of 21.2% of the time observed. Brooding bouts lasted between less than 2.5 minutes and over 45 minutes and were most extensive during cold spells and rain.

Spacing patterns

Intra-group:

The spacing patterns within the large families (broods of five) is shown in Figure D9.5. The distances presented apply only to active families, omitting geese that were swimming, resting or preening. No correlation was found between spacing and the type of active behaviour and thus scans have been pooled. Figure D9.5 shows that there was a doubling of the spacing distance over the observation period.

During the first days after hatching at the end of June, the parents kept very close together with the goslings in between them (e.g., Figure D6.34). When predators approached (e.g., Ravens calling, see section D7) the goslings immediately ran underneath the parents to seek protection. If a gosling walked too far from the rest of the family it was chased back by one of the parents.

By the time of fledging, goslings were allowed to walk further apart from the parents. When a predator approached, the goslings rapidly ran for the protection of the lake, and on one occasion when the families were grazing on a slope 50 m above Axewater, they took off and glided to the lake.

Spacing patterns differed with regard to brood size: both parents and goslings walked further apart in big broods compared to smaller ones ($t = 3.22$, $P < 0.001$ and $t = 2.67$, $P < 0.01$ respectively), although there were no significant differences between broods of one and three goslings.

There was no change in spacing patterns by non-breeders during the study period. Mean separation was 1.3 ± 0.1 m (95% confidence limits), showing no difference in the distances between parents with broods of 1 and 3; these were, however, significantly smaller than distances between parents with broods of 5 ($t = 4.16$, $P < 0.001$).

Inter-group:

The families under observation gradually congregated together on Axewater. The flock structure was loose, with a mean distance between family groups of 10.0 ± 0.9 m (95% confidence limits). Distance between pairs in non-breeder flocks were on average 5.1 ± 1.0 m (95% confidence limits), significantly less than the distance between families ($t = 5.69$, $P < 0.001$). When a non-breeder flock joined the family flocks, they kept on average 22.8 ± 4.9 m (95% confidence limits) away from the families, a significantly greater distance than that between families ($t = 4.27$, $P < 0.001$).

TABLE D9.1. Sample sizes expressed as total numbers of scans in 10 day periods. Number of scans of goslings are given in brackets. Comments: a: hatching date estimated from the early development of the goslings; b: an immature goose was attached to the family; c: bracket gives the number of scans for the immature only.

	Hatched	Brood size	24/6-3/7	4/7-13/7	14/7-23/7	24/7-2/8	3/8-12/8	13/8-22/8
Family 1	21 June[a]	1	68 (28)	0	0	0	240 (84)	62 (31)
Family 2	?	2[b]	0	0	0	0	188 (72)	42 (21)
Family 3	?	3	0	0	0	0	231 (114)	111 (51)
Family 4	27 June	4[b]	56(28)[c]	0	0	0	0	0
Family 5	27 June[a]	5	70 (0)	64 (32)	207 (102)	0	283 (110)	139 (70)
Family 6	21 June	5	134 (62)	0	210 (97)	0	296 (110)	50 (21)
Non-breeders			103	1092	0	385	270	156

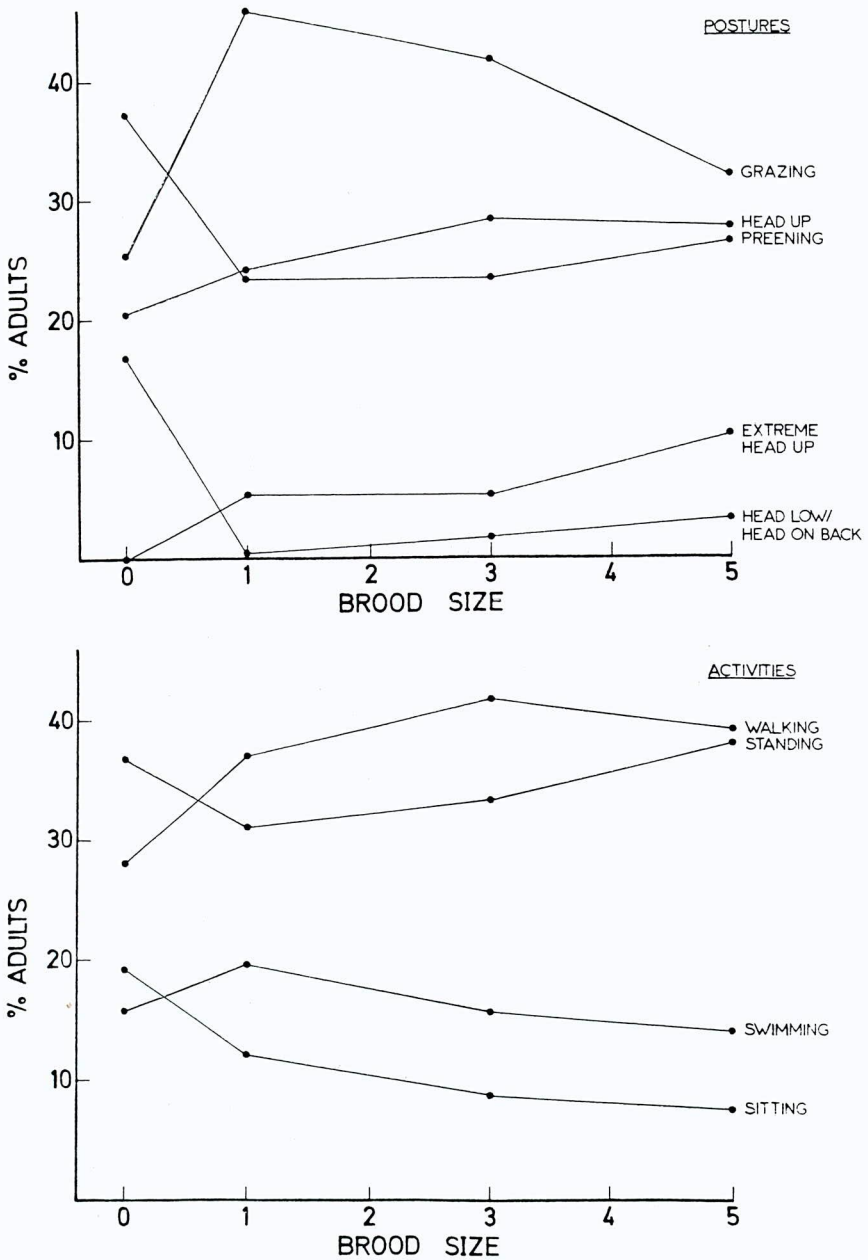


Figure D9.1. Relationship between behaviour and brood size (non-breeder pairs and families), expressed as time budgets (postures and activities, respectively).

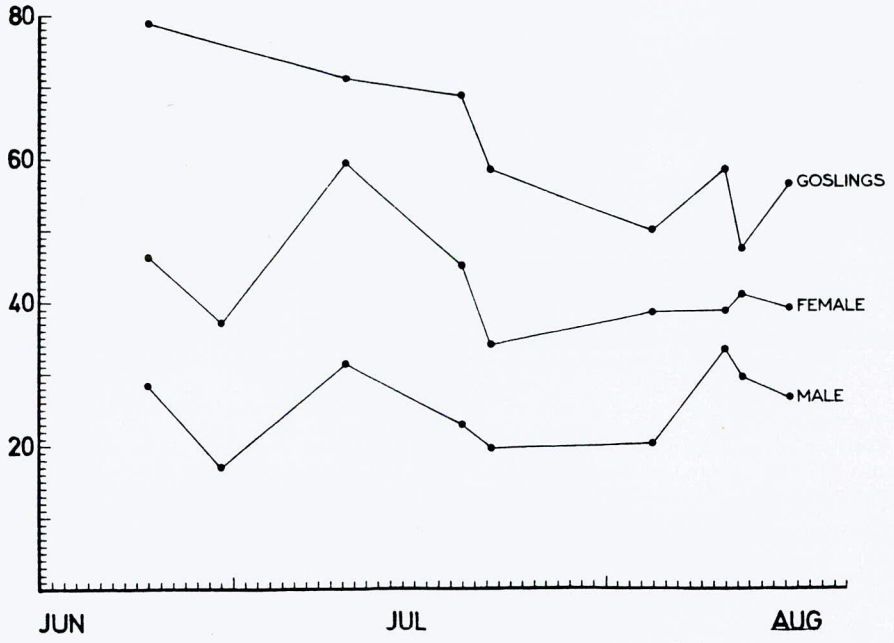


Figure D9.2. Grazing activity over the fledging period in families (broods of 5 only).

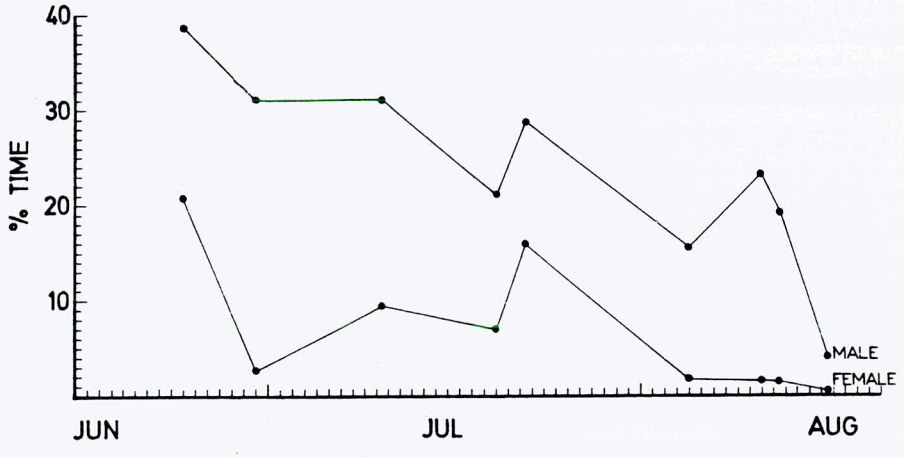


Figure D9.3. Extreme head up posture over the fledging period in families (broods of 5 only).

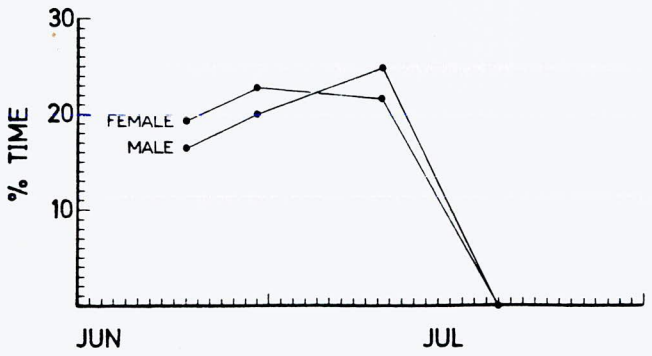


Figure D9.4. Brooding in families over the fledging period (broods of 5 only).

Encounters between groups

Encounters were observed on 24 occasions, including agonistic behaviour where a goose (or pair of geese) attacked another goose (or pair), running in a threat posture towards each other. Although there was not always physical contact, all attacks resulted in the retreat of the attacking bird. Of 18 encounters initiated by families the gander participated in all, but the female was seen to participate in only three of these attacks (17%).

Table D9.2 summarises the outcome of the encounters. The distance between birds just before the encounters was on average 4.3 m, and this did not vary between birds of different age, sex or breeding status. Encounters between families and non-breeders occurred more often than would be expected from the occurrence between families, taking into account the time non-breeders were observed in association with families (binomial test, $P < 0.001$).

DISCUSSION

The time allocation by families and non-breeders during the fledging period is consistant with present knowledge of nutritive demands and parental investment theory.

Response to nutritive demands

Raveling (1979) and Owen (1980) presented annual weight curves for both sexes of Canada and Lesser Snow Geese. These show that during incubation the nesting female loses weight, which is regained during the fledging period. A similar sequence is shown by the males although there is less overall variation in weight over the course of the breeding season. After hatching the goslings undergo rapid growth before fledging (Wurdinger 1975). The differing demands for food are reflected in the behavioural organisation within the family; thus the gander spends less time feeding than the female (although as indicated by Lazarus and Inglis (1978) and Prop *et al.* (1978) it might compensate for this by having a faster peck rate), and also spends longer alert to the benefit of the female and goslings.

The faecal analysis (section D8) revealed that the goslings had a different diet from the parents during the first weeks after hatching, but their food increasingly came to resemble the adult diet. This change in food selection coincided with a decline in the amount of time spent grazing. This could be for several reasons; it is possible that the feeding time is reduced because more efficient digestion offsets the smaller amount taken, or alternatively, it could be because growth of vegetation or the gosling bill later in the season means that a larger volume is ingested per unit feeding time.

From the time budgets of the non-breeders it would seem that they are able to obtain the necessary quantities of food throughout the moult period, although they show a weight loss in this period (section D10). The reasons for this are not clear, but may be related to food quality.

Behavioural responses of parents

The time-budgets presented suggest that rearing goslings imposes severe stress on the parents which must be more active and alert than non-breeding pairs, at the expense of plumage-care and sleeping. This is similar to the finding of Lazarus and Inglis (1978). Parents with larger broods have an extra burden as they spend even longer in vigilant postures, at the expense of grazing. Pink-footed Geese, however, show no increasing vigilance with larger brood sizes (Lazarus and Inglis 1978).

Geese become alert through either the head up or extreme head up postures. There is probably some functional overlap between the two vigilant postures, although since the parents spent more time extreme head up than did non-breeding pairs, this posture is likely to be more important for parental alertness. Vigilance is obviously of great importance to the parents, although the significance of the extreme head up posture in Pink-feet has been questioned by Lazarus and Inglis (1978). They concluded that the most likely function of the posture is for scanning for predators, and maybe for obtaining information on feeding sites, but that the posture is not important in monitoring the position of the goslings or in the regulation of spacing. They also found, unlike this study, that distances between individuals were similar for walking families and non-breeding pairs, and that the parent-gosling distance remained the same throughout fledging. A probable reason for this latter difference is that their study period extended from 18 July to 5 August, exactly the period in this study when there was no change in spacing (Figure D9.5; hatching dates were similar in the two studies). The reason for the former difference is not clear, and may be a species-specific difference due to the less social nature of the Greenland White-front.

As the young grow and become less vulnerable, the need to scan for predators becomes less, probably explaining the observed decline in the proportion of time spent extreme head up by the parents. The most likely explanation of the increased vigilance of adults with larger broods is that it takes longer to monitor the positions of more goslings, although why this should not also be the case for Pink-footed Geese (Lazarus and Inglis 1978) is not clear .

Another possible explanation of thegreatertime spent extreme head up by the parents of larger broods is that it takes longer to find good feeding sites since food is depleted at a faster rate. Thus geese in this posture might obtain feeding information, either by directly scanning for the sites or indirectly by watching the feeding of neighbours (Lazarus and Inglis 1978). Big families dominate smaller ones (Boyd 1953), and therefore neighbours can be ousted from their feeding sites.

In conclusion, the extreme head up posture seems to have several functions, the most important being scanning for possible danger, monitoring the position of the goslings and probably obtaining information on feeding sites. The reasons for the differences in behaviour between Greenland White-fronts and Pink-footed Geese in the same period are unclear.

Flock structure

The differences in flock structure between families and non-breeders suggests an adaptive significance. Owen (1972a) found that young geese walked faster than adults on the breeding grounds, and suggested (Owen 1976b) that the young geese were less efficient grazers. Families in winter were also found on the edges of flocks, where vegetation was denser and taller, so that the young could maintain a high intake rate despite inefficient action.

TABLE D9.2. Encounters between geese in July and August. In all encounters the attacker won.

		ATTACKED			
		Breeders (brood size)			Non-breeders
		5	3	1	
ATTACKER Breeders (brood size)	5	6	-	-	8
	3	-	-	1	3
	1	-	-	-	1
Non-breeders		-	-	-	5

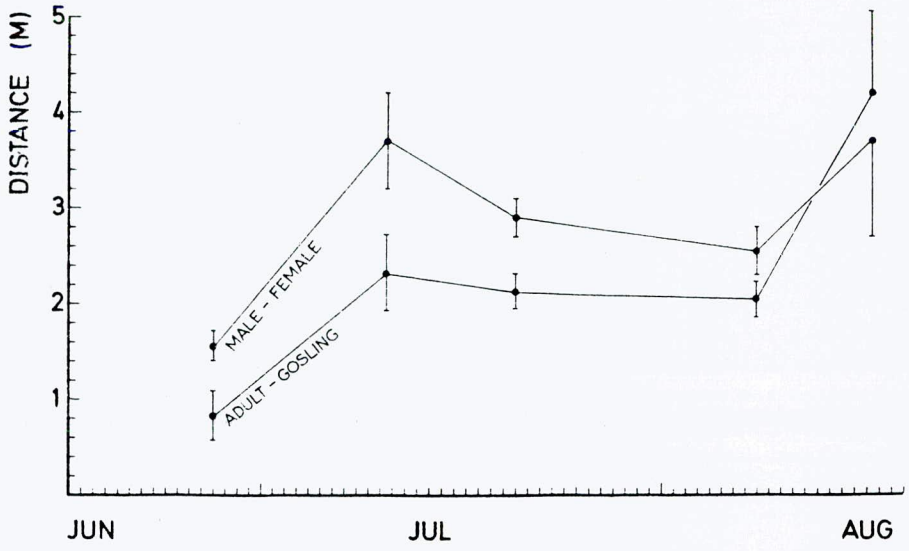


Figure D9.5. Spacing patterns in families (broods of 5 only) expressed as inter-adult and adult-gosling distances. Bars give 95% confidence limits.

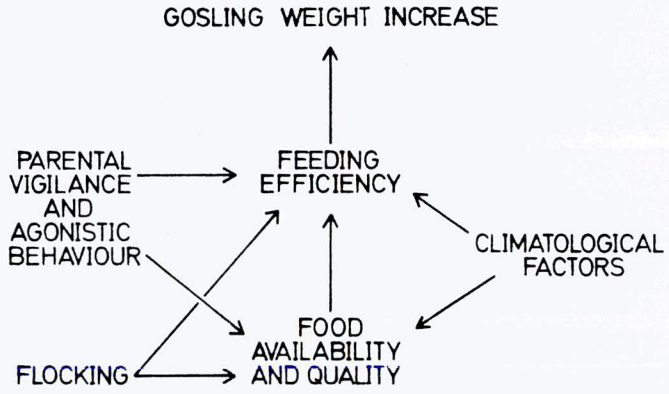


Figure D9.6. Scheme of components influencing weight increase of the goslings (further explanation, see text). Arrows indicate the direction of influence.

The situation may be similar in the loosely structured family flocks in summer. A greater spacing would be advantageous to the families, as the goslings would have more room for grazing. Moreover the biggest non-breeder flocks were separate from the families, and only a few non-breeders ever joined family flocks, most being actively chased off by the parent geese. Thus it seems that the non-breeders were 'unwanted' by parents. This may be related to the differing summer strategies of the breeders and non-breeders.

Non-breeders finish moulting earlier than families (section D10) so they can utilise other habitats before families. Since they were seen feeding along streams and in marshes away from lakes once they regained flight, it is of no advantage to non-breeders to join with still flightless families during this latter part of the moult period. It is advantageous for families to flock with other families as vigilance can be shared between the adult birds to the benefit of all, but disadvantageous to flock with non-breeders which profit from parental vigilance without contributing themselves; this was observed. Had non-breeders joined the family flock in large numbers, the lakeside vegetation, an important resource, might have been depleted at a faster rate.

Alloparental care of young

On three occasions immature geese associated with a family: in family 2 (see Table D9.1) an immature goose associated with the family, behaving as a gosling and keeping close to the adult geese. It was never vigilant. In family 4 (Table D9.1) an immature goose stayed close to the nest at about the time of hatching (see section D6 for details). It was often chased off by the gander, but three days after hatching it was adopted by the family, sharing vigilance with the adults and on one occasion leading the family in an extreme head up posture whilst the gander stood about 7 m away. An immature goose was seen once to join family 6 (Table D9.1). It was apparently associated with the family as no agonistic behaviour was seen among the geese. As the family saw the observer, the immature (not yet in moult), flew circling above and calling until the observer walked away over the ridge. The immature was never seen with the family again.

The break-up of the family usually occurs before or soon after the arrival on the breeding grounds (section D1); however there have been cases where yearling geese stay with their parents and accompany them back to the wintering grounds for a second winter together (Prevett 1972). There is some evidence that this happens in Greenland White-fronts since probable second year birds (on the basis of breast barring) have been seen loosely associated with families on Islay during November and December (Stroud pers. comm.). Both the ringed families resighted in 1980/81 had their young of 1979 still with them (section D10), although as in both cases one of the parents seems to have been missing (shot?) these may not be typical cases. Boyd (1953) did not notice any such association during his study of the wintering of European White-fronted Geese.

The immatures noted above may well have been yearling birds remaining with their parents for a second summer. This suggests some sort of alloparental care and rearing of the young, Various forms of co-operative breeding are known to exist in birds (Emlen 1978), but it is unusual in waterfowl. Recently, it has been described by Ely (1979) in Pacific White-fronted Geese. Brown (1974) gives several common features shown by most co-operative breeding birds. They usually have low fecundity, deferred maturity, high survival (long life), and low dispersal from their birth place. These are all characteristics of the demography of most arctic breeding geese, but several seem to be shown to a greater degree by Greenland White-fronts (Table D9.3). This may well indicate a greater propensity to show some alloparental care by Greenland White-fronts. Whilst one may suppose that in some geese such care may have been overlooked due to a lack of detailed investigation, there are some, such as Pink-feet, which have been the subject of intensive breeding studies, and it is probably safe to assume that such co-operative breeding never, or extremely rarely occurs, in such well-studied geese.

In summary, Figure D9.6 shows some of the components, environmental as well as behavioural, which influence the feeding efficiency and ultimately the weight increase of the goslings. Meteorological factors influence the feeding efficiency by directly reducing the time available for feeding, since in their first 14 days goslings are brooded during bad weather. Indirectly the weather affects plant production and thereby food quality. Vigilant behaviour serves a protective function in the family to the benefit of the goslings. Vigilant postures probably also serve to obtain information about feeding sites, so the goslings can be led to the best quality grazing. Gregariousness is advantageous to the family, as the flock probably serves as an information centre (Murton *et al.* 1971), as well as enabling vigilance to be shared. However, competition between families increases in larger flocks. Agonistic behaviour probably serves to ensure favourable spacing of feeding groups (Raveling 1966).

TABLE D9.3. Characteristics of co-operative breeders (after Brown 1974).

TRAIT	SHOWN BY ALL ARCTIC BREEDING GEESE?	ARE TRAITS SHOWN TO A GREATER EXTENT BY GREENLAND WHITE-FRONTS THAN OTHER ARCTIC BREEDING GEESE?	
Low fecundity	Yes	Yes	Low compared with other goose species. Proportion of young only 17.8% *cf.* 34% young for European White-fronts (Owen 1978). Only 810 successful breeding pairs on average from population of *c.* 15,000 birds (Ruttledge & Ogilvie 1979).
High survival (long life)	Yes	-	High mortality in first two years thereafter survival independent of age. Mortality 1-13 months probably *c.* 43%; 13-25 months old = *c.*34% (Boyd 1958b). This is slightly higher than other goose populations. Oldest ringed *A. a. albifrons* = 17.8 years (Rydzewski 1973).
Deferred sexual maturity	Yes	Yes	Capable of breeding at 2 years, but probably first breeding at 3-4 years. Given very low proportion of adults breeding, may even be later than this.
Low dispersal from natal site	Yes	-	Little or no data for Greenland White-fronts. Dispersal from breeding area to many winter flocks but probable return to same breeding area the following summer.
Permanently monogamous	Yes	No	
Single brooded	Yes	No	
Short, synchronous breeding season	Yes	No	

D10

RINGING AND RECOVERIES OF GREENLAND WHITE-FRONTED GEESE

P. J. Belman

Abstract

Ninety-six moulting Greenland White-fronted Geese were caught in Eqalungmiut Nunât, west Greenland in 1979. Catching techniques are described and data obtained listed. White-fronts increased their weight during the moult, which lasted about three weeks, with non- or failed breeders starting two weeks before breeders.

Large-numbered Darvic rings were used to follow winter dispersal. Fifty-three geese were found outside Greenland; two shot on passage in Iceland, the rest recovered in winter (46 sighted and nine shot, four of which were read first). These were scattered over most of the winter range, with 46 sighted and eight shot in Scotland, and one shot in Ireland, where three were seen but not read. Ring-reading effort was greater in Scotland than Ireland and the 8:1 ratio of shot birds is the only estimate of dispersal between countries.

It is concluded that the Eqalungmiut Nunât population was distributed fairly evenly across Scotland, with a much smaller proportion wintering in Ireland. The small Dyfi Estuary flock in Wales contained no marked birds.

CATCHING

Introduction

In late summer adult* geese become flightless during the simultaneous moult of wing and tail feathers and can be herded, with varying success according to species, into a corral of netting to be caught for study, ringing and release. Families can be caught intact for ringing, as the young are large enough to retain a ring before their parents complete the moult.

Successful round-ups exploit the escape behaviour of geese under threat from man. A feeding area or flock is surrounded unseen by the catchers who, at a pre-arranged signal or time, appear from cover and move inwards encircling and containing the geese. Pink-footed Geese assemble on hillocks when surrounded (Scott *et al.* 1955) and Barnacle Geese take refuge on lakes or the sea (Jackson *et al.* 1974). A handful of people can keep the flock on a hilltop or in the centre of a lake, while Snow Geese can be marshalled on land for considerable distances (Cooch 1957).

Once the flock is under control a catching pen is set up nearby and the geese are driven in. A large flock bunches and behaves as a unit, and can be directed into a small funnel of netting by a few catchers. Smaller parties are harder to control and need more catchers and longer wings of netting. Individuals tend to separate and escape if the flock is approached too closely, a situation that applies irrespective of group-size to Greylag Geese, which can only be driven into pens camouflaged by vegetation in an area familiar to them (Ogilvie 1978).

The species mentioned above congregate in favoured areas for the moult and are, excepting Greylags, easily caught in large numbers. Greenland White-fronted Geese present special problems since flocks are invariably small and are scattered over a wide area. The catching team needs to make frequent catches and cover as large an area as possible, and must be both mobile and independent of base-camp for days at a time, since much time and effort is needed to make each small catch. This paper describes the first large-scale ringing of Greenland White-fronts using large-numbered Darvic colour rings.

Equipment

Equipment was chosen for lightness and portability, with the constraints that it should be available at reasonable cost and durable enough for re-use in future years. Dual-purpose usage was intended for several items, for instance net stakes as mist-net poles and boats as ferries.

The catching pen was made from a 25 x 1.3 m 15/4 black polythene 19 mm square-mesh net threaded with 2 mm nylon cord tethered top and bottom (weight 2.6 kg), supported on twelve 1.6 m x 19 mm aluminium angle stakes (weight 5.9 kg) drilled so the net could be attached top, middle and bottom by 38 cm x 2 mm nylon cord ties, with the stakes pushed 30 or 15 cm into, or resting on, the ground, depending on the soil depth. The netting supplied was 1.5 m high (weight 3.0 kg) and the extra 20 cm was threaded and used as a stop to prevent geese jumping from the pen. This was found to be unnecessary and was discarded. This net could be shaped into a triangular or square pen of variable size with a narrow entrance and two short wings.

Long wings were made from one 50 m and two 25 m lengths of 1 m 4Z black nylon 29 mm square-mesh netting threaded with 2 mm nylon cord and tethered at the top (weight 3.3 kg), supported on twelve 1.2 m x 19 mm aluminium angle stakes (weight 4.4 kg) drilled so the nets could be tied as above with the stakes pushed 20 or 10 cm into, or resting on, the ground. These wings were used as lead-in extensions to one or both sides of the catching pen, to form a V-shaped funnel (Figure D10.1).

Guying was preferred to using longer and heavier stakes. The pen and wings were guyed as necessary with 4.5 m lengths of 2 mm nylon cord, and the pen especially was cross guyed to make a rigid structure. The bottom of the nets and the guys were held by 100×18 cm steel pegs (weight 1.6 kg), used double in an inverted V to give a firm anchorage.

Two inflatable PVC boats with paddles, of nominal three-man capacity (weight 5.9 kg each), were used to drive geese from the water (section L8). Three hand-held radios (weight 1.9 kg each, section L4) were taken for co-ordinating round-ups, and whistles and compass mirrors used for signalling. Three 50 cm diameter hand-nets on aluminium hoops with 70 cm wooden handles were made from 9 mm netting (weight 0.6 kg each), and although used for catching other species, were convenient weighing bags for geese.

The nets were entirely adequate and required almost no repairs. No geese jumped the netting and those that did escape either walked round the wings or, towards the end of the moult, flew over the top. The main net was carried with the stakes tied ready for use rolled up as a bundle. The wings were usually carried separately from their poles and assembled as required. The number of pegs taken was barely enough; 130 would have been better. The three hand-held radios were stronger, heavier and more powerful than necessary. Ideally six lightweight plastic sets should have been taken. The inflatable boats performed surprisingly well and the few punctures were easily mended. Care had to be taken with the plastic paddles which cracked if stepped on.

* For convenience 'adult' is used throughout to include first-summer birds and 'young' to describe pulli, juveniles and first-winter birds until their return to Greenland.

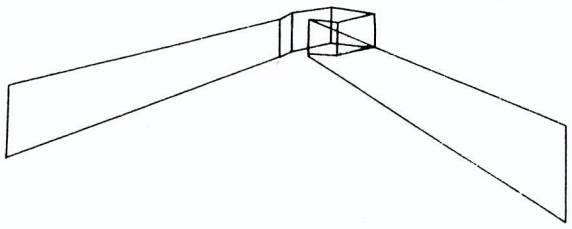


Figure D10.1. Diagram of catching pen and net funnel.



Figure D10.2. Three-character Darvic rings.

Colour rings were made from 2.25 mm PVC Darvic laminate, cut into 30-35 x 75 mm blanks and engraved with a three-character code repeated three times, using a 14 mm character height. These were shaped in a 22 mm mould to form an oval ring with about 15 mm of overlap, with internal dimensions of 15 x 17 mm (Figure D10.2). The bottom of each ring was bevelled on the inside edge, so that it would not cut the leg. Circlip pliers fitted with extended lugs were used to expand to rings for fitting.

Methods

Moulting White-fronts in Eqalungmiut Nunât were found on the plateau lakes, feeding close to the edge of the water (section D1). Flocks were very sensitive to disturbance, reacting to a human figure at a range of over 1 km by running quickly up the opposite hillside. Geese surprised at short range were reluctant to leave the water and would crouch under the far bank. To survey each lake for geese a slow and careful approach to a suitable vantage point was needed, followed by an equally cautious retreat. The use of sombre clothing was essential.

Once the geese were located, a control point was set up overlooking the flock and the catching party spread out to encircle the lake. This was the most difficult part of the round-up. While the geese continued to feed the catchers executed a pincer movement, using dead ground to stay out of sight. This involved detours to work round the back of inconvenient hills, and took up to two hours at large lakes. Radios were indispensable to co-ordinate these manoeuvres, especially when a flock moved from one end to the other of a large lake, and pre-arranged instructions had to be modified. Mirror flashes and hand-signals were useful to give general instructions, where dead ground such as concave ridges above opposite sides of a lake enabled catchers to see each other clearly while out of sight of the geese.

When all the catching party was suitably positioned, a whistle signal was given for everyone to appear simultaneously and close in on the lake. If the flock was feeding close to one bank, a radio or hand signal was used to instruct the nearest catchers to appear from cover first, starting the geese towards the far shore. As the flock reached the centre of the lake the whistle was sounded for the remainder of the catchers to appear. The flock was then easily kept in the middle of the lake by each of the catchers speeding or slowing his rate of approach as the geese swam towards or away from him. Usually a lake could be more closely approached using dead ground from one direction than the others, and it was then important for the nearest catchers to maintain a low profile during the initial stages. Occasionally a flock was found or surprised on a small lake which could be surrounded by a quick sprint, since geese would not take to land without a head-start.

With the lake surrounded, three or four catchers could keep the geese in the centre while the others inflated the boats and put up the nets. Except for the need for the pen to be on dry ground, siting the nets was not critical. The narrowest arm of a lake was usually chosen, so the escape to open water could apparently be blocked by catchers on shore as well as by the boats. The nets were set with the wings reaching the water to form a funnel leading from the lake to the pen, the size of which was kept as small as necessary for the number of geese to be caught. On uneven ground any gaps under the netting were filled with moss and rocks.

TABLE D10.1. Summary of catches of Greenland White-fronted Geese (*Anser albifrons flavirostris*).

Ring number	Darvic	Age/sex	Weight(kg)	Moult score	Belly score	Flock size	Date	Co-ordinates	Site name	Notes
278301	A01	4♂	2.5	3	-	12	10.07.79	67°37'N 50°23'W	Uniform	
278302	A02	4♂	2.5	3	-	"	"	"	"	
278303	A03	4♀	2.1	2	-	"	"	"	"	
278304	A04	4♀	2.0	3	-	"	"	"	"	
278305	A05	4♂	2.3	2	-	"	"	"	"	
278306	A06	4♂	2.6	2	-	"	"	"	"	
278307	A07	4♀	2.2	2	-	"	"	"	"	
278308	A08	4♀	2.0	2	-	"	"	"	"	
278309	A09	4♀	2.3	2	-	"	"	"	"	
278310	A10	4♂	2.6	1	-	"	"	"	"	
278311	A11	4♀	2.0	2	-	"	"	"	"	
278312	A12	4♂	2.5	2	3	17	11.07.79	67°36'N 50°37'W	Zulu	
278313	A13	4♀	2.1	2	2	"	"	"	"	
278314	A14	4♀	2.4	2	1	"	"	"	"	
278315	A15	4♂	2.5	1	5	"	"	"	"	
278316	A16	4♂	2.6	2	4	"	"	"	"	
278317	A17	4♂	2.6	2	1	"	"	"	"	
278318	A18	4♂	2.5	1	2	"	"	"	"	
278319	A19	4♂	2.5	2	3	"	"	"	"	
278320	A20	4♀	2.3	2	1	"	"	"	"	
278321	A21	4-	2.4	2	3	"	"	"	"	
278322	A22	4♀	2.2	2	2	"	"	"	"	
278323	A23	4♀	1.9	2	1	"	"	"	"	
278324	A24	4♀	2.2	2	1	"	"	"	"	
278325	A26	4♀	2.2	2	1	"	"	"	"	
278326	A27	4♀	2.0	1	1	"	"	"	"	
278327	A28	4♂	2.5	2	3	"	"	"	"	
278328	A29	4♀	2.1	1	2	"	"	"	"	
278329	A30	4♂	2.6	1	3	9	13.07.79	67°37'N 50°40'W	Mirrormere	
278330	A31	4♂	2.7	1	2	"	"	"	"	
278331	A32	4♀	2.0	2	3	"	"	"	"	
278332	A33	4♀	2.1	2	1	"	"	"	"	
278333	A34	4♀	2.2	2	5	"	"	"	"	
278334	A35	4♂	2.5	2	1	"	"	"	"	
278335	A36	4♀	2.2	2	1	"	"	"	"	
278336	A37	4♀	2.2	1	1	"	"	"	"	
278337	A38	4♀	2.2	2	1	"	"	"	"	
278320	*A20*	*4♀*	*2.2*	*2*	-	*6*	*15.07.79*	*67°35'N 50°44'W*	*Spidermere*	*7 km WSW*
278323	*A23*	*4♀*	*1.7*	*3*	-	"	"	"	"	*7 km WSW*
278328	*A29*	*4♀*	*2.0*	*2*	-	"	"	"	"	*7 km WSW*
278338	A39	1-				16	26.07.79	67°41'N 50°16'W	Worm	Pts A49/48?
278339	A41	1-				"	"	"	"	Pts A49/48?
278340	A42	1-				"	"	"	"	Pts A49/48?
278341	A43	4♂	2.8	4	4	"	"	"	"	
278342	A44	4-	2.5	4	5	"	"	"	"	
278343	A45	4♀	2.4	4	5	"	"	"	"	
278344	A46	4-	2.5	4	3	"	"	"	"	
278345	A47	4-	2.4	4	4	"	"	"	"	
278346	A48	4♀	2.1	2	1	"	"	"	"	Pd A49? B3P?
278347	A49	4♂	2.4	3	4	"	"	"	"	Pd A48? B3P?
278348	A50	4♀	2.3	4	4	"	"	"	"	
278349	A51	4♂	2.5	4	5	"	"	"	"	
278350	A52	4-	2.4	4	4	"	"	"	"	

TABLE D10.1. (continued)

Ring number	Darvic	Age/sex	Weight(kg)	Moult score	Belly score	Flock size	Date	Co-ordinates	Site name	Notes
278351	A53	4♂	2.4	1	3	16	27.07.79	67°42'N 50°13'W	Lake 72	Pd A54? B3P?
278352	A54	4♀	2.3	1	4	"	"	"	"	Pd A53? B3P?
278353	A55	1-				"	"	"	"	Pts A53/54?
278354	A56	1-				"	"	"	"	Pts A53/54?
278355	A57	1-				"	"	"	"	Pts A53/54?
278356	A58	4-	2.4	4	-	14	"	67°43'N 50°13'W	Lake 42	
278357	A59	4-	2.4	4	-	"	"	"	"	
278358	A60	4-	2.4	4	-	"	"	"	"	
278359	A61	4♀	2.4	4	-	"	"	"	"	
278360	A62	4-	2.5	4	-	"	"	"	"	
278361	A63	4♂	2.8	4	-	"	"	"	"	
278362	A64	4♂	2.4	2	1		28.07.79	67°42'N 50°15'W	Lake 33	Pd A65 B4P
278363	A65	4♀	2.2	2	3		"	"	"	Pd A64 B4P
278364	A66	1-					"	"	"	Pts A64/65
278365	A67	1-					"	"	"	Pts A64/65
278366	A68	1-					"	"	"	Pts A64/65
278367	A69	1-					"	"	"	Pts A64/65
278368	A70	4♂	2.8	2	2	16	**29.07.79**	67°38'N 50°12'W	Lake 58	Pd A72 B3P
278369	A71	4♂	2.6	4	3	"	"	"	"	
278370	A72	4♀	2.3	2	2	"	"	"	"	Pd A70 B3P
278371	A73	1-				"	"	"	"	Pts A70/72
278372	A74	1-				"	"	"	"	Pts A70/72
278373	A75	1-				"	"	"	"	Pts A70/72
278374	A76	1-				46	06.08.79	67°36'N 50°30'W	Axewater	Pt 278390
278375	A77	1-				"	"	"	"	
278376	A78	1♂				"	"	"	"	Pt 278390
278377	A79	1-				"	"	"	"	
278378	A80	1-				"	"	"	"	Pts A94/96
278379	A81	1-				"	"	"	"	Pt 278390
278380	A82	1-				"	"	"	"	
278381	A83	1-				"	"	"	"	
278382	A84	1-				"	"	"	"	
278383	A85	1-				"	"	"	"	
278384	A86	1-				"	"	"	"	Pts A94/96
278385	A87	1-				"	"	"	"	
278386	A88	1-				"	"	"	"	Pts A94/96
278387	A89	1-				"	"	"	"	Pts A94/96
278388	A90	1-				"	"	"	"	
378389	A91	1-				"	"	"	"	Pts A94/96?
278390	-	4♂	2.7	3	3	"	"	"	"	B
278391	A92	4-	2.4	4	1	"	"	"	"	B
278392	A93	4-	2.5	4	1	"	"	"	"	B
278393	A94	4♂	2.4	4	3	"	"	"	"	Pd A96 B5P
278394	A95	4♂	2.7	4	5	"	"	"	"	B
278395	A96	4♀	2.3	4	1	"	"	"	"	Pd A94 B5P
278396	A97	4-	2.4	3	3	"	"	"	"	

Notes: Site names are unofficial. Retraps are entered in italics. Age: 1 = pullus, 4 = 'adult'. Primary moult is recorded on a six point scale from 0(old) to 5(new). Belly score is an assessment from photographs of the extent of barring on a five point scale of increasing area covered. Pd = paired. Pts = parents. B-P = breeding bird with number of pulli in brood.

As soon as the nets were ready, the catchers between the geese and the nets withdrew behind the flock and the boats moved on to the water. The geese then swam quickly to the unguarded end of the lake and, by movements of the boats and catchers, could be positioned centrally in the open V of the nets. Sometimes the geese ran onto land and into the funnel at once, but usually some coercion was needed to induce them to leave the water. Once ashore most found their own way into the pen through the narrow entrance, but sometimes one crouched on the ground and often several were waiting by the entrance when the catchers and boats reached the open end of the funnel. A slow walk towards the pen flushed any crouching birds and drove in the remainder. One person entered the pen with the geese, keeping as still as possible, and the entrance was closed.

The rest of the party was withdrawn to a processing point out of sight of, or some distance from, the pen. Trapped geese remain remarkably calm, and would usually sit worrying at the netting with their bills. Each was picked up as required and passed to a runner who, avoiding sudden movements near the pen, ferried it to be ringed. Each goose was marked with a standard Copenhagen metal ring on the left leg and a white Darvic ring on the right, and, if adult, scored for wing moult and weighed before being individually released. Pulli were processed first and released together. Cloacal sexing of adults was attempted without success and abandoned, and most were photographed (section D12).

A maximum of twelve people was available for round-ups, more than was needed even at the largest lakes. One was completed with only four, but this was hardly sufficient to carry the catching equipment. The ideal was six to eight, enough to carry all equipment and up to four days food, which enabled the catching party to operate throughout the study area. Even so, the amount of time and physical effort required to locate White-fronts, transport equipment, surround the lake and complete the catch, was considerable; and the difficulties were compounded by the distance between the flocks and their small size. Only once were two catches made in one day.

Results

Ringing

An area of 750 km^2 was covered during the moult, containing an estimated 200 White-fronts including about 50 pulli (these figures are an attempt at an absolute count and are lower than those obtained by extrapolation from census data) (section D1). Ten catches were made and a total of 96 ringed, of which 67 were adults and 29 pulli. All but one adult with an old leg injury, probably from shot, were also Darvic-ringed. Table D10.1 summarizes the catches and lists the data for each goose. Those ringed on 11 July were disturbed by our activities two days later and some moved 7 km to another lake where three were inadvertently recaught on the 15th. The location of catching sites is shown in Figure D10.3.

Including a brood of six which made its first flight during an attempted round-up on 9 August, the mean size of ten broods large enough to ring was 3.5 young (section D1). Family relationships were not always determined in mixed catches, and on 6 August, when five broods were caught together, siblings could not be distinguished; those listed were obtained from winter observations.

Sexing

Only a few adults with young were sexed in Greenland, as cloacal sexing proved impossible. Those listed in Table D10.1 were sexed on extremes of weight, and by behaviour or post-mortem in winter. Despite the ranges given in Cramp and Simmons (1977), sexing on bill length, or, better, total skull length, is reliable and would have sexed the majority of adults had it been used.

Weights

All adults were weighed to the nearest 0.1 kg on a 20 kg Pesola balance. The weights are listed in Table D10.1 and summarized in Table D10.2, in which an arbitrary division of the catching period has been made in the third week of July. Weights of geese caught earlier in the season (mean 2.28 kg) are significantly different ($t_{66} = 3.47$, $P < 0.001$) from those caught later (mean 2.45 kg). This is considered below.

Moult

Adults were scored for primary moult on a five-point scale: 0 primaries old, 1 missing or in pin, 2 quarter-grown, 3 half-grown, 4 three-quarter-grown and 5 primaries new. Only geese in active moult (stages 1-4) were caught. Moult scores are listed in Table D10.1, and the weights of geese at each moult stage are presented in Table D10.3 and Figure D10.4. Weights were lowest at stage 2 and increased during the latter half of the moult, accounting for the observed difference in weights between birds caught early or late in the season.

Moulting geese could be divided into two groups: early (non- or failed breeders, 52 ringed) which started the moult in the first week of July and finished in the last, and late (breeders, 15 ringed as indicated in Table D10.1) which started in the third week of July and finished in the second week of August, coinciding with the first flight of the young. The moult took about three weeks, and both groups of birds showed a similar pattern of weight gain, which is detailed in Table D10.4.

MOVEMENTS

Introduction

Greenland White-fronts winter in Ireland, the west and north of Scotland, and in Wales (Ruttledge and Ogilvie 1979). The winter distribution corresponds with a mean January temperature of >3°C bounded by the nominate sub-species to the south and east. On spring and autumn passage south-west Iceland is used as a staging point (see section D15), although it is probable that some make the direct flight of 2500 - 3200 km from west Greenland to Ireland and Britain without stopping (Cramp and Simmons 1977). There are occasional records from eastern North America (Palmer 1976), but the three ringing recoveries are all from the St Lawrence area in October and do not seem to represent a wintering population.

Geese staging in Iceland need to change their direction of migration clockwise from that required to cross the icecap (in autumn from between SE by E for the most northerly breeders and E for the most southerly to between SSE and ESE, depending on whether they are to winter in Ireland or Scotland). It is interesting to speculate that the observed tendency for White-fronts from the northern part of the range to winter in Ireland and those from the south to winter in Scotland (Salomonsen 1967a) can be explained by all birds making a similar angular change in orientation after staging.

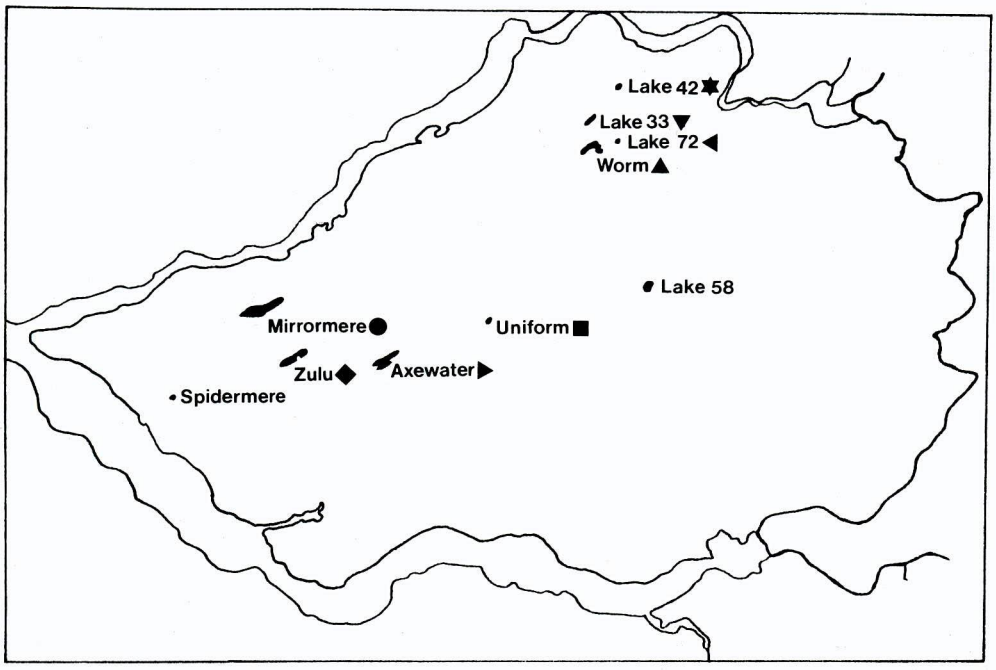


Figure D10.3 Catching sites in Eqalungmiut Nunât; symbols identify later sightings shown in Figures D10.5 and D10.6.

TABLE D10.2. Weights of Greenland White-fronted Geese (*Anser albifrons flavirostris*).

WEIGHT (kg)	*n*	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	MEAN	S.D.
10-15 July	40	1		1	6	4	9	3	2	8	5	1		2.28	0.24
26 July - 6 August	30					1	1	4	13	5	1	2	3	2.45	0.17
All	70	1	0	1	6	5	10	7	15	13	6	3	3	2.35	0.23

Note: The mean for 10-15 July is 2.31 (n = 37) and the overall mean 2.37 (n = 67) if retraps are excluded.

TABLE D10.3. Weights (kg) and moult stage of Greenland White-fronted Geese (*Anser albifrons flavirostris*).

MOULT STAGE	1	2	3	4
n	10	31	6	20
Mean	2.39	2.29	2.42	2.48
S.D.	0.23	0.21	0.23	0.14
S.E.	0.08	0.04	0.10	0.03

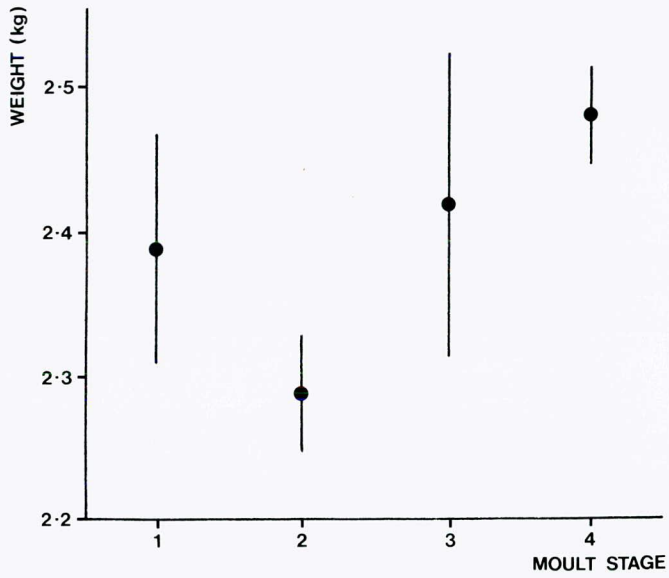


Figure D10.4. Weights and moult stage of Greenland White-fronted Geese *(Anser albifrons flavirostris)*. Means ± 1 S.E. are plotted.

TABLE D10.4. Weights (kg) and moult stage of non- or failed breeding and breeding White-fronted Geese (*Anser albifrons flavirostris*). Means ± 1 S.D. are given, with sample size in brackets.

MOULT STAGE	1	2	3	4
Non-breeding	2.40 ± 0.26(8)	2.27 ± 0.21(26)	2.33 ± 0.29(3)	2.49 ± 0.15(15)
Breeding	2.35 ± 0.07(2)	2.36 ± 0.27(5)	2.50 ± 0.17(3)	2.46 ± 0.15(5)

This winter segregation of geese from different parts of the breeding range has been used to account for the differences in annual breeding success measured in winter at Wexford, Ireland and Islay, Scotland. The Wexford birds (the more northerly breeders) have on average a higher percentage of young and larger brood size than those on Islay (Ogilvie 1978, Ruttledge and Ogilvie 1979). Since Eqalungmiut Nunât is in the centre of the breeding range, and the brood size of the families caught there in 1979 was intermediate between the winter brood sizes in Ireland and Scotland, it was difficult to predict where the Darvic ringed birds would winter. Brood size can only decrease with mortality from fledging to winter, so this would indicate that the Eqalungmiut Nunât White-fronts were perhaps more likely to winter in Scotland.

Recoveries and sightings

Of the 96 White-fronts ringed in Eqalungmiut Nunât no less than 53 have been recovered outside Greenland. Eleven of these were shot, and 46 read, four of which were later shot. Table D10.5 lists all recoveries and sightings reported by August 1981. Two birds ringed as pulli were shot in south-west Iceland, one in October 1979, the other in October 1980; the remaining recoveries (Figure D10.5) were from wintering birds in Scotland and Ireland. The wide dispersal of geese from one small area of Greenland to almost all parts of the winter range is both surprising and unexpected.

The distribution of the recoveries in Table D10.5 between Ireland and Scotland, and between sites in Scotland, needs to be interpreted with caution. Few Darvic rings are read by observers who are not scanning flocks for that purpose, and the distribution of sightings reflects the pattern of ring-reading effort. In addition, sightings are affected regionally by ease of access and approach to flocks, and by habitat as long grass and stubble may hide the rings. Observer effort was much greater in Scotland than Ireland (and within Scotland more intensive on Islay and in Caithness), and the Scottish flocks are generally more accessible and easily approached.

Ireland (all sites)

It is difficult to decide whether a significant proportion of ringed geese wintered in Ireland and were not detected, or whether the lack of sightings (and particularly of birds shot) indicates a real trend. Only one recovery from Ireland was confirmed; a non-breeder from the Uniform catch shot at Wexford in December 1980. Up to three Darvics have been seen but not read, one in December 1979 at Akeragh Lough, Co. Kerry and two together in April 1980 at Lough Gara, Co. Sligo. These three locations are from widely separated parts of Ireland, and can be compared to the wide spread of Scottish recoveries. Coverage in Ireland is discussed below.

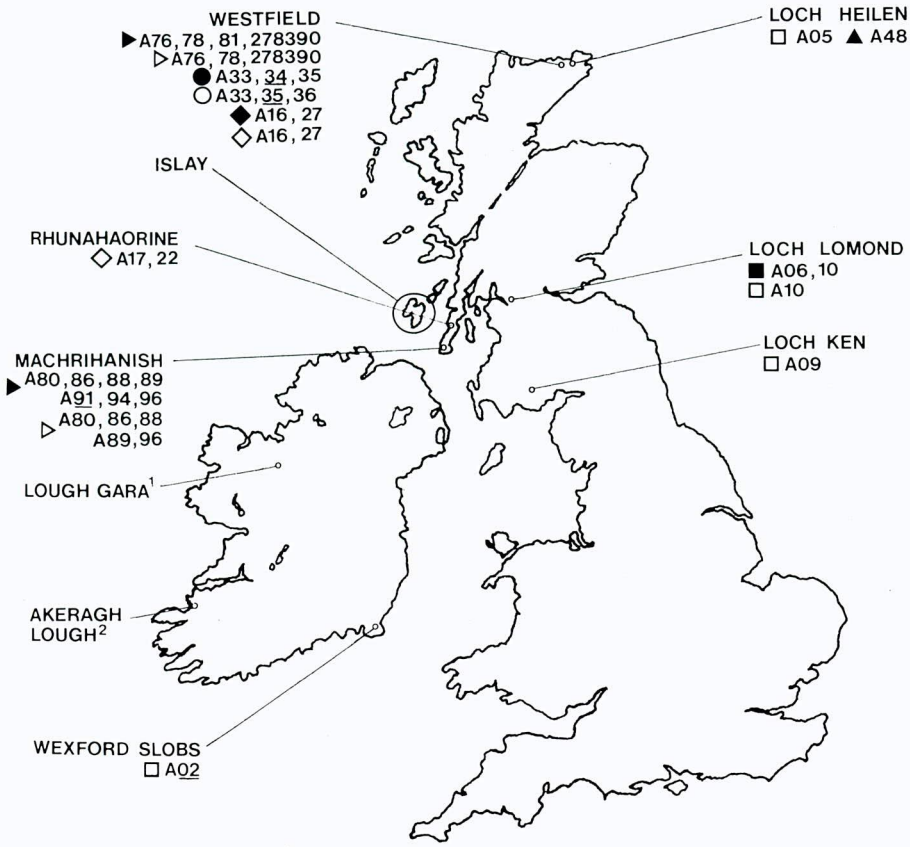


Figure D10.5 Recoveries in winter of Greenland White-fronted Geese (*Anser albifrons flavirostris*) ringed in Eqalungmiut Nunât. Ring numbers are listed by catching site (symbols as in Figure D10.3); closed symbols indicate sightings during winter 1979/80; open symbols indicate sightings during winter 1980/81. Underlined numbers indicate shot birds. See Table D10.5 for details of [1] and [2] which are unconfirmed Irish records. Islay recoveries are mapped in Figure D10.6.

Scotland

Caithness

A total of twelve ringed geese is known to have wintered in Caithness. One family of three young and one ringed parent (whose identity was determined by the association, a leg injury and the presence of only a metal ring, since the injury meant that a Darvic could not be fitted) and a party of five non-breeders wintered at Westfield. The family and the party were present in the same flock, but moved independently of each other within the flock. The five geese forming the party came from the Zulu and Mirrormere flocks of non-breeders which probably combined in Eqalungmiut Nunât soon after the moult. One other ringed goose from the Mirrormere flock was shot in Caithness but the exact locality is not known. The family was ringed in the Axewater catch. Two individuals were seen at different times at Loch Heilen, one was ringed at Uniform as a non-breeder, the other at Worm as a breeder. Neither of these sites provided any other Caithness recoveries. Both the family and the party of non-breeders were recorded at Westfield in the 1979-80 and 1980-81 winters; in the latter winter the young still associated with their parent (which had not bred successfully in 1980) and the party with each other.

Islay

A total of 28 ringed geese is known to have wintered on Islay (Figure D10.6). Two pairs and a party of eight non-breeders, and a family with four young, a total of 18 ringed geese, were recorded in 1979-80 in the Avenvogie/Cluanach area in the central part of the island. The party of eight, each of the two non-breeding pairs, and the family, although often seen together, behaved as discrete units moving independently within the flocks. Seven of the party of eight (one of which was shot in December 1980) and one of the non-breeding pairs wintered in the same area in 1980-81. The other non-breeding pair, not recorded on Islay after December 1979, was found the following winter on the mainland at Rhunahaorine, Kintyre, the only other than local movement between winter sites detected. The family also was not seen on Islay after December 1979, but one parent was shot in January 1981 at Mulindry, not far from Avenvogie, indicating that the rest of the family may have spent the 1980-81 winter on the island without being discovered.

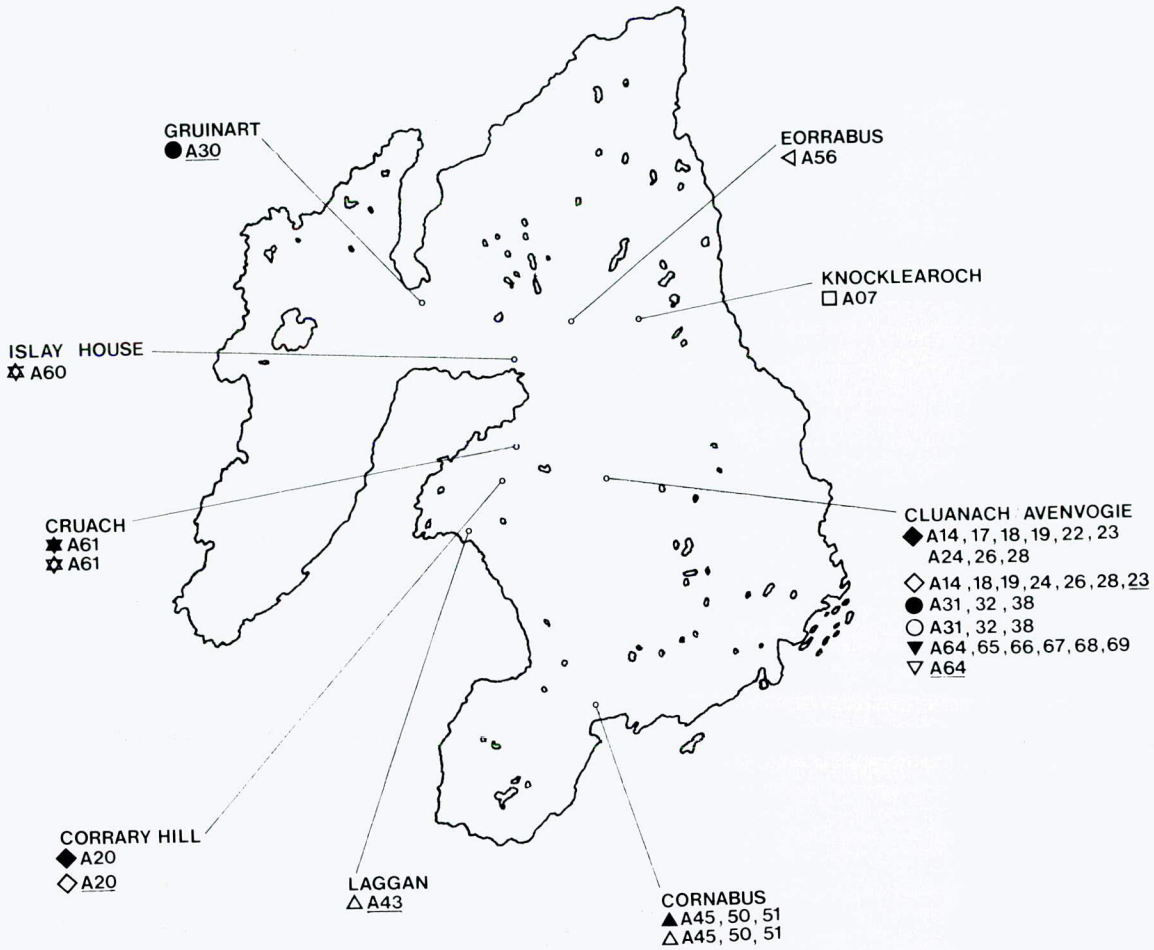


Figure D10.6 Recoveries on Islay in winter of Greenland White-fronted Geese (*Anser albifrons flavirostris*) ringed in Eqalungmiut Nunât. Ring numbers are listed by catching sites (symbols as in Figure D10.3); closed symbol indicates sightings during winter 1979/80; open symbols indicate sightings during winter 1980/81. Underlined numbers indicate shot birds.

A party of three ringed non-breeders probably spent the 1979-80 and 1980-81 winters at Cornabus, in the south of Islay, although in both years this party was seen only in March*. The Oa was searched earlier each winter on several occasions without their being seen and the possibility remains that they spent the first part of each winter elsewhere.

Six ringed non-breeders were reported from other parts of Islay. One was shot at Gruinart and another at Laggan, each in 1979 without being sighted first. Two were present in both the 1979-80 and 1980-81 winters, one at Corrary the other at Cruach, each female paired with an unringed male. The Corrary bird was shot at a nearby roost in December 1980 and the Cruach bird lost its mate after a shoot in the same month but paired with a different male after only eight weeks. (Unringedassociates of ringed White-fronts were recognised individually by their belly markings.) Two ringed non-breeders were each seen once only, both in December 1980, one at Knocklearoch paired with an unringed bird, the other at Islay House. A pullus ringed at Lake 72 was also seen once only at Eorrobus in March 1981, noted as paired to an unringed bird. These sites were searched on other occasions in both winters when no ringed geese were seen.

The party of eight and both pairs of non-breeders at Avenvogie, the Corrary and the Gruinart birds were all ringed in the Zulu and Mirrormere flocks that produced the party of five and one other recovery in Caithness. The party of three at Cornabus and the non-breeder shot at Laggan were ringed together at Worm, a flock that also produced a Caithness record. The Cruach and Islay House birds were both ringed at Lake 42, the only recoveries from this flock. The Avenvogie family was not associated with other birds when ringed in Eqalungmiut Nunât at Lake 33.

Ringed White-fronts recorded on Islay more than once in the same winter, or in both winters, were site-faithful, moving only short distances (<5 km) between suitable areas. However one pair was found on Kintyre in the second winter and, as the island was covered thoroughly, especially in 1980-81, some of the geese that were seen only once, or in only one part of the winter, may have spent the rest of the winter elsewhere.

* This party comprised Darvics A45, A50 and A51. In 1980 three ringed geese were seen on two dates but noted as A45, A51 and A55. A55, ringed as a pulli, was not noted as a juvenile and was almost certainly a misreading of A50. This record has been discarded. In 1981 the party was seen only once but A50 was confirmed as the third member with A45 and A51.

Kintyre

A pullus ringed at Axewater was shot at Machrihanish in November 1979, and a ringed family with four young spent the 1979-80 winter in the same area. The rings were not read until February 1980 but proved to be from the Axewater catch. The parents were the pair that was intensively studied in Eqalungmiut Nunât, and had reared five young (section D6). It seems likely that the juvenile shot was from the same brood. The remaining four young were together at Machrihanish in the 1980-81 winter, behaving as a party. The female parent, without a mate and having failed to breed successfully, was seen once accompanying the previous year's young at Machrihanish in the 1980-81 winter.

The non-breeding pair seen in November-December 1979 at Avenvogie, Islay was present at Rhunahaorine in December 1980, a shift of 36 km to the east. Rhunahaorine was visited a number of times in both winters, but some of the geese feed out of sight and the pair may have been present at other times.

Loch Lomond

Two ringed non-breeders from the Uniform catch were seen at Endrick Mouth, Loch Lomond in March 1980, the only occasion the site was checked that winter. One of these was seen again in March 1981. Earlier visits in the 1980-81 winter did not produce any sightings, but Endrick Mouth is difficult to check and few White-fronts were scanned.

Loch Ken

A ringed non-breeder from the Uniform catch was seen at Parton, Loch Ken in January 1981, paired to an unringed male. Loch Ken was visited in the 1979-80 winter and is a popular birdwatching area. It seems surprising that the Darvic ringed bird was not noted on other occasions if it had wintered at Parton.

Coverage at other sites

Scotland

Few Scottish White-front haunts were not visited during either winter. Those sites thought not to have been checked were the islands of Orkney, Tiree and Coll, Colonsay and Bute. Some sites were checked but no or very few geese were scanned, including the Isle of Skye, Lismore Island/Benderloch, Crinan Moss, Jura and Wigtown. The flocks on the outer Hebrides, at Loch Eye, Loch Sheil, Island of Danna (Strathclyde), and Stranraer were checked on at least one occasion without rings being seen.

Wales

The Dyfi Estuary flock was scanned regularly in both winters; no ringed birds were present.

Ireland

Comparatively few Irish haunts were visited and conditions for viewing legs were difficult. Those sites known to have been checked, except where stated in the 1979-80 winter only, are as follows (R.F. Ruttledge *in litt.*). Co. Donegal: a few checked at Sheskinmore Lough. Co. Sligo: most of the small flock at Bunduff were checked and at Lough Gara two Darvics were seen but not read when a flock was checked in April 1980. Co. Roscommon: most of the Lough Funshinagh birds were checked in the 1979-80 winter as were some in the 1980-81 winter. Co. Longford: most of the River Inny Mouth flock were checked. Co. Westmeath : the Lake Farm, Lough Ennell flock was checked once, and most of the Lough Iron birds were seen on two occasions. Co. Offaly: many of the flock at the Little Brosna River were checked. Co. Galway: the Rahasane Turlough and Creganna Marsh birds were checked. Co. Kerry: one of the four White-fronts seen to land on Akeragh Lough in December 1979 was Darvic-ringed. Akeragh is not a usual White-front haunt (nor close to one) and this party did not stay. Co. Wexford: the Wexford Slobs are the largest winter haunt, containing 35 - 45 % of the world population of Greenland White-fronted Geese. Large numbers of geese were checked in both winters, although the majority of legs could not be seen on any one visit. It is not too surprising that the ringed bird shot at this site in December 1980 was not sighted first.

Discussion

To what extent does the distribution of sightings between Scotland and Ireland reflect a real trend? In Scotland 50 individuals were recovered, eight of which were shot. Only four of these eight were shot before their ring numbers were read. The Irish data are meagre. One bird was shot without first being sighted, and up to three rings were seen without being read. Far fewer Irish winterers were scanned and conditions there are less favourable, so that the number of sightings can not be compared with the number from Scotland.

A more useful comparison is obtained if only shot birds are considered. Assuming similar reporting rates, the ratio of one goose shot in Ireland to eight in Scotland is the best available estimate for the dispersal of Eqalungmiut Nunât birds between the two countries. However little reliance should be placed on this figure since it is based on only a single recovery from Ireland, and because our activities encouraged reporting of shot birds, at least from Wexford, Islay and Caithness. Only two winter recoveries were not brought to our attention before being reported to the Copenhagen ringing centre.

More ringed birds were noted on Islay than at all other winter sites combined. To what extent is the Eqalungmiut Nunât population concentrated on Islay? If the number of recoveries is expressed as a percentage of the peak winter count from Ruttledge and Ogilvie (1979), for each site the highest proportion of Eqalungmiut Nunât birds was found in Caithness (2.4%), followed by Loch Lomond (1.7%), Kintyre (1.0%) and Islay (0.8%). The apparent concentration on Islay is an artefact of the large (3,700) winter population. (It should be noted that very few Greenland-ringed White-fronts have previously been recovered on Islay, and even fewer in Scotland. This is certainly due to most having been ringed in the northern part of the breeding range, producing an excess of Irish recoveries). The absence or paucity of sightings from other Scottish sites is at least partly due to their having been searched less efficiently than those in Caithness, on Islay, and perhaps Kintyre, and partly due to the low numbers present. From the data it is not unreasonable to conclude that the Eqalungmiut Nunât population was distributed more or less evenly across Scotland, with a much smaller proportion wintering in Ireland.

To what extent did geese associated in Eqalungmiut Nunât stay together for the winter? The amount of dispersal shown by the non-breeding flocks is astonishing. The Uniform catch produced winter recoveries in Wexford, Loch Ken, Islay, Loch Lomond (two) and Caithness - almost throughout the Greenland White-front's winter range. The Zulu and Mirrormere catches evidently combined soon after the moult as birds from both flocks were associated on Islay and in Caithness. These flocks produced 14 recoveries on Islay, two subsequently moving to Rhunahaorine, and six in Caithness, of which two pairs (including the pair that moved) and a party of eight birds on Islay, and a party of five in Caithness, were associated. The Worm catch produced four Islay recoveries (three of which were associated in a party) and one (a breeding bird) in Caithness. Two non-breeders from Lake 42 were seen separately on Islay.

Three families from Eqalungmiut Nunât were sighted in winter, in Caithness and at Machrihanish, both ringed in the Axewater catch, and on Islay. The broods from the Caithness and Machrihanish families were still together in their second winter, in each case more or less associated with one parent that had failed to breed successfully in 1980. The Islay brood was not located in its second winter.

Parties of associated non-breeding ringed geese were noted in Caithness (five ringed associates), and on Islay at Avenvogie/Cluanach (eight) and Cornabus (three). These parties remained intact in the second winter, but one bird in Caithness and one from Avenvogie did not reappear (presumably not having survived). The origin of the parties was not established. It is likely from the behaviour of known siblings in their second winter that they stay together in later years. Two parties were too large to consist of survivors from a single brood, but may have been formed by two or more broods joining up. Relationships within the parties were complex. Associations and apparent pairings are noted in Table D10.5 but some may in fact refer to siblings.

Effectiveness of Darvics

How effective are Darvic leg-rings on Greenland White-fronted Geese? In Scotland a network of observers spent many hours scanning flocks, some sites needing several visits before numbers were read. Expedition members toured most mainland sites in both winters, and Islay was visited regularly in 1979-80 and manned throughout 1980-81.

The same degree of cover was not obtained in Ireland, where sites are less accessible and conditions less favourable for seeing rings. An observer network was established in 1979-80, but the difficulties encountered discouraged much fieldwork in 1980-81. It was felt that Darvic neck-collars, visible in vegetation and when geese are swimming, would have facilitated sightings in Ireland. These were not used because they are known to increase mortality of incubating females in severe weather (Ankney 1975; Lensink 1968), and this period seems to be a critical time for Greenland White-fronted Geese.

In ideal light Darvics were read by telescope at a range of 450 m; this was by no means an upper limit. Poor light or weather, and the presence of tall vegetation, greatly reduced the range at which rings were legible. So that the serial was visible in short grass, Darvics were fitted with the (redundant) initial letter nearest the toes. Where possible, rings were read from a car, but at difficult sites or in poor light when a close approach was needed flocks were stalked using available cover.

A problem occurred in resolving the digits 6 and 8 due to the narrow gap left by the curved arm of the 6. No difficulty was noted with the 9, although it is an identical, but inverted, version of the 6. In future years a character with a shorter arm is required, or rings with the figure 6 should be discarded.

Advertising

A request for Darvic sightings was widely advertised in ornithological newsletters and journals in 1979, and follow-up articles appeared each winter. One group of rings was first noticed by a birdwatcher, but all other sightings were made either by known goose-counters or expedition members, emphasising the need for subsequent fieldwork in any colour ringing study.

ACKNOWLEDGEMENTS

The Zoologisk Museum, Copenhagen supplied rings and forwarded recoveries, the British Trust for Ornithology registered the colour-ring scheme and the Wildfowl Trust donated PVC Darvic which was engraved in the Physics Department, University College of Wales, by JF, assisted by G. Walker and colleagues. A grant from the Vincent Wildlife Trust aided one tour of Scotland.

It is a pleasure to acknowledge the assistance freely given by so many people. My special thanks to M.A.Ogilvie and Dr Finn Salomonsen for help, information and advice, to Steen Malmquist for liaison in Greenland; for their help in seeking rings to R.F.Ruttledge and his network of observers and to O.J.Merne in Ireland, and to E.M.Bignal, A.Breakwell. C.G.Booth, N.J.Buxton, D. Cabot, P.Collett, R.C.Dickson, A.G.Gordon, C.J.Headlam, S.Laybourne, J.Mitchell, S.Newton, J.A.Russell, C.J.Spray, S. Taylor, A.D.Watson and many birdwatchers, landowners and keepers in Scotland - the courtesy and unfailing hospitality of those we met was appreciated.

All expediton members caught geese, an occupation both arduous and time-consuming and JEB, PJB, PCD, PAIE, ADF, AEMF, APF, JF, WJH and DAS searched for ringed birds in Scotland.

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TABLE D10.5. Recoveries of ringed Greenland White-fronted Geese (*Anser albifrons flavirostris*).

Key

Arrangement of entry: ringing details are on the first, and recovery data on the following lines in the sequence; ring + Darvic number, age/sex or manner of recovery, date, locality, (notes).

Ring number: where this is in italics the ring has been returned.

Age when ringed: 1 - pullus (nestling or chick)
4 - 'adult' (hatched before calendar year of ringing)

Manner of recovery: v - caught and released with ring
vv - ring number read in field
\+ - shot or killed by man

Notes: br - breeding
pd - paired

278302 4♂ 10.07.79 Uniform, Eqalungmiut Nunât: 67°37'N 50°23'W GREENLAND (Moulting, non-br)
+A02 + 27.12.80 North Slob, Wexford: 52°22'N 06°25'W IRELAND (Shot)
(Weight 2.5 kg when ringed, 3.0 kg when shot)

278305 4♂ 10.07.79 Uniform, Eqalungmiut Nunât: 67°37'N 50°23'W GREENLAND (Moulting, non-br)
+A05 vv 04.01.81 Syster, Loch Heilen, Caithness: 58°36'N 03°15'W SCOTLAND

278306 4♂ 10.07.79 Uniform, Eqalungmiut Nunât: 67°37'N 50°23'W GREENLAND (Moulting, non-br)
+A06 vv 28.03.80 Endrick, Loch Lomond: 56°04'N 04°29'W SCOTLAND

278307 4♀ 10.07.79 Uniform, Eqalungmiut Nunât: 67°37'N 50°23'W GREENLAND (Moulting, non-br)
+A07 vv 24.12.80 Knocklearoch, Islay: 55°48'N 06°09'W SCOTLAND (Pd, mate unringed)

278309 4♀ 10.07.79 Uniform, Eqalungmiut Nunât: 67°37'N 50°23'W GREENLAND (Moulting, non-br)
+A09 vv 08.01.81 Parton, Loch Ken, Dumfries: 55°00'N 04°00'W SCOTLAND (Pd, mate unringed)

278310 4♂ 10.07.79 Uniform, Eqalungmiut Nunât: 67°37'N 50°23'W GREENLAND (Moulting, non-br)
+A10 vv 28.03.80 Endrick, Loch Lomond: 56°04'N 04°29'W SCOTLAND
vv 26.03.81 Endrick

278314 4♀ 11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A14 vv 15.02.80 Cluanach, Islay: 55°45'N 06°12'W SCOTLAND (Party of 8)
vv 17.02.80 Cluanach (Party of 8)
vv 09.04.80 Cluanach (Party of 7)
vv 16.11.80 Cluanach (Party of 6)
vv 28.11.80 Cluanach (Party of 6)
vv 05.12.80 Cluanach (Party of 6)
vv 22.12.80 Cluanach (Party of 6)
vv 28.12.80 Cluanach (Party of 6)
vv 29.12.80 Cluanach (Party)
vv 08.02.81 Kilennan, Islay: 55°45'N 06°12'W (Party of 6)
vv 22.03.81 Cluanach (Party of 6)
vv 31.03.81 Cluanach (Party of 6)
vv 10.04.81 Cluanach (Party of 6)
(A14, A31 and A38 were associated within the party)

278316 4♂ 11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A16 vv 22.02.80 Westfield, Caithness: 58°34'N 03°38'W SCOTLAND (Party of 5)
vv 15.03.80 Westfield (Party)
vv 23.02.81 Westfield (Party of 4 + 1 unringed, pd A27?)
vv 22.03.81 Westfield (Party, pd A27)
vv 04.04.81 Westfield (Party)
vv 05.04.81 Westfield (Pd A27)
vv 10.04.81 Westfield (Pd A27)

278317 4♂ 11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A17 vv 06.11.79 Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND
vv 02.12.79 Avenvogie (Pd A22?)
vv 21.12.80 Rhunahaorine, Kintyre: 55°41'N 05°39'W (Pd A22)

278318 4♂ 11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A18 vv 06.11.79 Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND (Pd A32)
vv 01.12.79 Avenvogie (Pd A32)
vv 02.12.79 Avenvogie (Pd A32)
vv 05.12.79 Avenvogie (Pd A32)
vv 14.02.80 Cluanach, Islay: 55°45'N 06°12'W (Pd A32)
vv 15.02.80 Cluanach (Pd A32)
vv 18.02.80 Cluanach (Pd A32)
vv 16.11.80 Cluanach
vv 28.11.80 Cluanach (Pd A32)
vv 05.12.80 Cluanach (Pd A32)
vv 21.12.80 Cluanach (Pd A32)
vv 09.01.81 Cluanach (Pd A32)
vv 09.02.81 Avenvogie (Pd A32)
vv 14.02.81 Kilennan, Islay: 55°45'N 06°12'W (Pd A32)
vv 14.03.81 Cluanach (Pd A32)
vv 22.03.81 Cluanach (Pd A32)
vv 01.04.81 Cluanach (Pd A32)
vv 16.04.81 Avenvogie (Pd A32)

TABLE D10.5. (continued...2)

278319	4♂	11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A19	vv	15.02.80 Cluanach, Islay: 55°45'N 06°12'W SCOTLAND (Party of 8, pd A26?)
	vv	17.02.80 Cluanach (Party of 8)
	vv	09.04.80 Cluanach (Party of 7, pd A26)
	vv	22.12.80 Cluanach (Party of 6, pd A26?)
	vv	28.12.80 Cluanach (Party of 6)
	vv	29.12.80 Cluanach (Party)
	vv	08.02.81 Kilennan, Islay: 55°45'N 06°12'W (Party of 6)
	vv	09.02.81 Cluanach (Party of 6)
	vv	14.03.81 Cluanach (Party of 6)
	vv	22.03.81 Cluanach (Party of 6, pd A26)
	vv	31.03.81 Cluanach (Party of 6)
	vv	10.04.81 Cluanach (Party of 6)
278320	4♀	11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A20	v	15.07.79 Spidermere, Eqalungmiut Nunât: 67°35'N 50°44'W (Moulting)
	vv	13.02.80 Corrary, Islay: 55°44'N 06°17'W SCOTLAND (Pd, mate unringed)
	vv	07.04.80 Corrary (Pd, mate unringed)
	+	05.12.80 Eilean na Muice Duibhe, Islay: 55°43'N 06°15'W (Shot at roost)
278322	4♀	11.07.79 Zulu, Eqalungmiut Nunât; 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A22	vv	06.11.79 Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND
	vv	02.12.79 Avenvogie (Pd A17?)
	vv	21.12.80 Rhunahaorine, Kintyre: 55°41'N 05°39'W (Pd A17)
278323	4♀	11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A23	v	15.07.79 Spidermere, Eqalungmiut Nunât: 67°35'N 50°44'W (Moulting)
	vv	14.02.80 Cluanach, Islay: 55°45'N 06°12'W SCOTLAND (Party of 8)
	vv	15.02.80 Cluanach (Party of 8)
	vv	17.02.80 Cluanach (Party of 8)
	+	18.12.80 Cluanach(Shot)
278324	4♀	11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A24	vv	15.02.80 Cluanach, Islay: 55°45'N 06°12'W SCOTLAND (Party of 8)
	vv	17.02.80 Cluanach (Party of 8)
	vv	09.04.80 Cluanach (Party of 7, pd A28)
	vv	16.11.80 Cluanach (Party of 6)
	vv	28.11.80 Cluanach (Party of 6)
	vv	05.12.80 Cluanach (Party of 6)
	vv	22.12.80 Cluanach (Party of 6)
	vv	28.12.80 Cluanach (Party of 6)
	vv	29.12.80 Cluanach (Party)
	vv	08.02.81 Kilennan, Islay: 55°45'N 06°12'W (Party of 6)
	vv	09.02.81 Cluanach (Party of 6)
	vv	22.03.81 Cluanach (Party of 6)
	vv	31.03.81 Cluanach (Party of 6)
	vv	10.04.81 Cluanach (Party of 6)
278325	4♀	11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A26	vv	15.02.80 Cluanach, Islay: 55°45'N 06°12'W SCOTLAND (Party of 8, pd A19?)
	vv	17.02.80 Cluanach (Party of 8)
	vv	09.04.80 Cluanach (Party of 7, pd A19)
	vv	28.11.80 Cluanach (Party of 6)
	vv	05.12.80 Cluanach (Party of 6)
	vv	22.12.80 Cluanach (Party of 6, pd A19?)
	vv	28.12.80 Cluanach (Party of 6)
	vv	08.02.81 Kilennan, Islay: 55°45'N 06°12'W (Party of 6)
	vv	22.03.81 Cluanach (Party of 6, pd A19)
	vv	10.04.81 Cluanach (Party of 6)
278326	4♀	11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A27	vv	20.01.80 Westfield, Caithness: 58°34'N 03°38'W SCOTLAND (Party)
	vv	22.02.80 Westfield (Party of 5)
	vv	30.03.80 Westfield (Party)
	vv	23.02.81 Westfield (Party of 4 + 1 unringed, pd A16?)
	vv	22.03.81 Westfield (Party, pd A16)
	vv	05.04.81 Westfield (Pd A16)
	vv	10.04.81 Westfield (Pd A16)
278327	4♂	11.07.79 Zulu, Eqalungmiut Nunât: 67°36'N 50°37'W GREENLAND (Moulting, non-br)
+A28	vv	14.02.80 Cluanach, Islay: 55°45'N 06°12'W SCOTLAND (Party of 8)
	vv	15.02.80 Cluanach (Party of 8)
	vv	17.02.80 Cluanach (Party of 8)
	vv	09.04.80 Cluanach (Party of 7, pd A24)
278329	4♂	13.07.79 Mirrormere, Eqalungmiut Nunât: 67°37'N 50°40'W GREENLAND (Moulting, non-br)
+A30	+	02.11.79 Gruinart Flats, Islay: 55°49'N 06°20'W SCOTLAND (Shot)
278330	4♂	13.07.79 Mirrormere, Eqalungmiut Nunât: 67°37'N 50°40'W GREENLAND (Moulting, non-br)
+A31	vv	15.02.80 Cluanach, Islay: 55°45'N 06°12'W SCOTLAND (Party of 8)
	vv	17.02.80 Cluanach (Party of 8)
	vv	09.04.80 Cluanach (Party of 7)
	vv	22.12.80 Cluanach (Party of 6)
	vv	28.12.80 Cluanach (Party of 6)
	vv	29.12.80 Cluanach (Party)
	vv	08.02.81 Kilennan, Islay: 55°45'N 06°12'W (Party of 6)
	vv	22.03.81 Cluanach (Party of 6)
	vv	31.03.81 Cluanach (Party of 6)
	vv	10.04.81 Cluanach (Party of 6)
		(A14, A31 and A38 were associated within the party)

TABLE D10.5. (continued...3)

278331	4♀	13.07.79	Mirrormere, Eqalungmiut Nunât: 67°37'N 50°40'W GREENLAND (Moulting, non-br)
+A32	vv	06.11.79	Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND (Pd A18)
	vv	01.12.79	Avenvogie (Pd A18)
	vv	02.12.79	Avenvogie (Pd A18)
	vv	05.12.79	Avenvogie (Pd A18)
	vv	14.02.80	Cluanach, Islay: 55°45'N 06°12'W (Pd A18)
	vv	15.02.80	Cluanach (Pd A18)
	vv	18.02.80	Cluanach (Pd A18)
	vv	28.11.80	Cluanach (Pd A18)
	vv	05.12.80	Cluanach (Pd A18)
	vv	21.12.80	Cluanach (Pd A18)
	vv	09.01.81	Cluanach (Pd A18)
	vv	09.02.81	Avenvogie (Pd A18)
	vv	14.02.81	Kilennan, Islay: 55°45'N 06°12'W (Pd A18)
	vv	14.03.81	Cluanach (Pd A18)
	vv	22.03.81	Cluanach (Pd A18)
	vv	01.04.81	Cluanach (Pd A18)
	vv	16.04.81	Avenvogie (Pd A18)
278332	4♀	13.07.79	Mirrormere, Eqalungmiut Nunât: 67°37'N 50°40'W GREENLAND (Moulting, non-br)
+A33	vv	20.01.80	Westfield, Caithness: 58°34'N 03°38'W SCOTLAND (Party)
	vv	22.02.80	Westfield (Party of 5)
	vv	15.03.80	Westfield (Party)
	vv	30.03.80	Westfield (Party)
	vv	30.12.80	Westfield
	vv	23.02.81	Westfield (Party of 4 + 1 unringed, with which pd)
	vv	22.03.81	Westfield (Party)
	vv	04.04.81	Westfield (Party, pd, mate unringed)
278333	4♀	13.07.79	Mirrormere, Eqalungmiut Nunât: 67°37'N 50°40'W GREENLAND (Moulting, non-br)
+A34	+	09.01.80	(Thurso), Caithness: c.58°35'N 03°32'W SCOTLAND (Shot)
278334	4♂	13.07.79	Mirrormere, Eqalungmiut Nunât: 67°37'N 50°40'W GREENLAND (Moulting, non-br)
+A35	vv	20.01.80	Westfield, Caithness: 58°34'N 03°38'W SCOTLAND (Party)
	vv	22.02.80	Westfield (Party of 5)
	vv	15.03.80	Westfield (Party)
	vv	30.03.80	Westfield (Party)
	+	31.01.81	Shebster, Caithness: 58°33'N 03°40'W (Shot)
278335	4♀	13.07.79	Mirrormere, Eqalungmiut Nunât: 67°37'N 50°40'W GREENLAND (Moulting, non-br)
+A36	vv	21.02.81	Westfield, Caithness: 58°34'N 03°38'W SCOTLAND
	vv	23.02.81	Westfield (Party of 4 + 1 unringed)
	vv	05.04.81	Westfield (Not in party)
278337	4♀	13.07.79	Mirrormere, Eqalungmiut Nunât: 67°37'N 50°40'W GREENLAND (Moulting, non-br)
+A38	vv	15.02.80	Cluanach, Islay: 55°45'N 06°12'W SCOTLAND (Party of 6)
	vv	17.02.80	Cluanach (Party of 8)
	vv	09.04.80	Cluanach (Party of 7)
	vv	22.12.80	Cluanach (Party of 6)
	vv	28.12.80	Cluanach (Party of 6)
	vv	29.12.80	Cluanach (Party)
	vv	08.02.81	Kilennan, Islay: 55°45'N 06°12'W (Party of 6)
	vv	22.03.81	Cluanach (Party of 6)
	vv	31.03.81	Cluanach (Party of 6)
	vv	10.04.81	Cluanach (Party of 6)
	(A14, A31 and A38 were associated within the party)		
278341	4♂	26.07.79	Worm, Eqalungmiut Nunât: 67°41'N 50°16'W GREENLAND (Moulting, non-br)
+A43	+	04.12.79	Laggan, Islay: 55°43'N 06°19'W SCOTLAND (Shot)
	(Weight 2.8 kg when ringed, 3.1 kg when shot)		
278343	4♀	26.07.79	Worm, Eqalungmiut Nunât: 67°41'N 50°16'W GREENLAND (Moulting, non-br)
+A45	vv	26.03.80	Cornabus, Islay: 55°38'N 06°14'W SCOTLAND (Party of 3)
	vv	28.03.80	Cornabus (Party of 3)
	vv	23.03.81	Cornabus (Party of 3, pd A51)
278346	4♀	26.07.79	Worm, Eqalungmiut Nunât: 67°41'N 50°16'W GREENLAND (Moulting, br)
+A48	vv	30.03.80	Loch Heilen, Caithness: 58°36'N 03°17'W SCOTLAND
278348	4♀	26.07.79	Worm, Eqalungmiut Nunât: 67°41'N 50°16'W GREENLAND (Moulting, non-br)
+A50	vv	23.03.81	Cornabus, Islay: 55°38'N 06°14'W SCOTLAND (Party of 3)
278349	4♂	26.07.79	Worm, Eqalungmiut Nunât: 67°41'N 50°16'W GREENLAND (Moulting, non-br)
+A51	vv	26.03.80	Cornabus, Islay: 55°38'N 06°14'W SCOTLAND (Party of 3)
	vv	28.03.80	Cornabus (Party of 3)
	vv	23.03.81	Cornabus (Party of 3, pd A45)
278354	1	27.07.79	Lake 72, Eqalungmiut Nunât: 67°42'N 50°13'W GREENLAND (Parents A53/A54?)
+A56	vv	26.03.81	Eorrabus, Islay: 55°48'N 06°13'W SCOTLAND (Pd? to unringed bird)
278358	4	27.07.79	Lake 42, Eqalungmiut Nunât: 67°43'N 50°13'W GREENLAND (Moulting, non-br)
+A60	vv	25.12.80	Islay House, Islay: 55°47'N 06°15'W SCOTLAND

TABLE D10.5. (continued...4)

278359	4♀	27.07.79	Lake 42, Eqalungmiut Nunât: 67°43'N 50°13'W GREENLAND (Moulting, non-br)
+A61	vv	17.02.80	Cruach, Islay: 55°45'N 06°16'W SCOTLAND (Pd, mate unringed)
	vv	12.11.80	Cruach (Pd, mate unringed)
	vv	05.12.80	Cruach (Pd, mate unringed)
	vv	11.12.80	Cruach (Pd, mate unringed)
	vv	21.12.80	Cruach (Not pd, following shoot *c*.14.12.80)
	vv	24.12.80	Cruach (Not pd)
	vv	09.01.81	Cruach (Not pd)
	vv	09.02.81	Cruach (Not pd)
	vv	12.02.81	Cruach (Pd to new mate, unringed)
278362	4♂	28.07.79	Lake 33, Eqalungmiut Nunât: 67°42'N 50°15'W GREENLAND (Moulting, pd A65, br)
+A64	vv	06.11.79	Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND (Pd A65, 4 young)
	vv	05.12.79	Avenvogie (Pd A65, 4 young)
	+	29.01.81	Mulindry, Islay: 55°45'N 06°13'W (Shot)
278363	4♀	28.07.79	Lake 33, Eqalungmiut Nunât: 67°42'N 50°15'W GREENLAND (Moulting, pd A64, br)
+A65	vv	06.11.79	Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND (Pd A64, 4 young)
	vv	05.12.79	Avenvogie (Pd A64, 4 young)
278364	1	28.07.79	Lake 33, Eqalungmiut Nunât: 67°42'N 50°15'W GREENLAND (Parents A64/A65)
+A66	vv	06.11.79	Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND (With parents)
	vv	05.12.79	Avenvogie (With parents)
278365	1	28.07.79	Lake 33, Eqalungmiut Nunât: 67°42'N 50°15'W GREENLAND (Parents A64/A65)
+A67	vv	06.11.79	Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND (With parents)
	vv	05.12.79	Avenvogie (With parents)
278366	1	28.07.79	Lake 33, Eqalungmiut Nunât: 67°42'N 50°15'W GREENLAND (Parents A64/A65)
+A68	vv	06.11.79	Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND (With parents)
	vv	05.12.79	Avenvogie (With parents)
278367	1	28.07.79	Lake 33, Eqalungmiut Nunât: 67°42'N 50°15'W GREENLAND (Parents A64/A65)
+A69	vv	06.11.79	Avenvogie, Islay: 55°44'N 06°13'W SCOTLAND (With parents)
	vv	05.12.79	Avenvogie (With parents)
278372	1	29.07.79	Lake 58, Eqalungmiut Nunât: 67°38'N 50°12'W GREENLAND (Parents A70/A72)
+A74	+	10.10.80	Holmar, Austur Landeyjar: *c*.63°45'N 20°00'W ICELAND (Shot)
278374	1♂	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Parent 278390)
+A76	vv	22.02.80	Westfield, Caithness: 58°34'N 03°38'W SCOTLAND (With parent/s)
	vv	15.03.80	Westfield (With parent/s)
	vv	30.12.80	Westfield (Party with sibling and parent)
	vv	21.02.81	Westfield (Party with sibling and parent)
	vv	15.03.81	Westfield (Party with sibling and parent)
	vv	21.03.81	Westfield (With parent and unringed ♂ in party of 4)
	vv	22.03.81	Westfield (With parent and unringed ♂ in party of 4)
	vv	29.03.81	Westfield (With parent and unringed ♂ in party of 4)
278376	1♂	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Parent 278390)
+A78	vv	22.02.80	Westfield, Caithness: 58°34'N 03°38'W SCOTLAND (With parent/s)
	vv	15.03.80	Westfield (With parent/s)
	vv	30.12.80	Westfield (Party with sibling and parent)
	vv	21.02.81	Westfield (Party with sibling and parent)
	vv	15.03.81	Westfield (Party with sibling and parent)
	vv	21.03.81	Westfield (With parent and unringed ♂ in party of 4)
	vv	22.03.81	Westfield (With parent and unringed ♂ in party of 4)
	vv	29.03.81	Westfield (With parent and unringed ♂ in party of 4)
	vv	04.04.81	Westfield
278378	1	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Parents A94/A96)
+A80	vv	19.02.80	Machrihanish, Kintyre: 55°26'N 05°41'W SCOTLAND (With parents)
	vv	21.12.80	Machrihanish (Party of 4 siblings)
	vv	30.12.80	Machrihanish (Party with parent A96)
278379	1	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Parent 278390)
+A81	vv	22.02.80	Westfield, Caithness: 58°34'N 03°38'W SCOTLAND (With parent/s)
	vv	15.03.80	Westfield (With parent/s)
278384	1	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Parents A94/A96)
+A86	vv	19.02.80	Machrihanish, Kintyre: 55°26'N 05°41'W SCOTLAND (With parents)
	vv	21.12.80	Machrihanish (Party of 4 siblings)
	vv	30.12.80	Machrihanish (Party with parent A96)
278385	1	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND
+A87	+	14.10.79	Biskupstungur: 64°15'N 20°30'W ICELAND (Shot)
278386	1	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Parents A94/A96)
+A88	vv	19.02.80	Machrihanish, Kintyre: 55°26'N 05°41'W SCOTLAND (With parents)
	vv	21.12.80	Machrihanish (Party of 4 siblings)
278387	1	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Parents A94/A96)
+A89	vv	19.02.80	Machrihanish, Kintyre: 55°26'N 05°41'W SCOTLAND (With parents)
	vv	21.12.80	Machrihanish (Party of 4 siblings)
	vv	30.12.80	Machrihanish (Party with parent A96)
278389	1	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Parents A94/A96?)
+A91	+	23.11.79	Machrihanish, Kintyre: 55°26'N 05°41'W SCOTLAND (Shot)

TABLE D10.5. (continued...5)

278390	4♂	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Moulting, br)
+leg	vv	22.02.80	Westfield, Caithness: 58°34'N 03°38'W SCOTLAND (Pd, 3 young)
injury	vv	15.03.80	Westfield (Pd, 3 young)
	vv	30.12.80	Westfield (Party with last year's young)
	vv	21.02.81	Westfield (Party with last year's young)
	vv	15.03.81	Westfield (Party with last year's young)
	vv	21.03.81	Westfield (Party of 4 with last year's young and unringed ♂)
	vv	22.03.81	Westfield (Party of 4 with last year's young and unringed ♂)
	vv	29.03.81	Westfield (Party of 4 with last year's young and unringed ♂)
278393	4♂	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Moulting, pd A96, br
+A94	vv	19.02.80	Machrihanish, Kintyre: 55°26'N 05°41'W SCOTLAND (Pd A96, 4 young)
278395	4♀	06.08.79	Axewater, Eqalungmiut Nunât: 67°36'N 50°30'W GREENLAND (Moulting, pd A94, br
+A96	vv	19.02.80	Machrihanish, Kintyre: 55°26'N 05°41'W SCOTLAND (Pd A94, 4 young)
	vv	30.12.80	Machrihanish (Party with last year's young, not pd)

In addition one Darvic ringed White-front was glimpsed on 30.12.79 at Akeragh Lough, Co. Kerry, IRELAND (not a usual haunt), and two were unread on 09.04.80 on Inchmore Island, Lough Gara, Co.Sligo, IRELAND.





D11 PARASITES RECORDED FROM GREENLAND WHITE-FRONTED GEESE

D. A. Stroud

Two cases of cestode infection were reported from Greenland. A mature segment was found in faeces collected from Upper Marsh in June, while a more or less complete *Drepanidotaenia barrowensis* (Schiller 1952) was found at the end of Lake 33 on 28 July. The latter was lying in shallow water where a family had been gathered prior to driving them into the nets and had presumably been passed by a goose during the stress of the catch. This species has also been reported from the Pacific White-front in Alaska and the genus is a common parasite of wild ducks and geese.

In addition, the cestode *Hymenolepis creplini* (Krabbe 1869) was found in the upper small intestine of a juvenile Greenland White-front shot on Islay in November 1980.

The nematode *Heterokis dispar* (Schrank 1790) was found in the caecae of two geese of 24 birds shot on Islay during the period November to January 1980/81. One infected bird was an adult, the other juvenile.

As far as is known, there have been only three other accounts of the parasites of the Greenland White-fronted Goose. Nielsen (1907), Henriksen and Lundbeck (1917) and Henriksen (1939) all record *Trinoton conspurcatum*, *Lipeurus jejunus* and *Docophorus icterodes* (Mallophaga) on White-fronted Geese caught in Gaase Land, east Greenland (70°15'W). These are obviously misidentifications of Pink-footed Geese.

D12 PLUMAGE VARIATION IN THE GREENLAND WHITE-FRONTED GOOSE

D. A. Stroud

INTRODUCTION

It is usually the case that when any animal population is studied closely enough it is possible to tell individuals apart. The intention of our photographic study was to confirm this for the Greenland White-fronted Goose, as well as to investigate the rather extreme and biologically unexplained variation of the dark breast and belly bars, and the extent of the white forehead patch.

Plumage descriptions: Adults:

Adult birds have a brown head, neck and chest, with darker brown on the nape and crown. The forehead and area around the base of the beak is white, bordered by a darker area which gradually merges with the head colour away from the bill. The white of the forehead patch does not usually extend to above the eye as in the Lesser White-front, although it does in some individuals. The throat is sometimes dark brown, contrasting with the paler brown sides of the head and neck. The feathers of the mantle, scapulars, sides of the body and flanks, broadly tipped buff to white. The belly and sides of the body also have varying amounts of black feathers (edged white when fresh), forming irregular dark patches or often transverse bars. The back and rump are also grey-black, with white under-tail coverts. The sides of the belly anterior to the under-tail coverts are frequently darker than the rest of the belly and breast base colour (Cramp and Simmons 1977).

Juveniles:

The juvenile plumage is similar to that of the adult, but the forehead is brown-black with no white, although these feathers have a white base which sometimes becomes visible by wear. The rounded feathers of the breast and belly are grey-brown edged with pale grey giving the breast a scaly appearance. The plumage of the head is renewed mainly in November and December, although that of the forehead may be somewhat later (Lebret 1968). In some late moulting birds the forehead moults directly to white, but often the moult gives new black forehead feathers in December to January with white appearing from January onwards. There is some moult of the mantle, scapulars, chest and longer flank feathers between November and January with all body feathers being renewed by February. Sometimes much of the juvenile belly, back, tail and wing coverts are retained until at least March. The most striking feature of first summer birds is their lack of black feathers on the belly (Cramp and Simmons 1977).

One of the distinguishing features of *flavirostris* is the generally darker plumage together with much heavier markings on the breast and belly; however individual variation in *albifrons* and *flavirostris* results in some overlap, making separation using this feature alone unreliable (Dalgety and Scott 1948, Salomonsen 1948a). The variation in the belly markings ranges from complete absence of dark feathers to complete absence of pale feathers. Boyd (1953) used the variations in the shape of the white forehead and the belly markings of *albifrons* to identify individuals in a flock. The variation we saw was sufficient to suppose that each bird, in any season, has a unique breast pattern.

METHODS

Three photographs were taken of each adult goose ringed, a ventral and two lateral views. This was primarily intended as a record of breast bars, although the head appears in most allowing the forehead variation to be shown (Figure D12.1) and investigated. On the basis of darkness of belly the geese can be placed in one of five categories (Figure D12.2).

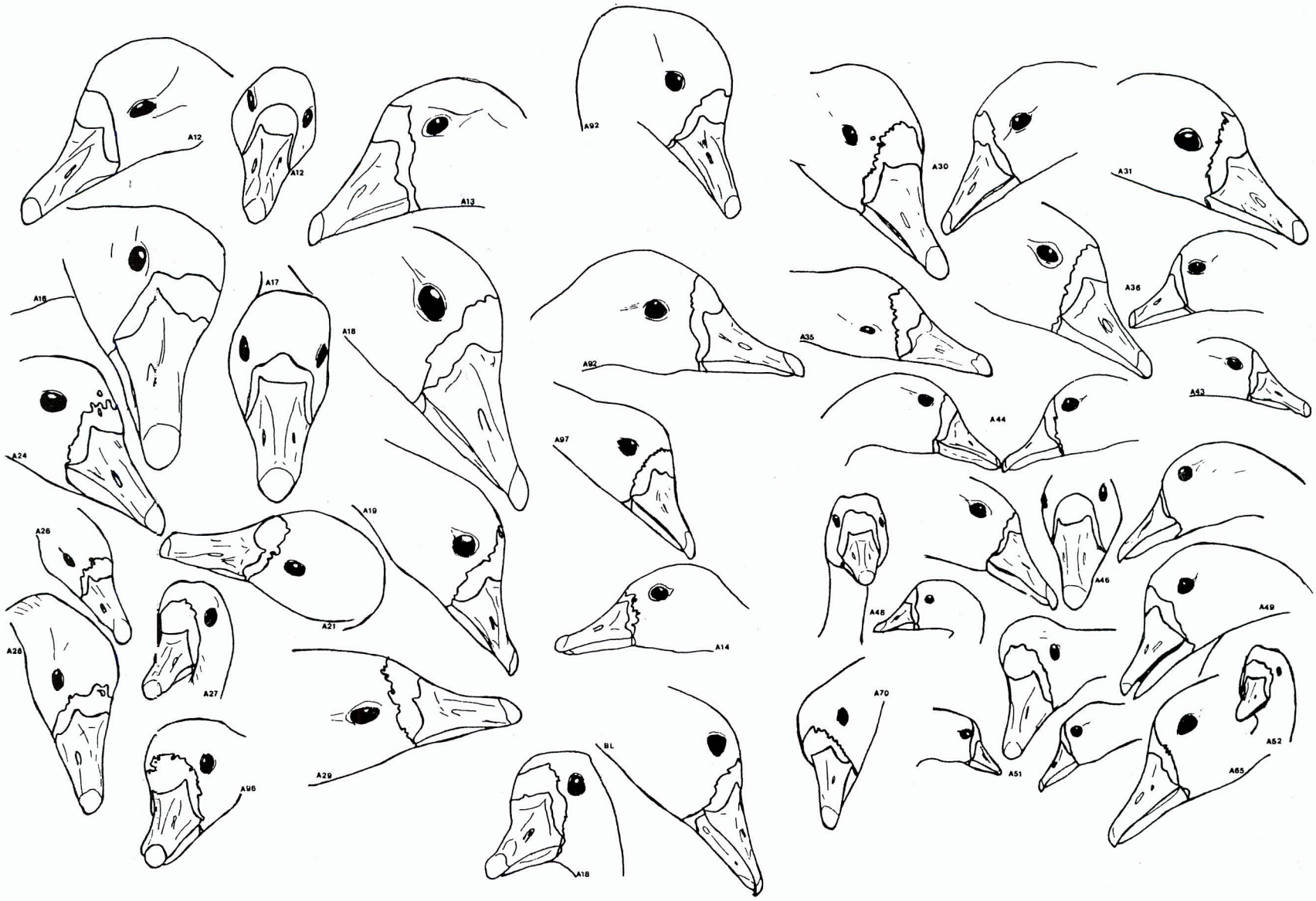


Figure D12.1. Variability in the extent of the white on the head pattern of Greenland White-fronted Geese *(Anser albifrons flavirostris)* caught in Eqalungmiut Nunât, 1979. Numbers correspond to Darvic ring codes.

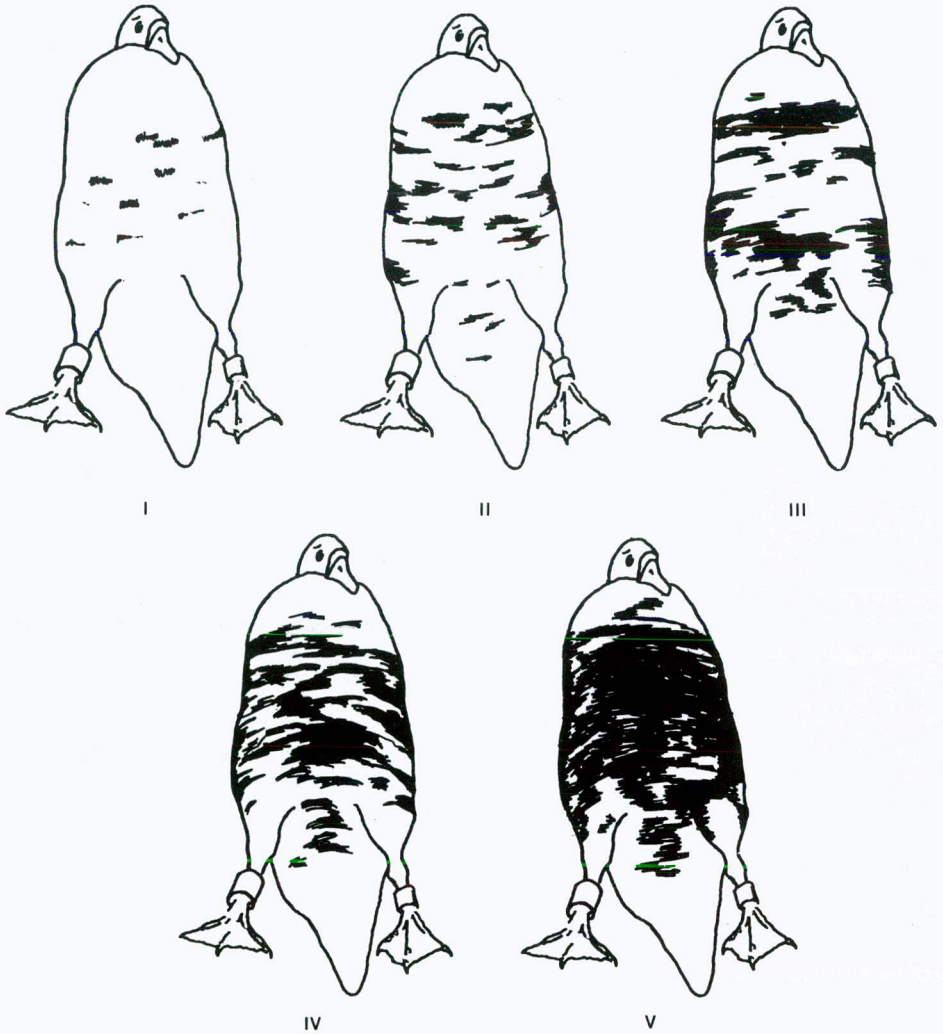


Figure D12.2. Character states used in the scoring of belly barring in Greenland White-fronted Geese *(Anser albifrons flavirostris)*.

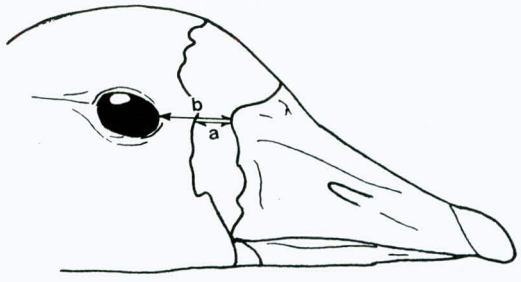


Figure D12.3. "Frons extent index" is calculated from the formula (a x 100)/b using the ratio of the measurements a and b shown above.

TYPE I: These birds have less than 20% of the feathers of the breast and belly tipped dark. Single black feathers may occur but with few, if any, transerve bars.

TYPE II: Between 20 and 40% of the breast and belly is covered with black, arranged in bars and patches. The impression given is of heavy dark flecking on a light background. The black of the belly never reaches as far as the vent.

TYPE III: Type III birds have a roughly equal proportion of dark and light feathers (40 and 60%). The dark areas form thick transverse bars that extend well up on both sides of the bird. Dark feathers also frequently extend to near the vent.

TYPE IV: These birds are predominately dark (60 and 80%) with black flecking reaching the vent.

TYPE V: Type V birds have more than 80% of the breast and belly covered with black feathers and may show no pale plumage at all.

The extent of the white forehead was measured from those slides where the head was held at right angles to the camera, and is expressed as a percentage of the distance between the top of the beak and the anterior edge of the eye (Figure D12.3). Wherever possible both sides of the head were measured and a mean value taken. However the sample size is such that it has not been possible to test for significant differences between one side of the head and the other. It is thought likely that there is no difference, however.

RESULTS

Table D12.1 shows the distribution of the plumage types in each catch, and the scores of breeders and non-breeders. Individual scores are given in Table D10.1. Birds were assessed as breeders or non-breeders in mixed flocks by their moult score (section D10). Some flocks, e.g. Zulu, have a high proportion of light coloured birds, whilst others, such as Worm, have many dark birds. However there is no significant difference between the darkness of breeders and non-breeders (Table D12.1). Sexes were assessed by weights, skull measurements and subsequent observations in Britain. There does seem to be a difference (Figure D12.4) in that the males are darker than females, although this is just not statistically significant. Birds which it was not possible to sex have a frequency distribution of darkness scores intermediate between that of the males and females. Boyd (1954) also found that whilst the males of 26 pairs of *A. a. albifrons* were slightly darker than the females, this difference was not statistically significant (males = 27% of lateral surface dark, females = 23%).

TABLE D12.1. Proportion of different plumage types in each roundup.

LAKE	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	TOTAL
% Dark -	0 - 20	20 - 40	40 - 60	60 - 80	80 - 100	(adults)
Zulu	7	4	4	1	1	17
Mirrormere	5	1	2	0	1	9
Worm	1	0	1	5	3	10
Lake 73	0	0	1	1	0	2
Lake 33	1	0	1	0	0	2
Lake 58	0	2	1	0	0	3
Axewater	3	0	3	0	1	7
TOTAL	17	7	13	7	6	50
Non-breeders	12 (34%)	5 (14%)	8 (23%)	5 (14%)	5 (14%)	35
Breeders	5 (33%)	2 (13%)	5 (33%)	2 (13%)	1 (7%)	15

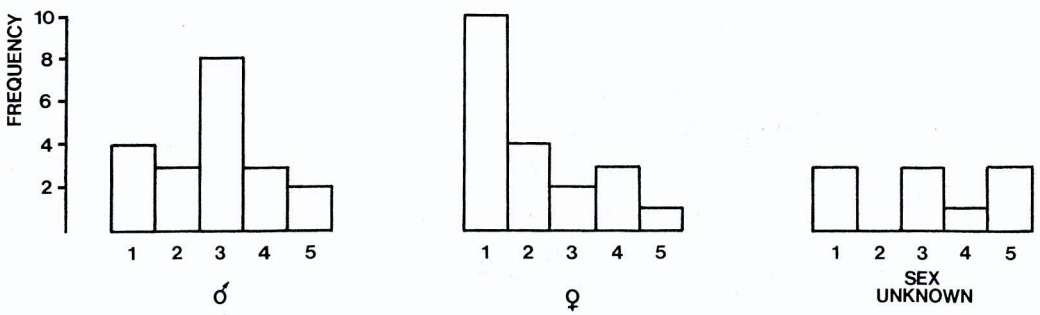


Figure D12.4. Sex differences in plumage barring types in male, female and unsexed birds. Histogram blocks 1-5 correspond to barring types I-V.

TABLE D12.2. Changes in breast darkness of known geese over *c.*18 months.

RESCORE	ORIGINAL SCORE 1	2	3	4	5
1	6	2			
2	3	1	1		
3				1	2
4					
5			1		

TABLE D12.3. Comparison of belly barring with mean frons extent in males, females, non-breeding and non-breeding Greenland White-fronted Geese *(Anser albifrons flavirostris)*.

FRONS EXTENT BELLY DARKNESS	MEAN FRONS EXTENT(%)	±S.E.	n
1	27.33	4.33	9
2	49.00	2.44	6
3	38.00	4.42	10
4	39.00	4.15	7
5	42.00	2.33	9
All Males	40.00	3.88	13
All females	38.27	4.22	11
Non-breeders	34.80	7.21	13
Breeders	42.30	2.88	12

In winter 1980/81 observations were made on the darkness of ringed birds on Islay. Although limited in number the results are presented in Table D12.2 and show that whilst some have increased the degree of darkness, most have stayed the same and a few have got lighter. Comparison of photographs taken in 1979 and 1981 of several individuals show that the patterns are broadly similar. In those that have got darker, the origin of dark bands and patches in 1981 can be seen in smaller groupings of dark feathers present in 1979.

The results of the measurements of forehead extent are presented in Table D12.3 and show that, whilst there is no relationship between extent of the forehead, darkness of belly and sex, the breeding birds have a bigger white patch than non-breeders, this is not however, a significant difference.

DISCUSSION

Boyd (1954) examined the proposition of Tucker (in Witherby 1939) that the variability of the belly markings is not related to age or sex. By taking a series of photographs of the same geese in the collection at Slimbridge he was able to show that in a sample of 31 birds there was no direct relationship between age, sex or degree of dark barring. Over three years, two birds showed a marked increase in darkness, six showed a lightening whilst there was little change in the degree of barring in the remaining 23. Similarly enigmatic results are shown by this limited investigation, and it is obvious that a much bigger sample followed over many more years is needed. Nevertheless, the results presented here suggest that there is probably a difference in darkness between the sexes.

It is unusual for such a high degree of individual plumage variation to occur in a monotypic goose, and certainly for the White-front there seems to have been no previous investigation of its functional significance. The variation would facilitate individual recognition, but would seem to be rather extreme just for this reason. Prevett and MacInnes (1980) found that juvenile Lesser Snow Geese, separated from their parents on migration, would frequently rejoin them during the winter. This recognition must be largely behavioural, and if a Snow Goose is able to discriminate amongst 163 000 individuals, then presumably other geese have a similar capacity.

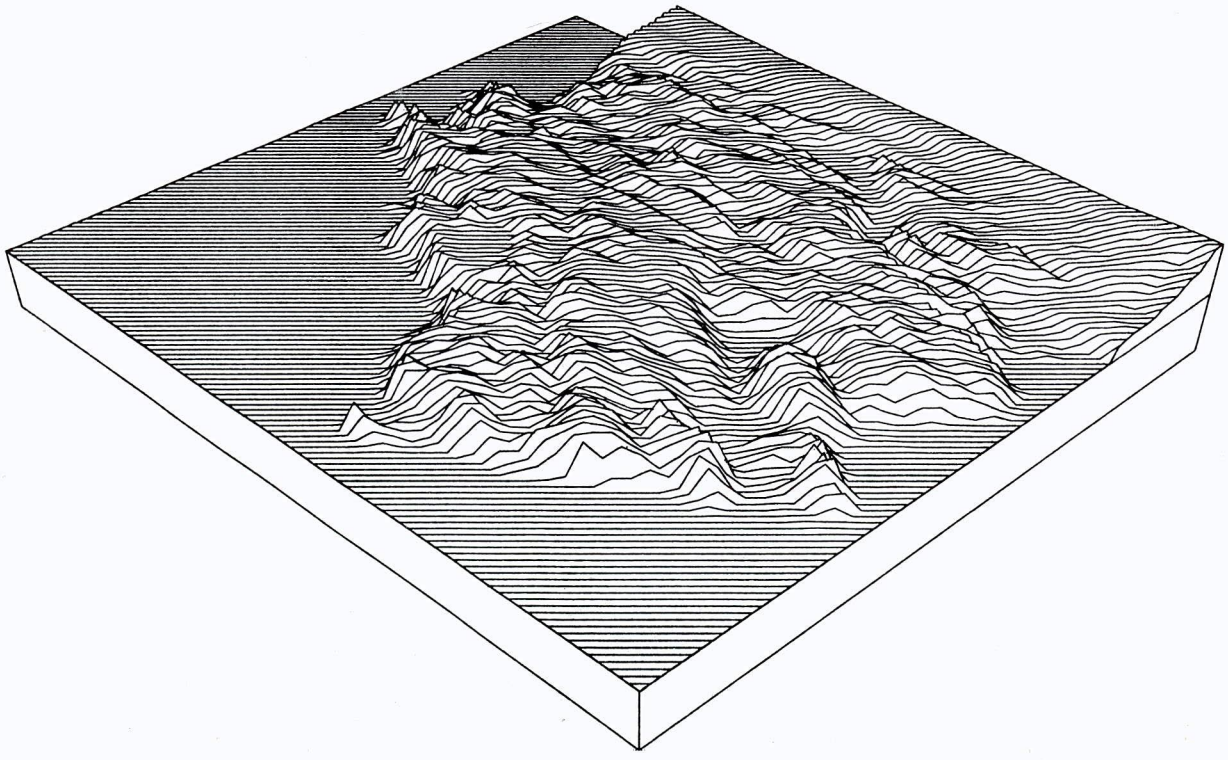
A more attractive theory is that the markings act as a signal of social status. Rohwer (1975) hypothesised that winter-plumage variability in birds was related to the social system through which access to resources is controlled. "When individuals compete for resources through territorial systems a single plumage type should be advantageous; when individuals compete through dominance behaviour, variations in plumage which serve to signal dominance status are increasingly advantageous as flock stability declines". He confirmed that the plumage of winter flocking species was more variable

than that of winter territorial species and that individual plumage differences signal dominance status in Harris Sparrows (Rohwer 1977, Rohwer and Rohwer 1978). This latter prediction from the theory has also been confirmed for the variable Dark-eyed Junco (Balph, Balph and Rosenburg 1979). The evolutionary outcome of this sort of signal is to reduce actual conflict in favour of ritualisation (see Dawkins and Krebs 1978 for a discussion of this and counter strategies), and both incoming and established flock members can accurately assess the social status of any bird without engaging in energetically costly fights.

Greenland White-fronts are a winter flocking species, although the social system is somewhat different from the dominance systems of variable plumage, seed-eating passerines, particularly inasmuch as the family unit continues over the course of the winter. It would seem likely that plumage variation of the degree shown by these geese, operates as some sort of social signal, although whether in exactly the same manner as has been shown for other species remains to be seen.

The use of plumage patterns to identify geese in successive years would seem to be of doubtful value. In some cases the patterns change significantly, and thus although unique in any season, belly markings do not seem to have the same long-term stability as some other individually diagnostic features such as the bill markings of Bewick's Swans (Scott 1966).

A suggested explanation of the darker males relates to the postural differences between the sexes during incubation (W. Sinclair pers. comm.). The male spends a large part of the time standing (either roosting or alert), and particularly during May and June will have considerable light from snow and ice reflected on his breast and belly. In this situation where the light source is, in effect, from below, the dark underside and light upper surface is a reversal of the normal counter-colour shading. The effect will therefore be to lessen the conspicuousness of the standing goose. The female, on the other hand, spends most time sitting and has less need of a dark underside. Before nesting she has the protection of the flock or her mate, and after nesting the snow and ice will have melted. This camouflage is thus of value only to the solitary male, against attack by, for instance, a stalking Arctic Fox.



D13 MISCELLANEOUS NOTES ON THE GREENLAND WHITE-FRONTED GOOSE IN EQALUNGMIUT NUNÂT

CALLS

The call of the female is much lower than that of the male. Virtually all flying geese in May and June were heard calling, but as the moult approached, the birds became quieter, and in late July and August, very few were heard. The females became silent before the males and throughout the trip to the ice-cap on 27-30 June, no calling female was heard.

Several variants on the disyllabic call were heard. A pair was seen during 12-23 June, the female of which had a very distinctive 'honk'. The alarm call of both sexes is higher pitched than the usual call and was heard on only a few occasions, notably in the presence of eagles.

The flight call of the geese has been variously rendered as "kyow-lyow" or 'lyo-lyck' (Scott and Boyd 1957), "ki-lick" or "kla-lick" (Bauer and Glutz 1968), "kru-it" (Salomonsen 1950a).

(DAS)

HIGH WINDS

On 12 June (02.55-03.30 hours) an extraordinary display of flying was seen in gale force winds. A pair of geese was noticed gliding along the top of the ridge above Base Camp (575 m). They were using the updraft, and gliding with arched wings and legs fully lowered (possibly in a steering or braking function). Every so often they would go through all the motions of landing but then speed away at the last moment. Occasionally, they did land for a short break before launching themselves into the updraft again. The observers got the impression that the geese were not trapped within the updraft and were quite capable of leaving had they wanted to. In Base Camp, winds of over 80 kph were recorded, but higher up the wind was certainly stronger.

(APF, JF)

COPULATION

Copulation was seen only once in Eqalungmiut Nunât during 1979. One of the goose pairs under continuous observation on Kûk Marshes was seen to walk deliberately towards a small shallow pool at 11.56 hours, 10 May. The display was initiated by swimming and drinking for two minutes, until the two birds began to swim about each other, engaging in exaggerated drinking movements. Copulation took place whilst standing in the water, the female standing with the gander balanced on her back, flapping his wings and pecking her neck. The duration of the mount was no more than five seconds, whereupon the pair washed and preened for a minute before commencing feeding.

(JM)

SOMERSAULTING

At 16.41 hours, 24 May, a single female goose alighted on one of the pools on George Eliot, drinking briefly. She fed for a short time and then started to preen, beginning on the breast and working along the flanks. The bird then motioned to up-end, but flung her entire body over on to her back, flailing her legs in the air as the position was held, belly uppermost, with her head, neck and back completely submerged. This position was maintained for a few seconds before the bird returned to the upright posture by rolling to the right and flapping the left wing. The sequence of events was repeated nine times before she emerged on to the bank to dry and preen.

This behaviour has been noted on the wintering grounds by Bayldon (1970) and witnessed by DAS and PCD at Loch Shiel, Inverness-shire amongst a group of some eleven birds out of a flock of *c*.46. In all cases, it would appear that the behaviour is associated with preening.

(ADF)

D. A. Stroud & A. D. Fox

The few sightings of Greenland White-fronted Geese in east Greenland permit a brief summary of their status to be presented. The general lack of sightings is probably due to the paucity of observers and the assumption that all grey geese are Pink-footed Geese. However, there may be scattered observations unpublished, or in foreign literature and expedition reports unknown to us, so we would be grateful for further records to incorporate in a fuller analysis at a later date.

The flight line of the geese on migration is thought to take them from west Iceland, where they stage in spring and autumn, across the east coast of Greenland where they pass over the Tasiusaq (Angmagssalik) District. While Brent Geese cross the ice-cap on a line Tasiusaq - Disko Bay (Salomonsen 1950a), many of the White-fronts may take a more southerly route (Wilson 1981). There are no data on numbers of geese crossing the ice-cap so it is possible that an unknown proportion round Kap Farvel and fly up the west coast from the south as Salomonsen (1950a) suggested.

The scattered literature of sightings from east Greenland shows White-fronts are most frequent in the Tasiusaq District during spring and autumn migration (Figures D14.1 and D14.2) with the occasional vagrant further north.

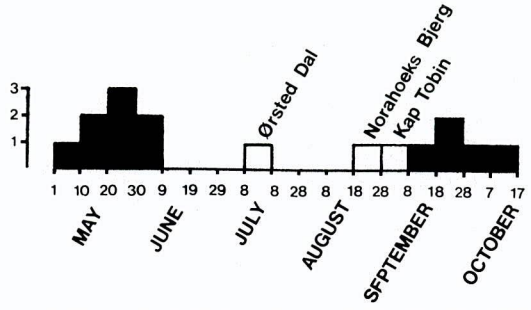


Figure D14.1. Distribution of Greenland White-fronted Goose records from east Greenland. Shaded area indicates birds from the Tasiusak district, unshaded represent records from elsewhere.



Figure D14.2. Distribution of Greenland White-fronted Goose sightings in east Greenland. Each symbol represents a single bird or group of birds except Tasiusaq from which there are 8 records.

Helms (1926) gives several sightings in the Tasiusaq area from Cape Dan, Tasiusak and Sermalik, mostly related to single birds shot by Greenlanders, but including a sight record of a flock on 20 May in Tasiusak. Chapman gives a record of a single bird sighted just south of Tasiusaq (at 65°30'N) on 18 September and one of another shot at the same locality on 3 May. It would appear that at Tasiusaq, the main autumn passage occurs between 18 September and 14 October.

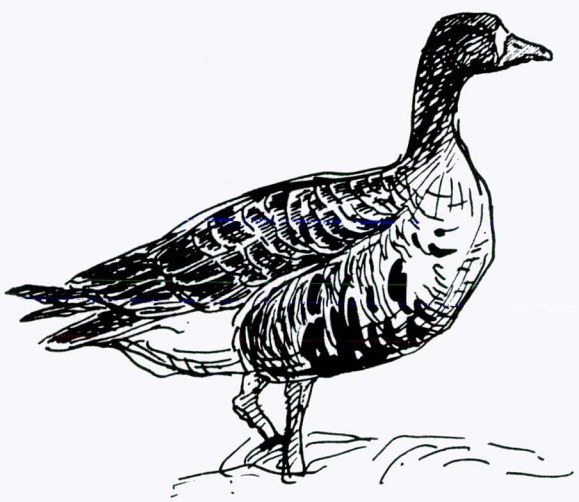
Whilst the occurrence of White-fronts in this region is not surprising, there are several records from north-east Greenland some distance from the migratory flight path. These vagrants associate with flocks of Pink-footed Geese. Hall and Waddingham (1966) saw a bird in Ørsted Dal, Scoresby Land on 18 July and Salomonsen (1950a) reported a single bird at Kap Tobin, Scoresby Sund on 4 September. Further north, four birds with Pink-footed Geese were seen by Hjort (1976) in Hudsonland.

On 2 August 1870 on Jackson Ø, off the north-east corner of Hold-with-Hope, Dr R Copeland of the German North Pole Expedition collected two dark feathers which were identified as belonging to White-fronted Geese (Koldeway 1874, Finsch 1874). That these feathers probably came from Pink-footed Geese has been pointed out by Helms (1926), Salomonsen (1950a), and Scott and Fisher (1953) amongst others. The record of White-fronts in the same area by Kolthoff (1903) is also thought to be suspect (Løppenthin 1932). Another possible case of Pink-footed/White-fronted Goose misidentification is referred to in section D11.

Some birds undoubtedly spend the whole summer in east Greenland. The goose in Ørsted Dal in July 1963, was moulting and flightless and there are several anecdotes given by Helms (1926) suggesting flightlessness, but for the dates of the incidents:

> " The method by which some of the White-fronted Geese were caught is very peculiar, and indicated the strange timidity in the bird. That which was brought in on May 30th 1901, was caught by a dog. The goose was so frightened when it saw the dog running towards it that it quite forgot the use of its wings. Of the one caught at Cape Dane on September 22nd 1913, Petersen writes: "a girl caught it in her hands, it having fallen amongst some little girls who were playing ball; by screaming and throwing the ball in the air they so scared the goose that it lost its flying powers." Two years before it is said that something of the same sort happened in the colony (of Tasiusaq) itself; some boys, by shouting and throwing their caps up at the goose, made it throw itself to the ground."

The vagrants spending the summer in north-east Greenland may well be the origin of the occasional White-front x Barnacle Goose hybrids seen on the wintering grounds. It is more likely that the pairing takes place in east Greenland through which the White-fronts must pass to reach west Greenland rather than in an area on the west coast, outside any flight path of the Barnacle Goose.



A. D. Fox & D. A. Stroud

INTRODUCTION

While it has been convenient to present separately the different studies undertaken in 1979, there has been no logical sequence. This concluding section serves to draw together the ideas and information presented in this report and elsewhere into a discussion of the overall life history and ecology of the Greenland White-fronted Goose, as well as suggesting some of the many areas where further work would be of value.

EVOLUTION

It is thought that White-fronts evolved from the closely related Grey-lag Goose, since the latter are known from Pliocene central Europe, whereas the oldest White-front fossils are of Pleistocene origin (Johansen 1956). It is possible that towards the end of the Tertiary, when the arctic climate became colder, they segregated from the Grey-lags which remained further south in more temperate regions and were of Old World Origin.

During the long Mindel-Riss Interglacial period, the White-fronted Goose spread over the entire arctic and into the New World, During the following glacial they were again forced south, splitting into 'Atlantic' and 'Pacific' groups. The Pacific group spread widely from the Bering Sea region during the last interglacial in both directions. During the last glaciation *Anser albifrons albifrons is* survived in north Siberian refuges, whilst the very closely related *frontalis* survived in the Beringian Refugium. After the glaciation receded this group spread over the whole of North America (Figure D15.1) and gave rise to the three subspecies found there today (Johansen 1956). The Atlantic group of ancestral White-fronts gave rise to *flavirostris* which survived the glaciation in the ice-free tundras of the southern North Sea and Ireland. After the glaciation they gradually moved north to their present restricted range in west Greenland.



Figure D15.1 Present distribution and taxonomy of the White-fronted Goose *(Anser albifrons)* after Johansen (1956)

Ploeger (1968), however, considers that the slight morphological differences between *flavirostris* and *albifrons* point to a common origin, and suggests the present separation was caused by the use of different refuge areas in the North Sea. Another possibility is that *flavirostris* detached itself from the easternmost American White-fronts after these had spread across the North American tundras in post-glacial times. Against this theory is the present disjunction between the most easterly breeding American birds and the Greenland population, the considerable morphological differences between *frontalis* and *flavirostris*, and the absence of regularly wintering *flavirostris* in North America (although there are occasional records from the eastern American seaboard: Finch 1973, Hewitt 1948, Parkes 1960).

Whatever the precise origins of *flavirostris* from the original *Anser albifrons* stock, it is evident that they represent one of the earliest groups to split off, both on the basis of their morphological differences and their isolated breeding area. The implication is that the ecology of the Greenland White-fronted Goose may significantly differ from other White-front races. Certainly in winter they show many differences in food and feeding habits when compared with *A. a. albifrons*, having a tendency to feed on upland bog and rough pasture (section D8). The nesting sites in Eqalungmiut Nunât, and probably throughout the range in Greenland, are very different from those chosen by *frontalis* in Alaska (Ely 1979), and one should be hesitant in assuming that the summer ecology of the Greenland White-fronts is the same in any aspect as that of any other race of White-fronted Goose.

SPRING MIGRATION AND ARRIVAL IN WEST GREENLAND

Iceland

Greenland White-fronts occur in Iceland on spring passage, but generally in small scattered parties contrasting with their autumn occurrence (Ruttledge and Ogilvie 1979, Gardarsson *in litt.*). The peak passage occurs between 20-25 April and early May, after the end of the shooting season which currently ends on 15 March (Ruttledge and Ogilvie 1979). The timing of recoveries of ringed birds, shot over many years is shown in Figure D15.2. The birds apparently resort to wet grassland areas and hill bogs in the south-west (see ringing recovery distribution, Figure D15.3), very little is known of their habits at this time, although their food is thought to be young sedge shoots and the over-wintering bases of *Eriophorum* (Gardarsson *in litt.*). In the absence of information from Iceland and extensive ringing programmes on the wintering grounds nothing is known about the relative condition of the birds or their relationships in family or larger units on arrival in Iceland or subsequently in Greenland. Our observations in Eqalungmiut Nunât suggest that the young second summer birds and possibly a substantial number of older non-breeders (indistinguishable in the field without marking) arrive generally later on the breeding grounds than the adult, potentially breeding birds (Section D1). For young birds, this is probably because there is less need for the time of arrival in Greenland to be critically linked to the start of plant production, as is essential for the breeding adults. In the case of the adults which do not successfully breed, it is obviously difficult to determine whether their late arrival is the cause or effect of their non-breeding status. It may be that the younger birds are able to feed longer in Iceland, maintaining their condition for the flight to Greenland. Observations in Scotland have shown that whole wintering flocks depart simultaneously, so if second summer young do sometimes separate from their parents before arrival in Greenland, this would seem to take place after they leave the wintering area.

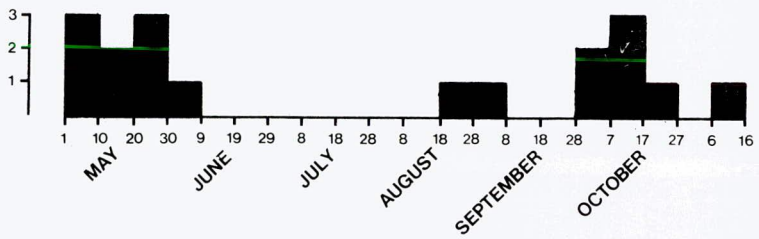


Figure D15.2. Timing of recoveries of Greenland ringed White-fronted Geese in Iceland over several years 1946-82.



Figure D15.3. Sites of recoveries of Greenland ringed White-fronted Geese in Iceland over several years 1946-82. Square symbols represent sites of recovery for Eqalungmiut Nunât ringed birds.

The importance of spring feeding in Iceland for breeding adults remains obscure: in the Lesser Snow Goose, feeding at regular staging areas en route to breeding areas has been shown to have a considerable effect on the nutrient reserves of the geese. Female geese feeding at these staging areas show an increase in protein levels equal to the protein content of an extra egg (Wypkema and Ankney 1979). It is unlikely that the same position prevails with Greenland White-fronts in Iceland as numbers seen in spring are generally small and the stop-over time brief. There seem few sites of major or traditional importance but counts of 4000 roosting on Lake Frakkavatn in Safamýri, up to 900 on Skúmsstadavtn and 1200 at Ferjubakkaflói-Nordura (Gardarsson 1976) are significant. However, more detailed studies in Iceland would clarify the situation and should be a future priority.

Arrival in Greenland

The earliest arrival of the adult geese in Greenland coincides with the first thaw at the lowest altitudes, where food can be exploited in the absence of young birds yet to arrive (Section D1). The forage at this time consists of subterranean perennating organs of plants restricted to the lowland mature sandur flats. Whilst this forage appeared sparse and poor, such plant material contains its highest concentrations of protein, carbohydrate and mineral nutrients just prior to the major onset of growth (Section D8).

Observations from this early period suggest an interaction between the constraints of optimal feeding in solitary pairs and in larger flocks. The high threat of predation (Section D3) favours the sharing of vigilance by a large group and thus a social feeding stategy, whilst agonistic behavioural interactions between feeding pairs, resulting from the defence of mobile feeding territories and the patchy nature of the food resource, would appear to favour solitary feeding. The result seems to be a compromise, with the limited food supply tending to concentrate birds into small areas, with social feeding and shared alertness, to the advantage of ganders which are consequently able to feed for longer periods (Section D2). However it is clear that many geese feed as solitary pairs and this became increasingly common as May progressed, leading eventually to the departure of breeding pairs away from the sandur areas in mid-May to feed in other lowland and mid-altitude marshes as they become progressively freed by thaw (Sections D1 and J2).

The concentrations of early arrivals in Greenland at a small number of traditional lowland sites seems to be a common phenomenon throughout the range of the Greenland White-fronted Goose, and it is thought that the arrival patterns observed on Kûk Marshes are probably similar at other such sites, with birds commonly feeding on the highly nutritious overwintering parts of *Triglochin palustre* and *Puccinellia deschampsioides*. It is important to determine the significance of these arrival areas for the geese, particularly with respect to their contribution to the nutrient reserves of the females. If the population continues to decline in numbers as it has done in the past (Ruttledge and Ogilvie 1979) for whatever reason, it may be that protection of geese from disturbance on these feeding grounds is an effective way of increasing breeding success. As it is, some of the sites seem to be subject to heavy disturbance from shooters (Section D3) since they are the only areas which ever hold high densities of geese in west Greenland. Further ringing on an extensive basis is also needed to show whether older birds arrive before immature birds in Greenland. Again this has implications for the continuance of shooting on the arrival areas in Greenland, since it is possible that shooting of the first arrivals early in the season might result in a disproportionate kill of breeding adults.

Prospecting for nest sites commenced in mid-May, and those selected were near lowland and mid-altitude *Sphagnum-Eriophorum* dominated wetland marshes, providing the gander with suitable feeding close to a nest site which gave the female a view of the surrounding terrain (Section D4). There seemed to be abundant marshes and flush sites suitable for breeding geese, and this habitat is also of importance for the feeding of arriving non-breeders before they move to the plateau in search of prime forage. It is postulated that the breeding males tolerate the non-breeding birds on the nesting marsh because of the large amounts of suitable food and the transitory nature of their competition (Section D6).

BREEDING

As breeding pairs settle around the lowland and mid-altitude marshes, the non-breeding and presumably failed-breeding element of the population move to higher altitudes to benefit from the later initiation of plant production there (Section D1). The margins of the upland plateau lakes form an even larger expanse of suitable feeding than that previously exploited in the lowland marshes. The geese begin to graze on the leaves of *Carex rariflora*, gradually neglecting the underground storage organs which previously dominated the diet. Further work is needed to investigate the hypothesis that the geese are able to optimise food intake by positional means (moving with the thaw) and social means (feeding in flocks). The effect of this feeding strategy on survival and breeding success is also of interest. Initially the non-breeding groups were small, gradually aggregating into larger flocks with social advantages. This probably minimises predation mortality later when the geese become flightless during moult.

For all located nests, the feeding area nearby included an *Eriophorum angustifolium* dominated marsh, with a food supply for the female during her recesses (Sections D4 and D6). There was little evidence of any territorial aggression by the gander despite the solitary nesting habits; the observed male apparently tolerated the presence of other breeding ganders and occasional groups of non-breeding birds on the marsh. However, on one marsh with two, possibly three, breeding pairs nearby, only one nest was successful. Aggressive interactions were seen more commonly between breeding males than between breeding males and non-breeding geese. Despite his absence from the nest area, the gander apparently fulfils a limited protective function during incubation, although he has sufficient time to feed during most hours of the day and thus to maintain, if not improve, his physiological condition prior to the assumption of the dominant role within the family (Sections D6 and D9).

During the 26-day incubation period of the observed pair (Section D6), the overall alertness of the pair progressively increased. The gander positioned himself close to the nest during the times of egg-laying, but except for short periods during incubation he remained some distance from the nest feeding on the marsh, returning to the nest just prior to the hatch. Both geese showed diurnal rhythms of activity, correlated with changes in environmental variables and predator abundance, and it is thought that the diurnal pattern of vigilance is timed to maximise the chances of predator detection. This apparent relationship between diurnal predator behaviour and diurnal goose behaviour needs further study to see if it is indeed causal, or if both are due to other or the same factors.

The physiological stress imposed on the female during incubation is reflected in the increased frequency and duration of her feeding recesses during incubation. The female was accompanied by the gander when feeding and most recesses occurred in the late evening when there was least predator activity (Section D6).

At one nest a young bird, probably in its second summer, was seen at the nest at the end of incubation. This, and other observations of immature birds accompanying parents with goslings (Section D9) suggest that Greenland White-fronted Geese show a form of alloparental care, where young stay with their parents in an extended family relationship, and assist in caring for the young of the year (in this case by sharing vigilant behaviour with the gander). Such behaviour has previously been reported for the Pacific White-fronted Goose (Ely 1979) and may be a common feature of White-front breeding biology. It is possible that it is shown to a greater extent in Greenland White-fronts than other races, although further studies are needed to determine the costs and benefits of this behaviour to both the immature goose and the adult parents.

The non-breeding part of the population follows the thaw on to the plateau in early to mid-June, whereas the breeding birds are more restricted in their feeding sites, remaining on the breeding marshes until the end of June. Once the goslings hatch they are taken immediately on to the plateau to find forage. The implication is that in the latter part of incubation the gander (and the goose on her feeding recesses) is feeding on sub-optimal forage.

POST-INCUBATION

Immediately after hatching, the gander assumes a sentinel role in the family,giving both the female and goslings maximal opportunity to feed. Vigilance is maintained at the expense of all other non-alert activities, and directly benefits gosling feeding in a fashion similar to the protective role with the female during the pre-nesting phase (Sections D2 and D6). In both observed cases, families were led away from their lowland nest areas up on to the plateau to exploit later emerging upland food plants (Section D9). The gosling diet differs from that of the adults despite the fact that the food plants of adults and goslings grow together, hence reducing competition within the family. As the goslings grew, the time spent feeding by them decreased, associated with the gradual change in diet which increasingly resembled that of the adults. This adult food may be more efficiently digested by the older goslings or the decrease in grazing may simply reflect a reduced dietary need (Section D8). However, it is most likely due to an increase in intake rate per unit grazing time due to the growth of the vegetation.

MOULT

The increasing flock size evident from June onwards amongst non-breeding birds on the uplands reflects the advantage to moulting birds of aggregation to offset the increased susceptibility to predation at this time. Similarly it is also of advantage to family parties to come together, sharing the alertness burden amongst more birds and increasing the efficiency of forage utilisation; however, there is a concomitant cost in terms of time lost by each gander in defence of the family feeding area within the structure of the flock. As the goslings grow older, parental investment in protection declines (Section D9).

Non-breeders and family parties were observed to flock separately throughout the summer. This is probably due to a different timing of the moult (Section D10) as well as to a conflict of interests - the non-breeders not sharing vigilance and yet competing for food (Section D9).

Throughout the summer, the geese continued to optimise nutrient intake by following the thaw on a microtopographical level, and in allcases, plants of young growth stages were selected. As the summer progressed birds moved from the early-thawing south-facing lake margins around to the north-facing lake edges. Eventually they fed close to semi-permanent snow-patches which were the very last areas to thaw (Section D8).

Owen and Ogilvie (1979) found that late moulting Barnacle Geese caught in Spitzbergen after 23 July showed no correlation between moult stage and weight, but that the immature and non-breeding element which moulted earlier declined in weight during the moult. This is thought to be due to the increasing quality of the forage after the moult of the non-breeding geese and indeed, some of the immature geese caught in the latter stages of moult weighed only 60% of their winter weight and were thought close to starvation. The Greenland White-fronted Goose from Eqalungmiut Nunât shows a similar relationship (Figure D15.4), but this is merely a result of the sex ratio since there is a significant difference in weight between the sexes (male mean weight 2.564 kg, female mean weight 2.143 kg; $F_{[154]} = 126.4$, $P < 0.001$) and there was no overall significant difference between the breeding parents and the earlier non-breeding geese ($F_{[66]} = 1.010$, $P > 0.05$). However, the fact that the non-breeders moult two weeks earlier than the breeding birds and that there is no appreciable difference between breeders and non-breeders in dietary composition is interesting. More detailed analysis of the energetic and nutritional status of the forage plants at this time is required to see if there is a significant difference between the periods when these species are exploited by non-breeders compared to breeding birds.

AUTUMN AGGREGATIONS AND MIGRATION

There is evidence that flocking continues prior to migration and by late August/early September the families probably join with the non-breeders for the migration south, first to Iceland and thence to the British Isles. White-fronts arriving in Iceland in September are seen in flocks of "thousands" in contrast to the smaller groups passing north in spring (Section D1). The shooting season opens in late August, thus the geese can be shot throughout the period of the autumn migration. In fact, there were only 600 waterfowl hunters in all Iceland in 1974, and there is little tradition of goose shooting in Iceland (Lampio 1974, Ruttledge and Ogilvie 1979) There are few conflicts with farmers at the present time, and the autumn food is similar to that of the Barnacle and Pink-footed Geese simultaneously passing through Iceland, namely *Polygonum* rhizomes and *Carex* seedheads (Gardarsson *in litt.*).

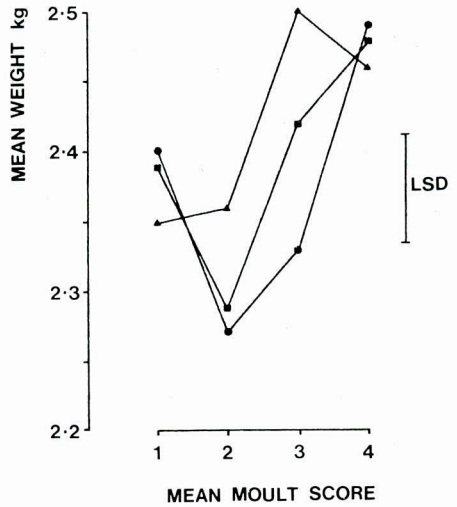


Figure D15.4. Changes in weight related to moult stage in Greenland White-fronted Geese *(Anser albifrons flavirostris)*. Closed circles indicate non-breeding birds, triangles indicate breeding birds and squares indicate all birds together.

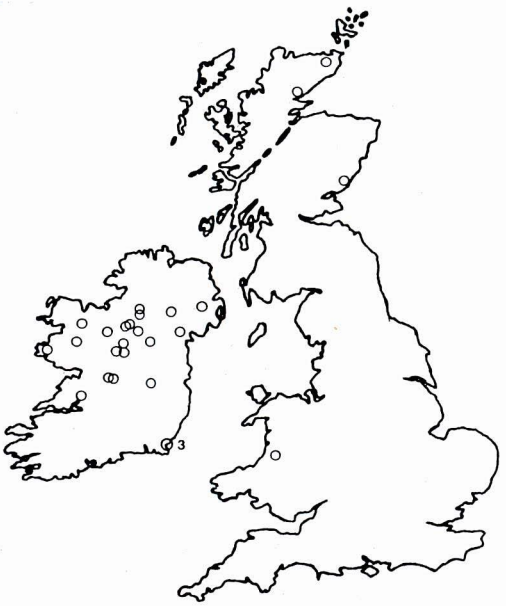


Figure D15.5. (left) Ringing recoveries of Greenland White-fronted Geese *(Anser albifrons flavirostris)* ringed at Ikamiut, Sudostbugten, Qasigianguit (68° 38'N 51° 51'W).



Figure D15.6. (right) Ringing recoveries of Greenland White-fronted Geese *(Anser albifrons flavirostris)* ringed at Sarqaqdalen, Nûgssuaq (70° 06'N 52° 08'W).

WINTER SEGREGATION AND DISPERSAL

The results of previous ringing of Greenland White-fronts have been published in a series of papers by Salomonsen (1947, 1948c, 1949a, 1950b, 1952, 1955a, 1957, 1961, 1965b, 1967b, 1971 and 1979b). The recoveries from this earlier ringing show that the dispersal of birds from one ringing site to many winter sites is not a phenomenon unique to geese from Eqalungmiut Nunât. Figures D15.5 and D15.6 present recoveries in the British Isles of geese ringed at two sites in Greenland: Sarqaqdalen, Nûgssuaq (70°06'N 52°08'W) and Ikamiut, Sudostbugten, Qasigianguit (Christianshaab) (68°38'N 51°51'W) respectively. As can be seen, geese from each site were recovered from a large number of winter sites, although mainly in Ireland.

Other recent studies have shown a similar pattern of dispersal for other species. Forty-six Whooper Swans were fitted with Darvic neck-collars at Lake Myvatn, Iceland, in summer 1980 and in the following winter 25 swans were seen throughout the range in Britain and Ireland (M. Brazil pers. comm.).

Abraham (1981), in a study of the eastern arctic Brant, found that Darvic leg-ringed geese from four localised breeding areas in high arctic Canada dispersed throughout the winter range on the eastern seaboard of America. In the two years of study, 16 out of 24 possible combinations between nesting and wintering areas were recorded, and it was thought that all combinations could have been recorded with greater observer effort. In areas of intensive observation the Brant populations were found to contain similar proportions of birds from different breeding areas and even at the level of local flocks there was great mixing with an average of two out of three, and usually in excess of three of the four nesting areas represented at each winter flock site (Abraham 1981). The ringed Brants showed great site fidelity both within and between the two winters of the study, indicating that the winter mixing of birds from different breeding areas is a regular phenomenon.

Abraham (1981) considers that such dispersal promotes gene-flow between breeding units, with pair formation when populations are mixed in winter and/or during spring migration. Such a situation is found in Lesser Snow Geese (Cooke *et al.* 1975), and is aided by each paired female taking her mate (of a different breeding area) back to her natal area. This is suggested as the reason for the slight morphological differences between Brants from different parts of the breeding range, contrasting with Canada Geese where gene-flow is limited by segregation of breeding units (Abraham 1981, Raveling 1979).

It is not known when the pairing of Greenland White-fronts takes place, but the pairing of two birds from different lakes in Eqalungmiut Nunât, suggests that it takes place either in the large pre-migratory flocks in Greenland or at sometime on the autumn passage. In either case, the pairing was between birds of the same breeding area representing a degree of inbreeding. Whilst it is unwise to extrapolate from such a small sample of marked geese, the observation certainly merits further investigation by more extensive ringing of known age geese to determine the place and time of pairing.

While it is true that the most northerly breeding geese tend to winter in the southernmost parts of the range (Figure D15.7), it is obviously no longer valid to regard each winter flock of Greenland White-fronted Geese being a breeding unit from one part of Greenland only. This has many implications particularly in the conservation and management of the population, since it implies that no one nesting area would be disproportionately affected by high winter mortality at one site (whether caused by weather or hunter kill), and differences in productivity on a local scale in summer will not unduly affect aggregations in any one wintering area (Abraham 1981). However, the Greenland White-front exhibits low productivity (below) and, with this type of dispersal system, continued shooting at a number of sites (as in Ireland) may influence the population over most of the breeding range; never catastrophically, but sufficient to keep the population at its current small size.

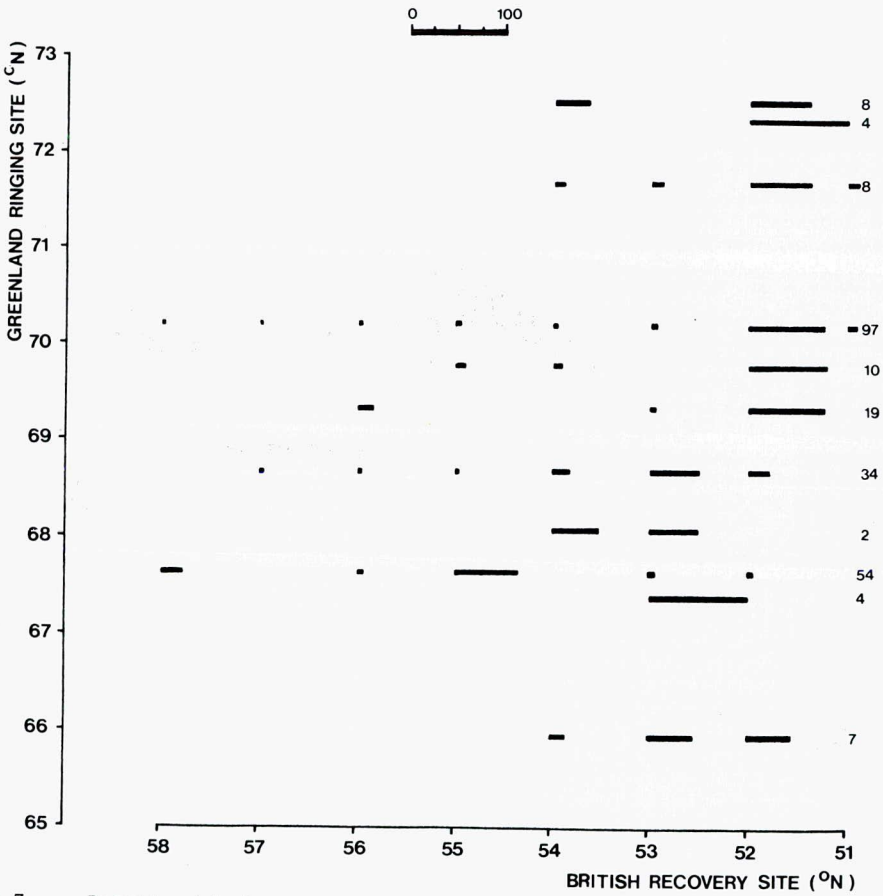


Figure D15.7 Relationship between latitude of ringing site and latitude of recovery site to demonstrate leap-frog migration in the Greenland White-fronted Goose *(Anser albifrons flavirostris)*. Bars indicate the percentage of geese from any one ringing site recovered at different latitudes; numbers indicate sample size for each ringing location.

The findings presented are of interest with respect to spontaneous site desertion as has happened in the past (see Section A2). In the case of the flock at Cors Tregaron, which totally deserted its winter haunt, and that on the Dyfi Estuary, which almost disappeared, it was previously thought that a likely explanation was disruption of a small breeding unit in Greenland. Thus an increase in hunting pressure near a conurbation was killing off the 'Dyfi breeding unit'. It is obvious now that this is unlikely to be the case, and desertion of haunts in winter is probably due to the changing attractiveness of the site to the geese. Although in many cases it is clear what has caused this, such as drainage of traditional bog sites, in the case of the Welsh birds there was no obvious physical change to the site. However this explanation is clearly more tenable, even though the factors influencing winter site fidelity are unclear, than a vague explanation invoking 'factors operating in Greenland'.

The simplistic model of explained differences in breeding success of Greenland White-fronts from different parts of the summer range by corresponding differences in winter forage quality in different regions of the wintering range will have to be revised somewhat to take this dispersal system intoconsideration. Geese from Eqalungmiut Nunât have been found wintering over the entire range in the British Isles, from Caithness to Wexford, and the condition of winter forage can be expected to vary considerably over six degrees of latitude.

GENERAL DISCUSSION

One of the major reasons for the initiation of the study was concern expressed for the general decline in numbers of Greenland White-fronted Geese wintering in the British Isles (Owen 1978, Ruttledge and Ogilvie 1979, Section A2). Whilst results of the expedition cannot categorically point to the reasons for this decrease, it is at least possible to discuss some of the factors affecting the breeding success of the sub-species in Greenland.

Counts in Britain and Ireland show the Greenland White-front to have a consistently lower level of production, but larger brood size than the Siberian breeding sub-species. These demographic features were also observed in Eqalungmiut Nunât in 1979, with a low proportion of breeding birds (an estimated 14% of birds arriving in May are successful breeders), and large brood sizes (mean = 3.50, compared with 11-year means at Islay of 2.6 and Wexford of 3.6; Section D1). There was a high proportion of predated or deserted nests within the study area (57% of nests found) but the part played by the presence of humans remains obscure (Section D3). Each of the likely factors involved in nest failure in a wider context is briefly discussed below:

(i) Human Predation

There seems to be very little human disturbance of the geese on the breeding grounds during the summer (Section D3). With the increased standard of living of the Greenlanders, traditional hunting practices in the larger settlements have been neglected in recent years and legislation has also, to an extent, protected the geese. The fattening of captive goslings has been outlawed and it seems that a general lack of interest in shooting geese where there are more 'profitable' game to be had ensures a passive adherence to these laws. The months in which the Greenlanders are in the interior regions hunting Caribou are those in which the geese are most difficult to locate,and this also protects the birds. Tradition plays a strong part in Greenlandic society, and such hunting of geese in some of the smaller settlements in the Disko Bay region over many years may have a more severe local impact (Section C25). The main mortality due to humans is undoubtedly the shooting at large migratory flocks on arrival in May, as near the Søndre Strømfjord Air Base as well as in other areas.

Subfossil remains of White-front bones were found in a midden site in Eqalungmiut Nunât (Section F4) indicating that historically the geese have been killed by the various Inuit ('Eskimo') cultures to inhabit the west coast of Greenland. The wide distribution of camps throughout parts of the interior regions of west Greenland, and their subsistence way of life could have resulted in severe local impact in some areas. We do not know whether goose bones occur in archeological sites excavated in west Greenland, but clearly this would repay further investigation. We know of no evidence to suppose that the Greenland Inuit ever developed techniques of mass goose capture as used by the Canadian Inuit. White-fronts would have been too insignificant a part of the avifauna for this to have occurred.

(ii) Other Predation

As outlined in sections D3 and D6, the number of potential predators in Eqalungmiut Nunât is less than for many other arctic nesting geese. It is not known how typical the region is in this respect and there are probably much higher densities of predators in the more coastal areas around Disko Bay. Here, gulls and particularly skuas are likely to be of considerable importance. The problem of nest predation is complicated by active and passive (i.e. following desertion) forms of predation, and although we have no information on the cause of failure of many of the nests we found, these may indeed stem rather more from desertion due to inexperience of the nesting geese (or for physiological reasons) than from predator abundance.

The possible effect of Ravens on breeding success has been discussed in Section D3. It seems that there has been a general increase in the numbers of Ravens seen in continental west Greenland over the last twenty years. This increase is roughly coincident with the decrease in Greenland White-fronts noted on the wintering grounds. Since egg predation by Ravens is likely to be more successful at the nests of young inexperienced breeders, the result will be that the only successful nests are those of older, experienced birds with larger clutch sizes. This will result in the small number of large broods seen in winter (Owen 1978).

(iii) Weather Conditions

The meteorological data from Søndre Strømfjord Air Base show that the continental areas of west Greenland close to the ice-cap have a more stable climate with a relatively predictable pattern of weather when compared to the coastal maritime areas which have a much bigger between year variation in most conditions. In the south of their range the Greenland White-fronts are found nesting close to the ice-cap only in the highly continental regions east of Nûk. This, together with the suggestions of higher densities of geese in the continental regions further north where the range extends to the coast (Section D1) suggests that there is an advantage to be gained from nesting in this predictable climate. For the majority of the population therefore there is no meteorological

reason for the large scale fluctuations in breeding success so typical of high arctic goose populations, and indeed, the annual production figures from winter counts have been relatively consistent. At the same time it should be pointed out that a few days' difference in the thaw of the lowland marshes, so crucial for pre-nesting feeding, may have a profound effect on the local breeding success of the geese.

(iv) Nest Site Limitation

In Eqalungmiut Nunât there seemed to be ample wetland sites at suitable altitudes (50 - 300 m) to support many more breeding pairs than were actually found (Section D4). In addition there was no shortage of upland feeding areas for the families to move to after hatching, although grazing in these areas may start to become limiting towards the end of the summer. However, the only two nests seen to be successful were on marshes of a large size and it is possible that the surfeit of suitable marshes is more apparent than real. Clearly this aspect of their breeding biology requires much more study in an effort to determine the carrying capacity of the west Greenland breeding grounds. If it is possible to determine the size and floristic composition of the marshes suitable for nesting, then it would be possible to assess the extent of this habitat type using infra-red satellite imagery from the MSS and VHRR systems currently in operation.

(v) Inexperience

Various studies have shown the relationship between age and nesting success and it could be that recent recruitment to breeding age classes has been reduced, resulting in a few older, more experienced pairs hatching larger broods, and many novice or young inexperienced pairs with very low success rates. In the absence of a population of marked birds of known life histories there is nothing to support this hypothesis apart from the demographic features mentioned above and the observed high nest failure rate. Ruttledge and Ogilvie (1979) have recently shown that while the Greenland White-front had increased in the early years of this century, there has recently been a marked decrease in many areas, particularly in Ireland. Furthermore, there has been a considerable spontaneous change in the winter habits of the geese with the traditional *Eriophorum angustifolium* bog sites neglected for improved pasture during recent years. The combination of change in diet and the local loss of habitat during the last few years may well have contributed to poor breeding success over a fairly long time span, now being reflected in the reduced recruitment of birds into breeding age classes.

The suggestion of alloparental care (Sections D6 and D9) supports this argument, since species with such nest care possess several common traits: namely low fecundity, deferred maturity, high survival, low dispersal from natal site, monogamy and single pulsed breeding in a short season (Table D9.3). All these are common features of a population with an old age structure, of a *K*-selected species, at or near the carrying capacity of the environment.

(vi) Condition

The physiological condition of the geese at commencement of nesting is of crucial importance for nesting success, and this largely depends on the quality of spring feeding on the wintering grounds and the limited feeding available on arrival (Section D2). Greenland White-fronts are possibly unique amongst arctic nesting geese in having no major staging areas. Although a limited number pass through Iceland, no major spring concentrations are known there. In this case it is possible that the Greenland arrival areas and pre-nesting feeding are unusually important to the geese as they lack these migratory feeding areas.

It has been shown that Brent Geese need to attain a body weight of about 1.6 kg in April for subsequent breeding success, thus conditions in spring determine whether they attain this threshold (Ebbinge 1979). A similar effect could well operate in Greenland White-fronted Geese, although, as stated above, feeding in Greenland will also be of considerable importance to breeding females. Condition can also be expected to act with the other effects mentioned above, particularly predation. Higher losses to predators can be expected if the female is energetically deficient and having to spend long periods off the nest feeding during incubation.

The effect of the condition of Greenland White-fronts on their subsequent breeding is probably of prime importance in understanding the curious demography of this race, although the topic will remain cloaked in mystery until detailed energetic studies are undertaken throughout the year and on large numbers of birds from different parts of the wintering and breeding ranges.



SECTION E ORNITHOLOGICAL OBSERVATIONS

E1

ORNITHOLOGICAL RECORDS

D. A. Stroud

INTRODUCTION

Section E contains systematic reports of all bird species seen in Eqalungmiut Nunât.

Each species' account commences with a brief description of the status and range of the species in Greenland taken, unless otherwise stated, from Salomonsen (1950a & 1967a) which are still the major sources of information on Greenlandic birds.

Reports presented here draw on observations made by all members of the expedition, and individual authors gratefully acknowledge these records and the reading and improvement of draft accounts. With so much movement within the study area, it is not feasible to list the areas covered by different observers or accredit observations to individual observers.

The report of the 1974 Joint Biological Expedition to north-east Greenland (Green and Greenwood 1978) was published when we were planning the expedition, and influenced our methodologies. In particular, section 20 of that report saved considerable effort in devising a suitable nest recording system. Nest, blank, habitat and ringing cards similar to those of the Joint Biological Expedition were printed. Feeding cards were redesigned more appropriately for geese, but since there were few feeding observations outside the main studies, most observations were made in log-books. All other cards were of similar design to those used in north-east Greenland. Ringing cards were found to be unnecessary since the ringers preferred the use of log-books.

Habitat Cards

Although slightly altered to take account of the low arctic vegetation of west Greenland, the habitat cards were of little use since the category of full tundra heath includes the majority of west Greenland plant communities. Trapnell (1933) was followed with regard to classification of plant communities, and while this remains one of the best for the area, it did not include wetland communities which were important for goose feeding sites. The revised habitat classification is given in Table E1.1.

TABLE E1.1. Habitat types and abbreviations suitable for use on west Greenland ornithological record cards.

OV	*Open Vegetation* :	Ground layer markedly discontinuous; field layer, where present, chiefly scattered herbs.
OM	*Open Mat* :	Ground layer sparse but continuous in small or shallow patches; open field layer usually present.
LM	*Lichen Mat*:	Ground layer with lichens predominating, continuous, hiding stones and forming a dense turf or carpet 2 cm and upwards in depth; field layer absent or discontinuous or in small patches.
MM	*Moss Mat* :	Ground layer with mosses predominating, structure as LM, field layer absent or discontinuous in small patches.
PM	*Patchwork Mat* :	Field layer of dwarf shrubs discontinuous in large patches, with lichens and mosses equally intermingled or in patches.
HM	*Heath Mat* :	Field layer of dwarf shrubs continuous, hiding ground layer or in large patches clearly dominant.
HBM	*Herb Mat* :	Herbs predominant in a close ground layer or grass field layer.
SC	*Scrub* :	Shrub layer continuous, hiding field layer.
MSM	*Moss Sedge Meadows*:	Rushes and sedges common, free water on surface for at least part of the summer.
TH	*Turf Hummocks* :	Characteristic hummock/hollow morphology and moderate heaving by frost action. Free water for at least part of the summer, but by late summer moist only.
CW	*Constantly Wet* :	Sheet flow areas and lake shores, gravel and boulders with little heaving.
SFP	*Sandy Flood Plains*:	Seasonally flooded, sand and loams; organic crusts with scattered vascular plants.
GFP	*Gravelly Flood Plains* :	Seasonally flooded, bare stones sometimes with scattered vascular plants.
DG	*Damp Gravels*:	Lichens and mosses on gravel, few vascular plants.
SD	*Sand Dunes* :	Dunes with occasional permanent pools, scattered vascular plants; no ground layer, sparse field layer. Includes: Mobile 'Yellow' dunes Stable 'Grey' dunes Dune heath
CL	*Cliffs*:	Rock face vegetation, scattered mosses, lichens and ferns.
RF	*Rock Falls* :	Boulders and stones, often on steep slopes and talus; vegetation as CL.

Breeding Record Cards

The design given by Green *et al.* (1978) was modified to take account of west Greenland habitats and breeding species. This more general card, suitable for low arctic use, is shown in Figure E1.1. Although this design gives greater versatility in its more generalised approach, more detailed notes were required for observers to obtain uniformity. The major area of difference, other than simplification, was the use of the standard categories of breeding evidence introduced by the European Ornithological Atlas Committee (EOAC), as listed in Table E1.2. The cards are illustrated in Figures E1.1 and E1.2.

SPECIES	CODE Nº	SITE	CROSS REF.	NEST SITE
HABITAT OM MSM OV TH LM CW MM GFP PM SFP HM DG HB Cliff Scrub Dunes Other:	COVER Vasc. plants Bryophytes Lichens Open ground Water Aspect Altitude Slope Terr. size Est. accuracy P F G VG Photo	DOMINANT PLANTS & COVER VALUES OTHER DETAILS		Height above ground or cliff base Construction Lining Cup depth width Down thickness How found

DATE	TIME	EGGS	YOUNG	BREEDING DETAILS (EOAC)	EGGS				
					Date / Nº	time	wt.	lth.	breadth

Figure E1.1. Upper side of breeding record card.

ADULTS & YOUNG

(INCLUDING RETRAPS)

CODES N Nest collected; B Blood smear; MC Moult card; D Dead; DR Droppings col.; E Ectoparasite col.; S Serum col.; P Pellet col.; F Feathers col.

DATE	TIME	A	S	RING NO.	WING	TARSUS	WEIGHT	BP	REF	PLUMAGE	MOULT	PHOTO

NEST SUCCESS unknown success failure

NOTES

Figure E1.2. Rear side of breeding record card.

Instructions

Each member of the expedition was given a set of instructions for the use of record cards, a description of the main projects, species' lists of mosses and lichens and the classification of Trapnell (1933) for plant community types.

TABLE E1.2. EOAC categories of breeding evidence for use on nest record cards.

GRADE A	
OO	Species OBSERVED in breeding season
GRADE B	Possibly breeding
H1	Species observed in breeding season in possible nesting HABITAT
S2	SINGING male(s) present, or breeding calls heard, in breeding season
GRADE C	Probably breeding
P3	PAIR observed in suitable nesting habitat in breeding season
T4	Permanent TERRITORY presumed through registration of territorial behaviour (song etc) on at least two different days a week or more apart at same place
D5	DISPLAY and courtship
N6	Visiting probable NEST-SITE
A7	AGITATED behaviour or ANXIETY calls from adults
I8	Brood patch on adult examined in the hand, indicating probably INCUBATING
B9	BUILDING nest or excavating nest-hole
GRADE D	Confirmed breeding
DD10	DISTRACTION DISPLAY or injury feigning
UN11	USED NEST or egg shells found (occupied or laid within period of survey)
FL12	Recently FLEDGED YOUNG (nidicolous species) or DOWNY YOUNG (nidifugous species)
ON13	Adults entering or leaving nest-site in circumstances indicating OCCUPIED NEST (including high nests or nest-holes, the contents of which cannot be seen) or adults seen sitting on nest
FY14	Adults carrying FOOD for YOUNG or faecal sac
NE15	NEST containing EGGS
NY16	NEST with YOUNG seen or heard

E2 RED-THROATED DIVER (*Gavia stellata*)

A. D. Fox

The Red-throated Diver is found on virtually all coasts but is most numerous in the north. It is common along the west coast north to Melville Bugt, with several pairs inland from Qânâq (Thule) Settlement; Eqalungmiut Nunât lies between Nûk and Disko Bugt where this species is most abundant in west Greenland. Four recoveries of birds ringed in east and west Greenland have all been from western Europe, two in south-east England.

Eight confirmed cases of breeding were recorded from an area of 350 km^2 of uplands at altitudes between 250 m and 550 m.

ARRIVAL DISPERSAL

Red-throated Divers were first noted on 22 May when three birds flew high over west Eqalungmiut tasia, with birds observed daily over the next ten days. Initially, birds arrived singly uttering the flight-cackle call (Cramp and Simmons 1977), although up to four individuals were in flight at one instance over Eqalungmiut tasê. On arrival, birds flew mainly north and east, subsequently circling uplands and lowlands alike, such that movements became obscure. The majority of birds passed through Eqalungmiut Nunât during 22 to 25 May, with some movement continuing into early June.

As a result of the comparatively early arrival of the species, the Red-throated Diver was initially restricted to lowland waters where the thaw was furthest advanced. During May, up to three birds were observed on Kûk Marshes, at Aberchar and on east Eqalungmiut tasia, with numerous records of one or two on lakes and pools adjoining the lowland waters, as at Caroline's Pool and on Ridgeway Marshes. On 23 and 24 May there were probably ten different birds in the Kûk-Eqalungmiut tasê - Ridgeway Marshes wetland area.

A pair remained at Aberchar well into June, indulging in courtship and prospecting for nest sites. It seems that the birds failed to nest in the vicinity due to the human activity there. A second pair appeared to settle on Caroline's Pool adjoining east Eqalungmiut tasia, and birds were frequently noted at Valerie's Pool above Kûk Marshes, but pairs apparently failed to breed at any of these sites.

Most nesting pairs fed well away from the breeding lakes, resulting in a considerable traffic to and from the fjords and larger lakes. Maximum numbers noted were nine feeding off Niaqorssua on 3 and 4 July, with eight in the same area on 3 August. There appeared to be some movement out of the region before 19 August, with regular flights of calling birds over Base Camp between 17.30 and 20.20 hr daily from 10 until 20 August. In addition, on 20 August, family groups of Red-throated Divers were seen in Kangerlugssuaq having presumably forsaken their breeding lakes.

BREEDING

At least eight pairs of Red-throated Divers bred in Eqalungmiut Nunât, all on relatively small (less than 0.1 km^2) freshwater lakes. In a land area of 350 km^2, it was considered that all breeding pairs were located, although failed early nesting birds would have been missed. In view of the feeding habits of the birds in west Greenland, it seems inappropriate to relate breeding density to feeding-water area as used by Merrie (1978) in Britain. Excluding the birds at Aberchar and Caroline's Pool which apparently failed to breed, seven of the eight pairs nested above 300 m above sea level, although all fed by necessity in the lowlands.

Nests and Nest Sites

Three nests were found, two on islets in lakes, the third at the waterside at Doodle. All were less than 40 cm from water in very open situations except the Doodle nest which was partly overhung by *Salix glauca*. The island nests at Delta and Juliet were essentially very similar, amongst *Carex rariflora*, *Eriophorum angustifolium*, *Salix arctophila* and *Vaccinium uliginosum* on *Aulacomnium turgidum-Sphagnum spp.* mat, with *Polygonum viviparum*, *Carex bigelowii* and *Luzula spp.* also present. Both islands were more than 2 m from the nearest lake edge, and both nests facilitated easy entry to deep water. All nests consisted of bare scrapes with well developed chutes leading into deep water.

Brood Size

The Delta nest was to have been the subject of special study but was deserted, probably as a result of human activity in pursuit of geese and none of the nests was followed through the season. Four cases of confirmed breeding resulted from the goose searches throughout July and all breeding records are summarised in Table E2.1.

TABLE E2.1. Summary of breeding records of Red-throated Diver (*Gavia stellata*) in Eqalungmiut Nunât, 1979.

Site	Clutch Size (Date discovery)	Brood Size (Earliest date noted)	Number of fledged young
Atanârssuk	-	1 (21 July)	-
Delta	2 (27 June)	Deserted	0
Doodle	1 (18 July)*	-	-
Hookwater	-	1 (29 July)	-
Juliet	2	2 (9 July)	1**
Lake 26	-	1 (27 July)***	-
Lake 58	-	1 (29 July)	-
Lake 65	-****	-	-

* Adults present on lake from at least 14 June

** Two young hatched, only one survived to mid-July

*** Less than five days old (based on Bundy, 1976)

**** Birds present at this site on many dates in July and heard in the incubation change ceremony on 16 July

FEEDING

This species feeds principally on fish (Cramp and Simmons 1977) with birds flying considerable distances to feed on suitable waters. The Juliet birds fed largely on west Eqalungmiut tasia, the Delta birds flew down Rimwater to the fjord beyond, and the pairs on Lake 65 and Doodle flew to and from the fjord to the south. It would appear that all feeding was done away from the nesting waters contrasting the Great Northern Divers and Red-breasted Mergansers which nested on feeding lakes.

No information was available on the prey species taken, but both Stickleback and Char are listed by Cramp and Simmons (1977) as food items and both fish were numerous in Manx Lake and Eqalungmiut tasê, two favoured feeding sites. Salomonsen (1950a) lists Polar cod (*Boreogadus saida*), sand-eels and sea-scorpions as prey items in fjord waters.

Submergence times from several dates in June, given in Table E2.2, show a mean of 8.8 s in depths of up to 2 m at Aberchar. This is considerably shorter than 'c.1 min' quoted by Cramp and Simmons (1977), but appears to be the usual duration of pursuit of *Gasterosteus* and char fry in shallow water. Dives were often prefaced by submergence of the head and on many occasions, prey was seized and consumed at the surface without diving. An adult was seen to carry a fish c.15 cm long from east Eqalungmiut tasia over the ridge towards Quebec, presumably a small Char being taken to feed the Juliet juvenile; this was the only observation of fish being taken to young birds.

TABLE E2.2. Mean submergence times of Red-throated Divers (*Gavia stellata*); diving times measured in seconds from several dates in June at Aberchar, Eqalungmiut Nunât.

Sex	SUBMERGENCE DURATION		SURFACING TIMES BETWEEN SUBSEQUENT DIVES	
	n	mean ± standard dev.	*n*	mean ± standard dev.
Male	7	7.9 ± 1.4	9	3.8 ± 1.8
Female	4	9.8 ± 1.7	4	5.3 ± 1.7
Indet.	12	9.0 ± 1.9	12	3.8 ± 1.2
Mean	23	8.8 ± 1.8		

BEHAVIOUR

Courtship and copulation were frequently watched at Aberchar during early June, with the "penguin-dance" (Huxley 1923) being witnessed from 23 May (Long-tail Pool) until 18 July when five birds were watched in display at Spidermere. Few signs of active aggression were noted although the male diver of the pair at Aberchar saw off other divers and a Merganser during the prospecting period. After the onset of breeding, birds became more social, the feeding aggregations on the fjord at Niaqorssua being an apparently common phenomenon (Salomonsen 1950a), with groups gathering prior to feeding as shown by four flying to feed over the Gullery on 2 August.

The change-over of nesting adults was witnessed on several occasions; outside of the change-overs, the female, at least, left the Delta nest for up to seven minutes for plumage care. The sitting bird would normally sit with head held slightly up, gradually falling as the bird dozed. Both sexes frequently snapped at insects during incubation (see Rankin 1947). In the presence of humans, Peregrines and Ravens, the head was stretched forward, obscuring the conspicuous contrast between the neck patch and throat.

After hatching, the young birds kept close to the accompanying adult during the absence of the other parent, often seeking refuge under the banks of the lake, moving out at the approach of humans. The Juliet pair falls into the shy group of Bundy (1978) as both adults left the lake at close approach.

E3 GREAT NORTHERN DIVER (*Gavia immer*)

A. D. Fox

In Greenland, this bird is typically low arctic, most common in the south-west of the country, with maximum densities in the northern part of Qaqortoq District. North of Nugssuaq peninsula, it breeds only locally as far as Upernavik, being until recently unknown to the Greenlanders of Qânâq Settlement where there has been some northwards expension of range in recent years. In the extreme south-west, this species has been hunted for its plumage in the past.

In Eqalungmiut Nunât, the species was restricted to the lowland waters, almost certainly as a result of the distribution of fish within the area. Three pairs are known to have nested, and it seems unlikely that many other birds bred, there being few other suitable bodies of water in the region.

ARRIVAL AND DISPERSAL

The first birds were noted on 25 May when a pair was seen at midday on west Eqalungmiut tasia, with birds present on both lakes until 20 August. There was some suggestion of birds passing through the area during the last days of May, with birds on Long-tail Pool and in flight along Afon Char and over Base Camp moving generally northwards. Birds were first noted on Ian's Lake at the east end of Pass of Jennings on 24 June during the first visit to this area. Birds were subsequently noted mostly from the Eqalungmiut tasê and Ian's Lake; records from elsewhere were unusual. One bird was seen diving on a relatively small Lake above Omphalis on 18 June, and during the period 26 June-2 July there was a bird on Rimwater on several dates, probably Eqalungmiut tasê birds. The only records from the uplands were a bird on Zulu, 27 June; a pair calling over Mirrormere, 13 July and one calling over Clearwater on 27 July. A single bird was also seen on a pool on the sandur terrace east of Marble Gorge above North Valley on 27 June, but was not revisited subsequently. During the last few days on the study area, birds were watched flying over the lowlands, virtually all moving south between 19.00 and 22.30 hr each night from 14 to 20 August, perhaps a movement out of the area, although the Eqalungmiut tasê birds remained on the lakes throughout this time.

BREEDING

All the breeding pairs nested on characteristically large, deep expanses of water; a pair on each of Eqalungmiut tasê and one on Ian's Lake. All these lakes were in excess of 0.4 km^2, while the two larger lakes were over 1 km^2 in extent. Activity around Ian's Lake was limited and, as a result, detail regarding this pair is scant. A single bird present on 24 June suggested an incubating bird elsewhere, with two adults and two young present on 4 July, giving a laying date in early June. The nests of the other two pairs were located on small islands in the lakes, some 5-20 m from the shore, although during extreme changes in water levels during the melt, the sizes and distances from the shore of the islands varied considerably. The western lake island showed no sign

of nesting on 30 May but on 4 June, a bird was seen on the nest. On 1 July, a visit showed the nest to be deserted, leaving two cold eggs in the shallow scrape. The nest on the east lake lay at the foot of the rockfall below Imajuitsoq, but was virtually impossible to view from the shore. Sitting birds flushed the nest, slipping silently into deep water to surface 20-30 m from the nest. These nesting birds were first located on 24 June, with birds present on the lake until the parents were noted with a large chick on 9 August.

FEEDING

Birds were frequently watched fishing on all three lakes; dives were usually prefaced with searching, dipping the head below the surface before slipping below the water in pursuit of prey. As with the Red-throated Diver, this species initially fed about the shallows of the lakes, but later with the thaw was less constrained to feeding in the shallower depths than the smaller species. No birds with prey were ever noted at the surface, but Cramp and Simmons (1977) list both Arctic Char and Gasterosteidae as prey items which were both abundant in these lowland lakes. In spite of diving in the deeper parts of the lakes, this species spent much time fishing at Aberchar and Lakesmeet. Diving times from Aberchar in depths of 1-3 m gives a mean of 9.5 s (n=19, s.d.=3.3), remarkably less than values given by Kinnear (1978), but consistent with times for Red-throated Diver and Red-breasted Merganser under similar conditions.

E4 CORMORANT (*Phalacrocorax carbo*)

A. P. Fowles

The Cormorant is a typical low arctic species in Greenland, confined to the west coast, breeding from Kangerdlugssuaq north to Upernavik. Salomonsen (1950a) singles out Nagssugtôq as holding a large breeding concentration and claims there are "no less than fifteen colonies according to the Greenlanders . . . they maintain that colonies comprising several hundred pairs nest on islets at the head of the fjord".

Although none of these colonies was visible from Eqalungmiut Nunât, adult birds were seen on all visits to Niaqorssua (3 and 16 July, 3 August) either fishing on the full tide or resting on the rocky shore of the headland. A maximum of six birds was seen on 3 August.

A juvenile was observed on Manx Lake on 13, 14 and 15 August.

E5 TEAL (*Anas crecca*)

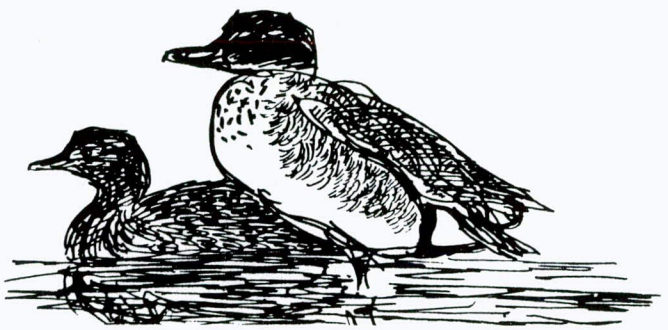
A. D. Fox

There had been fifty records of the nominate race of Teal up until 1967 from Greenland (Salomonsen 1967a). Most of these had occurred in the Nanortalik-Nûk region, and most of the birds follow the pattern of adults appearing during April-July and young birds during September-November. In addition, there had been thirteen occurrences of the Green-winged Teal (*A.c. carolinensis*) with similar distributions of sightings to those of the Common Teal. Since that time, there have been several more sightings of the species and a case of suspected breeding in Nûk Fjord in 1974 (Boertmann 1979).

Three Teal were seen in the study area during 1979:-

17 June - A drake Teal was flushed with a drake Mallard from the edge of a small pool adjoining the large lake at the foot of Pass of Jennings. Although the observers noted the lack of horizontal white stripe along the side, the vertical white marking on the flank was not identified and the origin of the bird remains obscure. The bird flew off eastwards and was not seen subsequently.

13 August - A pair of Teal was present on Long-tail Pool, Kûk Marshes, remaining until the following day. The birds were in eclipse plumage and hence were not ascribed to subspecies.



MALLARD (*Anas platyrhynchos*)

A. D. Fox

The Mallard is a common low arctic species breeding from south-west Greenland as far north as Âsiât, becoming infrequent around Disko Bugt and breeding locally as far as Upernavik. The species is represented in Greenland by the sub-species *conboschas* , remarkable for its habit of wintering along the coastal fringe of its summer range, although there is a movement of northern birds south for the winter.

In Eqalungmiut Nunât, the Mallard was widespread and common on plateau and lowlands alike, being the most widely distributed of the waterfowl present, proven to breed in 20 situations, nesting more frequently at lower altitudes.

ARRIVAL AND DISPERSAL

The first birds seen were nine individuals, including five drakes, on Kûk Marshes on 7 May, with numbers increasing to 28 on 29 May and subsequent counts of 50-60 over the next few days (Figure E6.1). The birds fed exclusively on the pools and marshes and as with the geese, Mallard were restricted to Kûk Marshes for the first two weeks of May. The species also moved back to the pools on the fringe of Kûk dunes as the smaller pools froze over after sunset (see Section D2). It was during the period of lowest temperatures that counts were made, when the birds were confined to areas devoid of cover. The increase shown in Figure E6.1 is thus likely to reflect the arrival and build up of Mallard on the marsh complex. After 13 May there was a decline in the numbers, with birds flying north-west up Goose Valley from 11 May, especially towards midnight as the substrate froze. By 21 May, Mallard were present on Eqalungmiut tasê, Ridgeway Marshes, Phalarope Pool and other lowland wetlands and had begun to frequent peripheral areas of the plateau such as Frihensdam and Top Tarn; by mid-June birds were present on open water over much of the plateau. By August, Mallard had been noted from virtually all water bodies between the Eqalungmiut tasê and Boulder Lake-Zulu-Doodle water system and it seemed likely that most areas of open water in Eqalungmiut Nunât were visited at some time during the season.

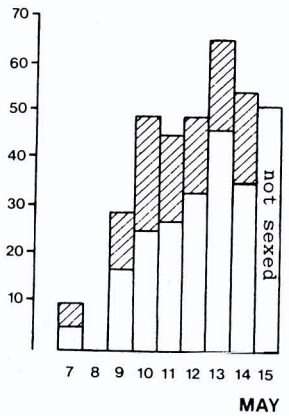


Figure E6.1. Maximum daily counts of Mallard (*Anas platyrhynchos*) at Kûk Marshes, Eqalungmiut Nunât, 1979. Cross-hatching indicates female birds, the remainder drakes.

Little return movement out of the area was noted, but there was a considerable decrease in the number of drakes encountered, and the aggregations noted on the fjord flats in July-August (Table E6.1) may represent non-breeding birds leaving freshwater areas for the fjords and coasts as observed by Salomonsen (1950a).

With the exception of the pre-melt build-up on Kûk Marshes, no large aggregations were noted from freshwater localities.

TABLE E6.1. Maximum concentrations of Mallard (*Anas platyrhynchos*) in Eqalungmiut Nunât, 1979.

DATE	LOCALITY	NUMBER
10 May	Kûk Marshes	49
11 May	" "	45
12 May	" "	49
13 May	" "	65
14 May	" "	57
15 May	" "	63
3 July	Niaqorssua	41
4 July	"	c.60
2 August	"	34
3 August	"	36

BREEDING

A total of twenty breeding pairs was located. From the area of the plateau above Base Camp to the Boulder Lake-Zulu-Doodle system, it is likely that all cases of breeding were discovered, giving a land area density of 1 pair per 5 km^2. The lowland aggregations of breeding pairs around the wetland sites make comparison with upland sites difficult: there were five different broods raised on Kûk Marshes, three at George Eliot and two nests were discovered at Upper Marsh. Longstaff (1932) found eleven pairs in 20 km^2 in a similar lowland area near Godthabsfjord.

The nesting season appears long; the first nest with seven eggs was found on 9 June, while a female with newly hatched young was on Fish on 11 August. The spread of clutch discovery dates is given in Table E6.2.

TABLE E6.2. Details of Mallard (*Anas platyrhynchos*) nests found in Eqalungmiut Nunât, 1979.

LOCALITY	DATE FOUND	CLUTCH SIZE
Goose River below Top Tarn	9 June	7*
Calamagrostis slopes near Base Camp	10 June	5
Ptarmigan Gorge	5 July	6
Ptarmigan Gorge	6 July	8*
Lake 6/Atanârssuk	5 July	8

* denotes full clutch size

Nests and Nest Sites

Five Mallard nests were located by flushing the duck from the nest. All were on the ground, four under *Salix glauca* canopies, one lying close to Base Camp under *Betula nana* scrub on an open *Calamagrostis purpurescens* covered slope some 400 m from water. All nests consisted of shallow scrapes lined with mixed grass litter and down covering the clutch in the absence of the duck.

Only two of the nests were followed, so it is not known whether the remainder represent full clutch size - Table E6.2 gives details of nests discovered. Salomonsen (1950a) quotes clutch sizes of eight to ten, with some of only six or seven, rather less than the European records for the species (Table E6.3).

TABLE E6.3. Records of Mallard (*Anas platyrhynchos*) clutch size from the Western Palearctic.

SOURCE	REGION	SAMPLE	RANGE	MEAN
Cramp and Simmons (1977)	W. Palearctic	?	9-13	?
Harrison (1975)	W. Palearctic	?	10-12	?
Ogilvie (1964)	British Isles	95	6-18	12.6
Fog (1964)	Denmark	33	5-17	9.6
Hilden (1964)	Finland	84	6-11	8.2
Bengston (1972)	Iceland	68	?	8.5

Egg Measurements

Of twelve eggs measured from two clutches (Table E6.4) mean measurements were 59.4 x 42.1 mm with a mean weight of 80.2 gm. The clutches are considerably different, but both fit well with those of Salomonsen (1950a) who quotes 57 - 66 (mean 61 mm) x 40 - 45 (43 mm), and are slightly larger than mean values of 57 x 41 mm given for the nominate race in Cramp and Simmons (1977).

TABLE E6.4. Measurements of eggs from two Mallard clutches, Eqalungmiut Nunât, 1979.

LENGTH (mm)	BREADTH (mm)	WEIGHT (gm)	LENGTH (mm)	BREADTH (mm)	WEIGHT (gm)
62.05	45.00	81.0	56.40	40.90	81.0
60.05	45.00	80.0	55.50	40.00	79.5
61.60	46.05	81.5	56.80	40.10	80.5
58.80	41.05	79.0	57.45	39.10	79.0
59.30	41.60	79.5	61.65	39.10	80.0
61.60	44.90	81.5			
61.60	43.00	80.0			

Brood Size

None of the nests located was followed to hatching, but several broods were subsequently recorded without being aged. The possibility of broods being recorded twice from different sites was kept to a minimum but this may have occurred in some instances from neighbouring waters. Mean brood size from these data is 4.65 (n=20) based on a spectrum of age classes.

FEEDING

Little is known of the feeding ecology of the Mallard in Greenland. During summer 1979, Mallard were observed feeding in several ways: on dry land, grazing; by submerging head and neck; by dabbling in shallow water; and by up-ending in shallow water to obtain submerged food items.

During May and June, birds began to associate in breeding pairs on smaller quieter waters freed by the thaw. Here the ducks spent long periods feeding with an alert drake in attendance, serving a protective function for the female as she attained peak condition prior to laying. In Eqalungmiut Nunât, the paired females spent long periods feeding in this manner, punctuated only by short periods of alertness. Data suggest that a feeding drake feeds for shorter bursts interspersed with longer bouts of extreme head-up vigilant posture (Table E6.5). At all times, the male remained in close proximity to the female and from scans of George Eliot, 65.3% of the female diurnal activity is spent feeding compared with 22.5% in drakes.

TABLE E6.5. Duration of feeding/alertness (in seconds) in feeding pairs of Mallard (*Anas platyrhynchos*), George Eliot, Eqalungmiut Nunât, from several dates in May 1979.

ACTIVITY	MEAN DURATION ± STANDARD DEVIATION	*n*
Female duration of up-ends	7.3 ± 1.9	23
Alertness between up-ends	2.9 ± 1.4	21
Female duration of head-submergence	7.0 ± 0.9	12
Alertness between head submergences	7.5 ± 0.8	12
Male duration of up-ends	4.6 ± 1.7	17
Alertness between up-ends	4.7 ± 2.1	17
Male duration of head-submergence	3.3 ± 1.0	12
Alertness between head submergences	3.4 ± 1.4	12

Comparision of populations using Student's *t*-test, giving values of *t* and level of significance.

female u/e alert	5.24***	
female h/s alert		17.34***
	male u/e alert	male h/s alert

female up-end	7.59***	
female head-sub		22.49***
	male up-end	male head-sub

Females were seen at Phalarope Pool and George Eliot pattering the feet in shallow water to stir up food items taken at the surface. On 24 May, a drake was observed to dive for 6 s, apparently feeding along Afon Char.

In early May, the diet would have consisted of solely vegetable matter. The birds fed throughout the day on the same pools on Kûk Marshes as utilised by geese, with heightened activity between 06.00-09.00 and 17.00-21.00 hr, feeding on the over-wintering organs of *Triglochin palustre* and *Potamogeton filiformis* at this time.

As other sites became available from the ice, the below ground parts of *Ranunculus hyperboreus* and the fleshy developing *Hippuris vulgaris* stems were taken. Later still, observations of feeding were limited, but birds were watched feeding on *Equisetum variegatum*, while in July and August, large numbers of Chironomid larvae were taken, as by a pair observed dabbling for semi-emerged insects at Uniform, 10 July.

MOULT

The first flightless drake was noted on Doodle, 4 July with others subsequently throughout Eqalungmiut Nunât. The last flightless males were five together on Lake 18, 27 July. Eclipse-plumaged drakes were noted from 25 July until 20 August; a few females, presumably failed breeders, were seen from 23 July to the end of that month.

BEHAVIOUR

The gregarious flocks of birds in early May broke up as the thaw progressed and pairs and small groups appeared on smaller waters and marshes from the second week of May. There was little evidence of aggregations of drakes after dissociation from nesting ducks, although during early June the proportion of males increased, including groups of three to five drakes communually roosting at Lakesmeet, Aberchar, etc..

E7 EIDER (*Somateria mollissima*)

A. D. Fox

The Eider breeds on virtually all coasts of Greenland and is of great economic importance to the Greenlanders as a source of food, both flesh and eggs, and for the skin and down (Salomonsen 1970, Doughty 1979). It is reasonably common along much of the south-west coast of Greenland, extending up along the long fjords of the region to the interior. It is interesting to note that Salomonsen (1950a) states that "the remote islets at the head of the large fjords Nørdre Strømfjord (Nagssugtôq) and Arfersiorfik form its only important stronghold in south Greenland; here breed several thousand pairs". Although the southern fringe of Eqalungmiut Nunât constitutes the same area of the head waters of Nagssugtôq, it would appear that the region referred to lies to the north and west of Eqalungmiut Nunât and Ipiutârssûp Nunâ. This region, known as Ugssuit Nunât, appears more attractive for the species and it is likely that the large concentrations reported come from the many islands of that region.

The only records of Eider from the study area came from sporadic visits to the extreme western end of Eqalungmiut Nunât as follows:

3 July - 9 males, 2 immature males and a single female were seen off Niaqorssua.

16 July - 42 females with a total of 68 ducklings feeding on the tidal flats off Niaqorssua, close to the shore. The adult females were generally feeding without diving in the shallows, while the young were diving for periods rarely exceeding three seconds. In addition to this loose group, there was a raft of 80 - 90 birds far out in the mid-waters of the North Fjord, north-west from Niaqorssua.

3 August - 10 females with 19 ducklings off Niaqorssua. Also 1 female flying west past the point.

There would thus appear to be a breeding population of about 50 pairs at the western extremity of Eqalungmiut Nunât. No attempt was made to discover the actual breeding site, but a quiet bay along the western shore and a suitable island off the southern fringe of Niaqorssua both seemed attractive sites. The large aggregation of birds in mid-channel on the northern side might represent a moulting assemblage of predominately male birds which are commonly encountered in sheltered inlets and quiet fjord areas at this time.



E8 LONG-TAILED DUCK (*Clangula hyemalis*)

A. D. Fox

The Long-tailed Duck is found throughout most of Greenland, being generally more numerous in high arctic regions and with maximum densities in the Qânâq District of west Greenland and the Scoresby Sund area of the north-east. Northern birds winter off southern Greenland, while birds ringed on the west coast have been recovered in Iceland, Denmark and Altantic coasts of North America (Cramp and Simmons 1977).

In Eqalungmiut Nunât, the Long-tailed Duck was proven to breed in fifteen cases and was numerically the most abundant waterfowl.

ARRIVAL AND DISPERSAL

The first birds were thirteen (six drakes) on Long-tail Pool, Kûk Marshes on 23 May. The upland lakes at this time had melted to give at least some peripheral open water, so dispersal of Long-tailed Ducks followed rapidly. Three drakes were courting a female at Aberchar later on 23 May with others on George Eliot and Lakesmeet on subsequent days. By 26 May, drakes were present on Lake Line 5 and a group of four on Atanârssuk; by the end of the month there were many birds throughout the upland areas. This pattern suggests that the factor restricting the arrival of Long-tailed Duck in continental west Greenland is exerted on the population outside the region and is probably linked to coastal conditions.

Long-tailed Ducks were noted from the majority of lakes and pools varying from Eqalungmiut tasê to ponds the size of Phalarope Pool, and from fast-flowing streams, as in the case of a female in the rapids below Boulder Lake in early June. All records of ten or more individuals are shown in Table E8.1.

It would appear that Eqalungmiut Nunât supported a large non-breeding population, with a low proportion of nesting adults. The sex-ratio of the species remained at approximately 1 : 1 throughout the summer and there was no evidence of any movement out of the area before 20 August. One synchronous count of nearly thirty lakes in a land area of 46 km^2 gave a total of 73 Long-tailed Ducks or 1.6 birds/km^2. Counts from the 25 km^2 area of plateau gave a similar concentration of 1.92 birds/km^2. Both estimates come from upland areas with relatively high proportions of open water, hence using an adjusted value of 1.5 birds/km^2 overall, the summering population of Eqalungmiut Nunât would be in excess of 1000 birds, considerably more numerous than Mallard, but probably representing a smaller breeding population.

From field notes, it would seem that first year and other sub-adult non-breeding birds were present in Eqalungmiut Nunât (see Salomonsen 1941a).

TABLE E8.1. Table of maximum aggregations of Long-tailed Ducks (*Clangula hyemalis*) encountered in Eqalungmiut Nunât, 1979.

SITE	DATE	NUMBER
Kûk Marshes	23/5	13
Kûk Marshes	24/5	12
Kûk Marshes	14/6	10
Pass of Jennings Marshes	17/6	20+
West Eqalungmiut tasia	19/6	14
Kûk Marshes	24/6	10
Atanârssuk	24/7	16
Atanârssuk	25/7	19
Lake 27	25/7	13
Atanârssuk	26/7	13
Lake 37	27/7	26
Unidentified lakes between 630 m and 601 m	15/8	23 & 16

BREEDING

Fifteen pairs of Long-tailed Ducks were found breeding from upland and lowland sites, although in view of the late arrival of the species, it seems possible that further clutches may have hatched after 20 August. Thus, although all cases of breeding were probably located between Base Camp and the Boulder Lake-Zulu-Doodle system, this may not represent the total breeding population. Five breeding records give a density of 1 pair/km^2, similar to that of Mallard, but with 27% of birds present being nesting pairs. In view of the large numbers of non-breeding birds elsewhere in Eqalungmiut Nunât, it seems likely that the proportion of breeding pairs is considerably less taken over the entire area.

The nesting season is clearly shorter than for Mallard. The earliest nest, containing five eggs, was located on the shores of Eqalungmiut tasia on 18 June and a nest of seven eggs was found at Wallbanger on 26 July.

Nests and Nest Sites

Five nests were located, all made of grass litter with a lining of down, although the nests at Eqalungmiut tasia and Welsh contained no down and the Pass of Jennings nest contained large amounts of down in the absence of eggs. Full details are summarised in Table E8.2.

TABLE E8.2. Details of nests of Long-tailed Ducks (*Clangula hyemalis*) in Eqalungmiut Nunât, 1979.

LOCALITY	SITE	DATE	CLUTCH SIZE
Pass of Jennings Marshes	Open site at end of spit on dune pool, amongst *Eriophorum angustifolium*, *Aulacomnium turgidum* and various grass species.	19/6	0
West Eqalungmiut tasia	Under *Salix glauca*, *Betula nana* and grass below bank of lake, nest virtually floating on submerged grass bank.	19/6	5
Lake Line 4	Nest in *Salix glauca* scrub 75 m from lake edge.	5/7	5
Welsh	Very open site amongst moss mat with some *Betula nana*, 20 m from lake edge.	9/7	4*
Wallbanger	Nest between moss hummocks below thick *Salix glauca* scrub 200 m from lake edge	26/7	7

* The eggs of this nest were predated within the confines of the nest.

The absence of down and the unusual sites of the Eqalungmiut tasia and Welsh nests suggest young or inexperienced females were involved. None of the nests was followed, but in view of the late discovery date of the Wallbanger nest, it is thought that this was a full clutch. Salomonsen (1950a) gives a mean clutch size of between 5 and 7, but up to 11 eggs have been recorded. Bengston (1972) gives first clutch size mean of 7.9 from 150 Iceland nests and Alison (1975) gives 6.8 from a study in Churchill, Manitoba.

Egg Measurements

Only the west Eqalungmiut tasia eggs were measured as shown in Table E8.3. The mean values fall within the ranges quoted in Schönwetter (1967) of 47 - 58 x 35 - 41, but are much heavier than those given in Dementiev and Gladkov (1952) of 38 - 40 gm.

Brood Size

Ten broods were subsequently noted, four of which were less than five days old. Table E8.4 shows the distribution and dates of discovery of these broods.

TABLE E8.3. Egg measurements from Long-tailed Duck (*Clangula hyemalis*) nest, west Eqalungmiut tasia, 19 June 1979.

	WEIGHT (gm)	LENGTH (mm)	WIDTH (mm)
	41.5	55.2	37.8
	46.5	56.1	39.0
	45.5	55.6	39.4
	43.5	53.65	38.45
	44.5	55.5	38.5
mean	44.3	55.2	38.6

TABLE E8.4. Distribution of discovery dates of Long-tailed Duck (*Clangula hyemalis*) broods in Eqalungmiut Nunât, 1979.

LOCALITY	BROOD SIZE	DATE FOUND
Yankee	6	14/7
Doodle	5	15/7
Lake 42	5*	27/7
Phalarope Pool	6*	30/7
Delta	7*	31/7
Mike	7*	31/7
Whisky	6	10/8
Bourbon	7	10/8
Kûk Marshes	5	14/8
Aberchar	3	16/8

* less than five days old

FEEDING

In Greenland, this species obtains its predominately animal food by diving, the diet being composed of larvae of gnats, and water beetles as well as the adult forms of dipterans and beetles (Salomonsen 1950a, Manniche 1910). Birds spent most of their time diving in shallow water. From the middle of June, breeding pairs resorted to the smaller lakes and in the case of Charlie-Delta-Echo, the ducks were observed feeding in the presence of drake birds, and although there is no numerical evidence, it seems likely that during the pre-laying phase, the male Long-tailed Duck serves a protective function for the feeding female. Diving times are summarised in Table E8.5. Pairs were frequently

TABLE E8.5. Mean submergence durations of Long-tailed Duck (*Clangula hyemalis*) during feeding dives, Eqalungmiut Nunât, 1979.

DATE	LOCALITY	SEX	MEAN SUBMERGENCE DURATION (*n*)	MEAN SURFACE TIME BETWEEN DIVES (*n*)
23/5	Kûk Marshes	male	11.9 (7)	4.6 (7)
		female	16.0 (5)	8.8 (5)
25-27/5	Aberchar	male	15.2 (12)	6.8 (5)
		female	14.5 (29)	10.8 (18)
28/5	George Eliot	male	20.8 (3)	3.0 (1)
		female	15.0 (51)	5.2 (49)
2/6	Aberchar	synchronous	12.9 (17)	36.35 (17)
27/6	Charlie	male	29.0 (1)	-
		female	24.7 (11)	8.6 (10)
MEAN		male	14.4 (40)	
		female	13.2 (113)	(Times in seconds).

watched diving in synchrony, resulting in shorter dives with longer periods at the surface between successive dives. Aggregations of feeding birds appeared to follow each other in diving, submerging successively in loosely associated groups (see Stewart 1967).

In addition to conventional feeding methods, birds were also noted foraging and presumably feeding by submergence of the head, apparently seizing food items just below the surface. This activity was particularly frequent during observations of the pair on Charlie, where the female fed for long periods in this manner. Head submergence was sustained for 4-8 seconds, interspersed by resting periods of 3-5 seconds in the presence of an alert drake. Birds were also watched feeding from the surface of the water; this was especially noticeable on 10 July on Uniform, when the emergence of large numbers of mosquitoes was interrupted by a heavy blizzard and many Mallard and Long-tailed Duck were seen feeding on the vast numbers of semi-emerged insects floating on the water surface.

MOULT

During July and August, some drakes were noted attaining eclipse plumage, moulting scapular feathers and the plumage along the flanks, but no flightless birds were seen in Eqalungmiut Nunât.

BEHAVIOUR

There were few large aggregations of Long-tailed Duck early in the season (Table E8.1), with pairs distributed on lakes throughout and with groups of birds appearing only on larger waters.

Courtship display was frequently witnessed throughout much of June, but rarely involved more than two birds; most adults appeared to be paired on arrival and many non-breeders appeared similarly paired. The exception was a group of 14 Long-tailed Duck on Eqalungmiut tasia at 02.00 hr, 19 June, when up to ten drakes were involved in the pursuit of two females in flight and on the water. Later three males were chasing a single female at Aberchar on the same day, the latter chase lasting eighteen minutes.

A female was prospecting at Aberchar forming a shallow scrape while the alert drake watched from the water 3 m distant. The site was not used and indeed was subsequently flooded. Drakes remained in the vicinity of sitting ducks at least part way through incubation; the female flushed from a nest on 19 May flew to join her mate sitting out on west Eqalungmiut tasia some 30 m away, while many lone drakes during the nesting period corresponded to later proven sites of breeding.

E9 RED-BREASTED MERGANSER (*Mergus serrator*)

A. D. Fox

The Red-breasted Merganser breeds in low-arctic Greenland, with a distribution similar to that of the Mallard, common from the south northwards to Nûgssuaq but found infrequently north of Ûmânâq. In Eqalungmiut Nunât, it was the least numerous of all breeding waterfowl in the areas visited, with only one proven instance of breeding.

ARRIVAL AND DISPERSAL

The first bird noted was a drake by the north-east end of east Eqalungmiut tasia at 13.00 hours on 19 May, but despite daily observations of up to four birds at this time, the first female was not seen until midday on 26 May. During the first week of arrival, all records came from Eqalungmiut tasê, the birds feeding on areas of open water around the edges of the ice on the lakes. Maximum numbers during this early phase were four drakes feeding and roosting on the edge of the east end of Eqalungmiut tasia on 24 May. Birds were most often noted at Aberchar and Lakesmeet, both sites being large areas of open water holding considerable numbers of Three-spined Stickleback. Birds were seen there until July. On 29 May three drakes were noted on Manx Lake, and later a pair was present on 13 and 26 June. Observations at the Eqalungmiut tasê ceased during July and much of August, but no drakes were noted after 2 July until 14 August when there was a single fully feathered adult on Manx Lake. The last record was of a female/immature at Lakesmeet on 16 August, by which time there had been little evidence of a major movement out of the area.

The maximum numbers seen together were three pairs (Aberchar, 28 May) and five birds (including two ducks) involved in aerial pursuit around Aberchar on 2 June. There was only one record from the uplands; a bird was seen flying from Charlie down to Rimwater on 26 June.

BREEDING

Nesting and incubation occurred during the period of observer absence from the favoured waters. A female was watched prospecting near Aberchar on 27 May and a pair was present on George Eliot on 2 July, but breeding was not confirmed until 15 August when a female was seen with a very small duckling at Aberchar.

FEEDING

The activity of the species was confined to lowland freshwater sites known to hold Sticklebacks and Arctic Char. Small fish constitute most of the food of the Red-breasted Merganser (Cramp and Simmons 1977). A drake was watched regurgitating a small fish, and on many occasions birds were observed catching fish at Aberchar. Fish were secured in two ways: the greater number were obtained by foraging with the head held below the water with subsequent diving in pursuit of prey; however, birds were also seen to take fish from the surface without diving (see Curth 1954). Initially feeding was restricted to the fringes of the lakes, but, after the thaw, birds continued to fish about the shallows in depths of water generally between 0.5 and 1.0 m. Mean duration of dives at Aberchar was 7.0 seconds (range 3 - 13, n=33 from male and female birds, several dates), considerably less than European values in deeper waters (Cramp and Simmons 1977). Fish seized underwater were also swallowed below the surface; the head-dip foraging procedure was frequently observed and, doubtless due to the depth of the water and abundance of prey, direct seizing of prey without diving was very frequently observed. Mean scores of this predatory behaviour gave mean duration of head-dip as 6.8 second (n=39, s.d.=2.1), mean duration of alert sequence between head-dips as 13.3 seconds (n=31, s.d.=3.6). Whilst it was not possible to assess relative frequency or levels of success of the two methods, birds were often observed feeding for substantial periods without actually diving.

Only once was "co-operative" feeding witnessed at Aberchar, on 27 May, when two males and a duck were fishing synchronously. Fishing was most active during 06.00 - 11.00 and 17.00 - 22.00 hours with flights between waters most frequent during the middle of the day. Birds roosted on the water on calm days, on ice or under the shelter of the lake banks.

BEHAVIOUR

Solitary drakes tended to gather to roost, with pairs forming and aggregating together on the arrival of the female birds, although there was always a surfeit of males throughout May and June. Three birds fishing together were tolerant of each other on 27 May, yet after 28 minutes of communal feeding, the single drake began to approach the 'resident' male and his mate, and was promptly forced away by the male. Subsequently, this male pursued most birds which appeared at Aberchar, including on a number of occasions Mallard drakes. Very little courtship was witnessed, although, on 28 May, a male was watched in the salute-curtsy sequence (Johnsgard 1965) before a female at Aberchar. On 2 June, two ducks were chased around west Eqalungmiut tasia by three drake birds uttering a subdued growling call in flight, while on the following day, three drakes pursued a female at Lakesmeet, the males clashing wings in flight.



E10 WHITE-TAILED EAGLE (*Haliaeetus albicilla*)

A. P. Fowles

The White-tailed Eagle is confined to the southern part of low arctic west Greenland, breeding from Kap Farvel to Disko Bugt. A survey in 1974 estimated a population of 85 - 100 pairs, the majority breeding in the south-west (Hansen 1979) with little likelihood of breeding north of Arfersiorfik Fjord (67°30'N), although the northern limit of regular breeding is poorly known. Eqalungmiut Nunât thus lies on this northern limit.

The first sighting was of an adult bird flying up Goose Valley and over towards Rimwater on 16 May. During the last week of May and the first week of June there were six more sightings, with a further three records in the first week of July. All observations involved single adults, although missing primaries of one bird indicated more than one individual present in the Goose Valley area. Two adults were watched soaring high over the south side of Atanârssuk on 25 July.

The observation of 6 June involved a single eagle mobbed by two pairs of White-fronts over Base Camp. From its talons, the eagle trailed a substantial amount of vegetation and held a ball of grasses between its feet. In 1977, Wille (1978) observed an adult eagle bringing nest material to the eyrie on 79 occasions during a behavioural watch covering 7 to 16 June and five dates in August.

Despite covering three-quarters of Eqlaungmiut Nunât in some detail, no sign of an eyrie past or present was discovered. The Greenlandic hunting party, present in the region from early August, told of an eyrie containing three eaglets on one of the hills of Nagssugtûp Nunâ south of South Valley. Christensen (1979) records that "only a few eyries are placed several kilometres from salt water, 5 km being the maximum recorded distance". This breeding record far exceeds that distance.

E11 GYRFALCON (*Falco rusticolus*)

A. P. Fowles

The Gyrfalcon is found breeding more frequently in the interior fjord country than on the coast, nesting from Kap Farvel to the north coast. Unlike the Peregrine in west Greenland, Gyrfalcons tend to nest in association with seabird colonies on steep cliffs. In central west Greenland all three phases - dark, grey and white - are to be found in varying numbers, the white phase becoming increasingly common further north.

A study near Søndre Strømfjord Air Base conducted by the Peregrine Falcon Survey of west Greenland located three active Gyrfalcon eyries in an area of 2000 km^2 in 1972 (Mattox *et al.* 1972) and four active eyries in 2300 km^2 in 1973 (Burnham *et al.* 1974). The present expedition located two active eyries in Eqalungmiut Nunât (750 km^2) and another cliff was occupied throughout the season but was most probably inactive. Each of these sites was high up on near-vertical cliffs bordering the melt rivers, the two active eyries being approximately 8 km apart.

Eyrie A was an old Raven's nest on an exposed SW-facing ledge about 130 m up a 170 m cliff. The grey phase female used the rim of the nest as a perch when she fed the eyasses. The much smaller, white phase male was not observed to visit the nest. Unfortunately, the nature of the eyrie did not allow the observers to make a definite count of the number of young, although on 17 June a minimum of two downy young was standing high in the nest.

On 13 June the female was seen to stoop a short distance down the cliff face onto a small bird, which she then carried to the eyrie, plucked, and fed to the young. This conflicts with a statement of Meinertzhagen (1959) that raptors do not hunt near their nests, but agrees with Jenkins' (1978) observations of occasional hunting in the vicinity of a Gyrfalcon eyrie.

Eyrie B was located on a steep 100 m cliff forming the east-facing side of a broad gorge, but it was impossible to view the immediate stretch of cliff to confirm if the eyrie was active or not. The behaviour of the adults, a pair of similar-sized white phase falcons, strongly suggested that the eyrie was in use, although it must be borne in mind that falcons will display territorial behaviour at an inactive site (Burnham *et al.* 1974). On the four days that the site was watched the adults frequently perched on the cliff top above the site. On 16 June an adult, calling with a weak mewing sound, flew across the gorge and passed close in front of JF as he stood on the cliff top. The bird returned to the perch and then repeated the performance several times, sometimes circling the gorge three or four times without alighting. This (probable) eyrie was located within 500 m of a successful Peregrine eyrie. No Gyrfalcons were recorded during a return visit to the two cliffs in mid-August.

At the third, unconfirmed, cliff a white phase male was seen standing at the entrance to a deep recess about 80 m up a 170 m sheer cliff with a southwest aspect. The falcon flew after giving a high-pitched mewing call and did not return within the next two hours. The floor of the recess was not visible from the observers' position. Out of four subsequent visits to the cliff single falcons were recorded on two occasions, probably being different birds each time.

Of twenty sightings of adult Gyrfalcons away from the vicinity of the eyrie cliffs, ten were of white phase birds and ten grey phase. Juveniles were seen on the wing on 13, 15 and 18 August. Gyrfalcons were seen flying between 07.30 - 23.20 hours, whereas Jenkins (1978) records eyasses as having food brought to them during every hour of the day with a peak of activity around 16.00 hours. In Eqalungmiut Nunât there was a general lull in passerine activity between 01.00 - 04.00 hours and it is possible that feedings during this period are from prey items cached on the eyrie cliff. The 23 sightings away from the eyries were distributed as shown in Figure E11.1.

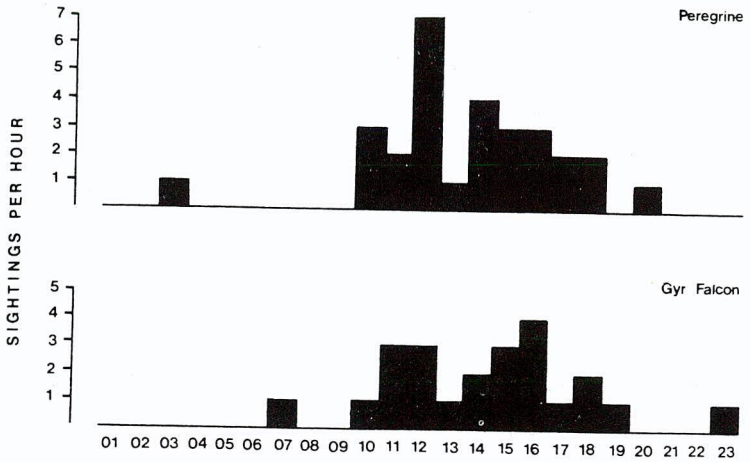


Figure E11.1. Diurnal frequencies of Peregrine (*Falco peregrinus*) and Gyrfalcon (*Falco rusticolus*) away from eyries, Eqalungmiut Nunât, summer 1979.

Seven instances of interaction between the two falcon species were recorded, on each occasion within 2 km of a known Peregrine cliff. The large falcon tended to look clumsy and confused as it attempted to evade the agile stoops of the incensed and highly vocal Peregrines.



F12 PEREGRINE (*Falco peregrinus*)

A. P. Fowles

The Peregrine breeds on the west coast from Kap Farvel to the Qânâq District, although only locally north of Nûgssuaq. It is much more common in the interior and the fjord country than along the coast. The Peregrine Falcon Survey in their study area around Søndre Strømfjord Air Base located seven active eyries in 2050 km^2 in 1972, and nine active eyries in 2300 km^2 in 1973 (Mattox *et al.* 1972, Burnham *et al.* 1974).

Assuming a similar density in Eqlaungmiut Nunât it would be expected that the region was capable of holding three active eyries in the 750 km^2 that were covered. In fact, only two successful eyries were located but at a further three cliffs where adults displayed territorial behaviour we were unable to confirm or disprove breeding. A further adult female was recorded on a single day at one other cliff.

The first Peregrine seen was a female, clutching a passerine in her talons, flying past Observation Hill on 24 May. Three days later a pair of full adult birds were observed flighting back and forth across a 150 m cliff face, landing briefly on different ledges, calling shrilly and preening, then gliding back out across the cliff face again. A very conspicuous white stain marked the site of the eyrie ledge, which was situated in a large recess in a sloping fault line. Eyrie I was some 300 m above a lake with an open view of the surrounding grassland. By 15 August the three eyasses had fledged and were clumsily testing their wings as they flew short distances along the cliff. At one point the male brought in food and the female, who had spent most of the afternoon on the cliff preening, flew out to meet him. They made a food-pass in mid-air and she took the prey to the top of a nearby bluff where she plucked it before flying to the cliff and feeding it to the youngest eyass.

Eyrie II was on a broad grassy ledge three-quarters of the way up a 130 m cliff. The female was incubating on 14 - 16 June when the eyrie was discovered and the male was perched for most of the time within 100 m of the nest. The three eyasses were almost fully fledged by the time of a return visit on 13 - 14 August, although they had not strayed from the eyrie ledge. This was c. 500 m away from the occupied Gyrfalcon eyrie B.

The two successful cliffs were some 16 km apart, but the six cliffs on which Peregrines were recorded were spaced with remarkable regularity. The distances to the nearest cliff from each were: 5.7 km, 7.9 km, 8.1 km, 9.0 km and 7.3 km, giving a mean inter-eyrie distance of 7.6 ± 1.22 km. A common feature of all these cliffs was their height and sheerness, each of them being in excess of 100 m high. In every case the eyrie ledge was situated in the upper third of the cliff face. Two of the eyries had a southwest aspect, three had a west aspect and the sixth faced due south. Five of the cliffs commanded an open view of a large area of rolling tundra which held a high density of nesting passerines. It is probably significant that four of these cliffs also overlooked a large lake. Cade (1960) records that Peregrines regularly hunt land birds which they spot flying over large expanses of open water. The remaining (successful) eyrie cliff offered a restricted view to the perched falcons as it formed the side of a steep gorge.

Differences in the falcons' responses to human presence were recorded by Harris and Clement (1975) at the two Greenland eyries they studied. One male was very vocal and aggressive when the observers were still a mile distant from the eyrie, whilst another pair tolerated their presence until they began to ascend the eyrie cliff. At both sites they noticed that the falcons ceased to be aggressive once the observers were out of direct sight of the eyrie, even if the observer merely moved behind a large rock. This behavioural response was also noted at three eyrie cliffs in Eqalungmiut Nunât and one instance is typical.

An attempt was made to reach Eyrie I on 15 August to collect pellets after the young had fledged. The female remained motionless and silent on her perch until the observer was 70 m from the foot of the cliff when she began a continuous chakking "whee, whee, whee .....". However, she stopped calling as soon as the observer was out of sight behind the angles of the cliff face. She remained on the cliff until the observer had climbed to within 40 m of the eyrie, when she took off and circled directly over his head, still calling but not stooping. She kept this up for 1.5 minutes and then flew off out of sight.

On two occasions Peregrines were observed carrying unidentified passerines in their talons, and on a third occasion an adult was seen to take a Lapland Bunting from the ground. A Long-tailed Duck carcass was found at Aberchar in July which bore the characteristic marks of a Peregrine kill (Salomonsen 1950a).



There were twenty-nine sightings of Peregrines away from the vicinity of the occupied cliffs and three of these involved a pair together. Peregrines were observed on the wing between 03.45 and 20.00 hours supporting the statement of Harris and Clement (1975) that "No appreciable activity, including hunting, feeding, or flying, occurred between 21.00 and 03.00 hours of each day". The twenty-nine sightings, fifteen of which occurred in August when the adults increase their hunting activity to provide for the eyasses, were distributed as shown in Figure E11.1.

There was just one record of intra-specific aggression. In the early hours of 4 July a female was spotted flying c. 400 m away from an occupied, but unconfirmed, cliff. A second female flew out from the cliff and stooped upon the first falcon, who turned on her back and presented her talons. The intruder then changed direction and flew off south, whilst the 'resident' female, after stooping once more, followed 30 m behind. This territorial aggression should not be taken as evidence of breeding as Peregrines will defend their cliffs without breeding (Burnham *et al.* 1974). Records of interaction with Gyrfalcons are discussed in section E11.

E13 PTARMIGAN (*Lagopus mutus*)

J. McCormack & A. D. Fox

The Ptarmigan has an arctic/alpine distribution, being found throughout Greenland, although at the highest latitudes only at sea level. It is one of the few resident land birds.

In Eqalungmiut Nunât, the Ptarmigan was a widespread if somewhat uncommon breeding species, showing a well defined preference for altitudes above 300 m during the nesting season. The sub-species present in this part of Greenland is an intergradation between *Lagopus mutus saturatus* and *L. m. reinhardti* according to Browning (1979).

DISPERSAL

With few exceptions, the majority of records showed a uniformity in habitat preference. Initially, birds were noted in the presence of *Salix glauca*, often near streams and waterfalls. In May, the white birds tended to frequent areas of late snow lie, or ice where there were many boulders and/or dense cover. Later some birds clearly moved to higher altitudes, although the pattern is difficult to interpret in the light of observer bias (section B4). However, during the first three weeks of May, birds were frequently encountered in Goose Valley, yet after early June Ptarmigan records were rare below 300 m. A pair of birds consistently present upstream of George Eliot marshes during May later moved up on to the plateau, and although three pairs were regularly seen at Aberchar, apparently only one of these pairs stayed to breed there.

Considerable accumulations of faecal pellets were found at the lower levels of Goose Valley, suggesting that the area supports a larger population of birds during the winter period, but they were already dissipating on our arrival on 7 May. The altitudinal movement, following the retreating snowline, has been previously noted by Gelting (1937) who relates it to the advantage of unused food resources.

After 9 May, birds were apparently defending territories and, in particular, a male Ptarmigan was noted with considerable regularity above Base Camp from that date, so regular defence of areas is probably general at this date. Upland birds were presumably delayed after this date, and birds continued to move around the region until June. After mid-June, birds were seen throughout the region from the plateau areas, with birds in all areas explored. Unfortunately no one area was sufficiently well covered as to give indications of breeding densities. Defended territories generally corresponded to the later occurrences of broods, and by mid-August there was no sign of any break-up of the characteristic family parties. Some early territories were quickly deserted, and doubtless there was a pool of non-breeders establishing only transitory territories. There were no indications of flocking of unmated and failed breeding birds as reported by Salomonsen (1950a).

BREEDING

The first broods were discovered during July, the earliest of an estimated ten young birds at the edge of Upper Marsh on 4 July. An adult with at least five young was seen near Quebec on 9 July, a male with four young near 612 m on 21 July and there were five fledged juvenile birds at 612 m on 23 July. Subsequently, many other family groups were reported from a variety of sites.

It is interesting to note that, although no Ptarmigan nests were found, on two occasions eggs were found amongst *Salix glauca* scrub on the slopes below the Crusties in the absence of any nest structure or indication of breeding.

FEEDING

Sequential collection of fresh faecal material gave some indication of the plant species taken by Ptarmigan, and from subsequent analysis it appears that the important species is *Salix glauca* which features heavily in the pellets collected.

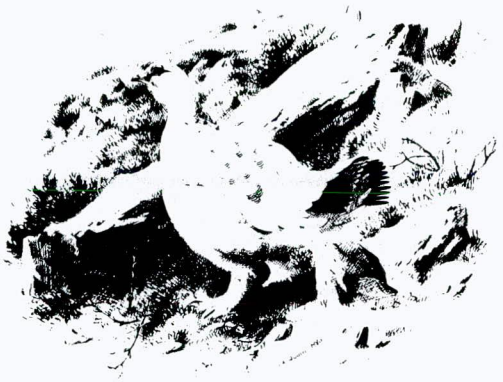
Analysis of faecal pellets was carried out along the lines of Owen (1975), and the relative abundance of items found is shown in Table E13.1. Faecal material was collected from the same male bird above Base Camp, and gave results similar to the work by Weedon (1968) and Moss (1973). Ptarmigan select for the most nutritious food and those foods taken also depend on seasonal availability (Cramp and Simmons 1979). In the light of their movements over the summer (above), it seems quite likely that selection for the most nutritious foods in Eqalungmiut Nunât follows a similar pattern to that of the White-fronts (section D8).

TABLE E13.1. Percentage composition of Ptarmigan (*Lagopus mutus*) faecal pellets from Eqalungmiut Nunât, 1979. (Based on 100 point scores on a microscope sample after Owen 1975).

	May 22	June 16	July 21	August 11
Salix glauca shoots, buds and leaves	97	90	86	88
Betula nana shoots, buds and leaves	2	1	2	3
Vaccinium berries	-	-	-	1
Empetrum berries	-	-	1	1
Unidentified material	1	9	11	7

MOULT

The moult is timed to coincide with changes in vegetation through the season, particularly with regard to the female. On arrival both sexes were in full winter plumage, but as early as 12 May, a female was seen showing the first signs of moult, with a few grey feathers on the nape. By the end of June, all females were in summer plumage while the males retained their worn winter plumage. The males first showed signs of moult in early July, with the first seen in full summer plumage on 17 July. Subsequently, almost all birds seen were in full summer plumage until our departure on 20 August. For detailed discussion of the moult and its implications, see Salomonsen (1939) and Dyke (1979).



E14 RINGED PLOVER (*Charadrius hiaticula*)

A. D. Fox

The Ringed Plover is a passage migrant in west Greenland and may well be a regular breeding species in certain areas. It is an extremely common species in most parts of east Greenland and north from Qânaq. In all these areas, the bird nests in high arctic habitats, yet in low arctic west Greenland it is local in summer. Most records of nesting until recently were not proven and generally coastal. The exact status of this bird remains obscure and the group was unable to prove nesting in Eqalungmiut Nunât. For the past 17 years, the Ringed Plover has occurred during the summer 2.5 km from Søndre Strømfjord Air Base and has been proved nesting in the last 5 seasons (S. Malmquist, pers. comm.). Here the birds bred in situations very similar to the conditions of Kûk dunes and the following represent all sightings from Eqalungmiut Nunât:-

- 23 May - 1 pair on the fringe of the fjord on the edge of the Kûk sand dune complex. The birds were considered a pair, male and female, but showed no breeding activity.
- 28 May - 1 pair on a pool adjacent to Long-tail Pool, Kûk Marshes.
- 16 June - 1 bird, Long-tail Pool, Kûk Marshes.
- 30 June - 1 pair, Long-tail Pool, Kûk Marshes - no suggestion of breeding, although the birds seemed loath to move elsewhere, despite attempts to catch them. Also noted in similar circumstances on the following day.
- 13 August - Several birds calling over the Kûk Marshes.
- 14 August - A group of 9 birds flying around Kûk Marshes. This flock included at least two adults and two immatures; the remainder were not ascribed to age groups. There were a further two adults feeding around the pools of Kûk dunes and later another pair of adults with two birds of the year feeding on the shores of Long-tail Pool. It would seem that all these birds were different individuals resulting in a minimum of 15 Ringed Plovers on the Kûk Marshes complex.

The distribution of records merely reflects the observer cover on the Kûk dunes system. It seems likely that the birds appeared during mid-May and were present throughout the season, with a considerable build-up during mid-August as the population was swollen by migrants. If this type of habitat constitutes nesting area, there appears no shortage of breeding sites along North and South Valleys.

E15 PURPLE SANDPIPER (*Calidris maritima*)

A. D. Fox

The Purple Sandpiper is a low arctic species, breeding from Kap Farvel to Melville Bugt on the west coast of Greenland, the most northerly station recorded being at Ryder Island, 74°34'N. It breeds mainly in the interior of the region forsaking the winter coastal quarters. Salomonsen (1950a) states that the species is rarely found more than 4-5 km from the nearest fjord and is most abundant at 100-200 m above sea level, nesting down to the fjord margins.

An unobtrusive species, the Purple Sandpiper was found breeding at eight sites in Eqalungmiut Nunât, but was probably overlooked elsewhere. All bar one of the breeding records were more than 10 km from the nearest fjord system at altitudes between 400 and 600 m above sea level, the exception being a young bird near Niaqorssua on 3 August, perhaps the first indication of a movement from higher altitudes.

ARRIVAL AND DISPERSAL

This species appeared initially at lower altitudes, following the thaw and moved to higher ground as the season progressed. The first bird was flying around Upper Marsh piping loudly at 22.00 hours on 6 May, with another flushed the following day from a wet runnel draining from Upper Marsh. Birds were noted on and around Kûk Marshes on 9, 10 and 11 May and later on the fringe of the upland zone with three birds below Romeo and Quebec on 21 May and one on the shores of Fish on 26 May.

BREEDING

The first sighting during the nesting period was from the marsh south of Axewater 'blade' on 27 June, although none was seen in the area subsequently. No courtship display was seen, but a pair was watched near Teilhard Tarn from 1 July throughout the month, frequently being seen in the "rodent-run" distraction display in the presence of humans. During the last two weeks of July, many breeding records were confirmed by alarm calls and distraction displays. In addition, a family party of two adults and three almost fledged young was found on a small marsh next to the west end of Lake 27 on 27 July. One of the adults of this family was watched, without human disturbance, swimming across c. 5 m of open water which in places was 40 cm deep.

All records were from essentially similar habitat types, consisting of dry barren areas adjacent to either lake margins or to small marshes with some areas of open water. This type of habitat was most common in the inner parts of the high plateau and probably accounted for part of the distribution of breeding records.

During late July, many observers were based around Atanârssuk at a time when adult Sandpipers were protecting young and were thus more conspicuous than at other times. It seems likely that much of this area, undisturbed before this time, was consequently well censused.

Eight pairs in an area of 750 km^2 represents a considerably lower density than that found by Longstaff (1932) of 1 pair per 1 km^2 at a coastal site.

E16 SNIPE (*Gallinago gallinago*)

A. D. Fox

The Snipe breeds throughout North America and as close to Greenland as Labrador. Three sub-species of the bird have been shown to occur in Greenland, making a total of 17 accepted records up to 1967 (Salomonsen 1967a). The scarcity of records makes the following series of observations all the more notable.

23 May - 13.15: 1 bird flushed from the marshy area at the south west end of west Eqalungmiut tasia. The bird was disturbed from feeding at the edge of a small pool and flew off towards Kûk dunes area.

10 June - 14.50 - 15.15: Heard drumming over Observation Hill near Base Camp, with reports of 'Tick-tocking' at this time. Later a bird was heard drumming from the vicinity of George Eliot Marshes from the slopes below the hide. Drumming commenced again around 16.48 and continued for at least ten minutes.

15 June - c. 18.30: Bird drumming over Kûk Marshes until at least 19.15 hours.

16 June - Drumming again over Kûk Marshes for much of the afternoon.

26 June - 21.14: Drumming over George Eliot Marshes for almost 30 minutes heard from Llyn Anne area.

This appears to constitute the first record of displaying Snipe for Greenland, although the record has not been accepted by the Sjaeldenhedsudvalget, the Rarities Committee of the Danish Ornithological Society, since field notes of the bird were not taken at the time.



E17 RED-NECKED PHALAROPE (*Phalaropus lobatus*)

A. D. Fox

On the west coast of Greenland, the Red-necked Phalarope breeds in abundance from Kap Farvel up to Upernavik. In Eqalungmiut Nunât, it was the most abundant and widespread breeding wader species, characteristic of smaller lakes and ponds in marshy areas. The species was absent from the larger lakes and many of the upland lakes lacking cover about their edges. Birds were noted on stretches of Afon Char along swiftly flowing sections of the river where there were adjacent wetland communities.

ARRIVAL AND DISPERSAL

The first bird was noted on Kûk Marshes, 10 May when disturbed by a goose, but the main arrival occurred during 16-20 May when birds were seen from many suitable sites in the lowlands, with larger numbers appearing from 23 May to the end of the month. This arrival is generally earlier than records from west Finland (63°15'N, Hilden and Vuolanto 1972), but corresponding to dates given by Salomonsen (1950a) for west Greenland. No large aggregations were seen during this early period and birds were paired on arrival contrasting with the different times of arrival found by Tinbergen (1935). Both Timmerman (1949) and Salomonsen (1950a) state that birds congregate in favourable feeding areas before dispersal to the breeding grounds, and it seems likely that this results in Phalaropes arriving at the feeding areas freed from the thaw. In this way, the species is able to commence nesting following occupation of the breeding areas (Barry 1970).

Initially, birds were present on Kûk Marshes, later appearing on Afon Char, around Aberchar, on George Eliot, Lakesmeet and along the Eqalungmiut tasê to Ridgeway Marshes. Birds appeared on Upper Marsh in early June, and during the latter half of the month birds settled in suitable habitat on upland lakes.

During the nesting period, an excess of females was noted resulting from females dissociating from the incubating males. During late June and early July, the hen birds departed (presumably before commencing moult) which with the males incubating contributed to a decline in sightings at this time. During July, males were protecting newly hatched young, with a corresponding preponderance of vociferous males and increased sightings. Birds commenced movement out of the area during the latter half of July, with the last female seen on 16 July, by which time many of the young had fledged in the lowlands. The first moulting males were seen on 17 and 18 July and most family groups had moved off the plateau by early August. The last Red-necked Phalaropes seen were 25 (mostly immatures and the largest number seen together in Eqalungmuit Nunât) on Long-tail Pool, Kûk Marshes on 14 August (see Figure E17.1).

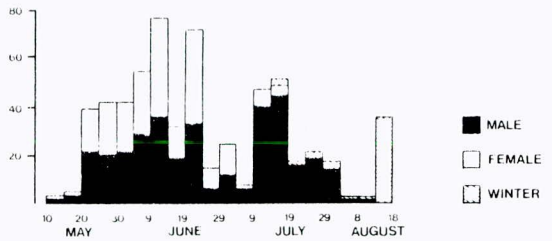


Figure E17.1. Distribution of Red-necked Phalarope (*Phalaropus lobatus*) sightings throughout summer 1979, based on plumage composition.

MOULT

After the first moulting male was seen on X-Ray Pass on 17 July, the decline in sightings probably reflected departed females and the skulking behaviour of moulting males. The last summer-plumaged male was seen on November on 11 August, the last record away from Kûk Marshes.

BREEDING

In Eqalungmiut Nunât, 29 confirmed cases of breeding were located. Two pairs were found nesting in 1 km^2 censused on Kûk Marshes, but there were up to 27 birds present in this area during mid-June and doubtless more pairs bred than suggested by nest location. Similarly, it is thought that as many as five pairs nested at George Eliot and probably rather more than the two pairs discovered bred on Upper Marsh. At the end of June, up to seven pairs were resident on Phalarope Pool, but it is not known if all these birds bred. Few areas were covered in sufficient depth on suitable dates to determine breeding densities on the uplands, but on the basis of territories consistently held over several visits, there would appear to be 9 pairs present in a land area of 20 km^2 between Foxtrot, Quebec and Lake-line with similar densities elsewhere. Breeding densities on the uplands were noticeably lower than in the lowlands, due principally to the oligotrophic nature of many plateau lakes and the resultant lack of suitable cover and nest sites. In spite of this, breeding birds were frequently encountered on the uplands up to 500 m altitude, with birds raising young at two sites (Uniform and below 601 m) above the 550 m contour.

The first nest was located at Aberchar on 12 June, with nests and eggs found through until the beginning of July. Arrival on the plateau was delayed compared to the areas below 200 m, but this species was able to exploit the shallows of thawing lakes from the early stages with the first nests located in the uplands during the first week of July (see Figure E17.2).

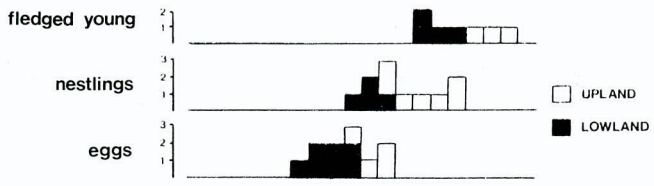


Figure E17.2. Distribution of discovery dates of Red-necked Phalarope (*Phalaropus lobatus*) broods (regardless of age) in Eqalungmiut Nunât, 1979. Abiscca as in Fig. E17.1.

Nests and Nest Sites

Twelve nests were found in all, generally by flushing the males from eggs. Seven were from lowland sites, five above 200 m. All were situated on small hummocks in marshes with the exception of a nest found on the slopes below Observation Hill which was within a *Salix glauca* stand in a drainage runnel. Several sites had experienced considerable elevation of the water table after nest construction, leaving the nests on small dry islands. Most were rather exposed, but as the *Eriophorum angustifolium* cover increased, the nests became well camouflaged.

Nests were all positioned less than 20 m from open water, most less than 10 m. In all cases, the nests were constructed of grass and *Eriophorum* and some were lined with feathers. All nests found held clutches of four eggs with apices pointed inwards.

Egg Measurements

Two clutches were measured (Table E17.1) fitting well with values quoted in Salomonsen (1950a) and Harrison (1975).

TABLE E17.1. Measurements of eggs from two Red-necked Phalarope clutches, Eqalungmiut Nunât, 1979.

LENGTH (mm)	BREADTH (mm)	WEIGHT (gm)	LENGTH (mm)	BREADTH (mm)	WEIGHT (gm)
29.8	20.9	5.5	31.1	21.7	7.0
30.3	20.7	5.5	31.3	21.2	6.9
30.1	21.6	5.5	30.6	21.7	6.9
31.0	20.6	5.5	29.9	21.5	6.7



E18 GREY PHALAROPE (*Phalaropus fulicarius*)

A. D. Fox

In west Greenland, the Grey Phalarope breeds in the northern low-arctic areas from Disko Bugt to the Upernavik District, although in Canada it extends further south (Godfrey 1966). Throughout this range, it is restricted to islands and skerries along the coastal zone. By contrast, the birds in east Greenland are present in the high-arctic, but nest on essentially mainland sites. The one record of a bird from Eqalungmiut Nunât is thus of considerable interest. The bird was seen on 2 July at Boulder Lake where it was apparently roosting on a very small marshy island. In an attempt to secure a better view of it, the bird was inadvertently flushed and not subsequently relocated. Considerable searching of the area in subsequent days failed to reveal the bird again. It was in full breeding plumage at the time when breeding birds would normally have been nesting. The unusual nature of the weather on the preceeding days (section J1) might contribute to an explanation of this extraordinary occurrence, but the origin of the bird must remain obscure.

E19 RING-BILLED GULL OR COMMON GULL (*Larus delawarensis* or *Larus canus*) A. P. Fowles

At mid-day on 1 July a gull was seen resting on the water at Aberchar. As the observer (JM) approached, it took off and flew southwards down the lake. The following details were recorded:

The bird was an adult with steel-grey mantle and wings, black wing-tips with white 'mirrors', and the legs were pale olive. The head was considered to be more bulky, and the eyes more obvious, than in the European Common Gull and this may have been attributable to the presence of an eye-ring. The observer was not aware of any band around the bill.

This record has not been accepted by the Sjaeldenhedsudvalget, the Rarities Committee of the Danish Ornithological Society. There have been four records of Common Gull and no records of Ring-billed Gull in Greenland up to 1967 (Salomonsen 1967a).

E20 LESSER BLACK-BACKED GULL (*Larus fuscus*) A. P. Fowles

On 3 July the Gullery was visited at approximately 20.00 hours. A group of c. 30 Glaucous and 8 Iceland Gulls had gathered on the sandur mudbank below the colony and amongst them was what was considered to have been a Lesser Black-backed Gull, most probably of the Scandinavian race *L. f. intermedius*. The bird had the dark mantle and wings of *L. marinus* but in all respects the size and shape were of the proportions of the smaller species. Unfortunately, light conditions were not good enough to ascertain the colour of the bare parts against the refective surface of the wet mud and the bird did not fly to enable a view of the underwing pattern. The size was particularly striking in comparision with the noticeably larger Glaucous Gulls and the bird was of similar size to the Iceland Gulls present.

This record has not been accepted by the Sjaeldenhedsudvalget, the Rarities Committee of the Danish Ornithological Society. Salomonsen (1967a) mentions 2 - 4 sightings in west Greenland up to 1967, all of the *L. f. graellsii* race.

E21 ICELAND GULL (*Larus glaucoides*) A. P. Fowles

This low-arctic species is restricted to the west coast from Kap Farvel to Upernavik. The Iceland Gull always nests in association with other seabirds and is found almost exclusively in colonies in the interior fjord country where it favours steep cliffs facing fjords. Salomonsen (1950a) claims that " it breeds consistently below Glaucous Gulls" and that "in mixed colonies the Glaucous Gull terrorises all other species and is particularly addicted to attack and pursue Iceland Gulls when they approach its territory".

Contrary to this, in Eqalungmiut Nunât both species were intermingled with each other, though with a tendency for the Iceland Gulls to be lower down on the cliff, and there was no evidence of harassement by the larger species.

An estimated 50 pairs were present at the Gullery (see also section E22) and there were no records of either solitary nesting or the presence of immature, non-breeding birds. As with Glaucous Gull, it appeared that the majority of the young fledged during the first week of August and nine juveniles were ringed.

Away from the colony the only sightings were in the area of Kûk Marshes: ten on 10 May, two on 23 May and one on 28 May. On each occasion these were adults flying purposefully along South Valley.

E22 GLAUCOUS GULL (*Larus hyperboreus*) A. P. Fowles

The Glaucous Gull breeds along most of the Greenland coastline and is one of the commonest sea-birds. It is predominantly colonial although solitary pairs do nest on the coastal islands and, less frequently, in the outer regions of the fjords. The colonies are usually found at great heights along the fjords, although they have also been recorded on cliffs facing lakes in the interior. They consist of about twenty to fifty pairs and are generally in association with other seabirds. In such places it is said that the Glaucous Gulls "invariably place their nests above those of other species" (Salomonsen 1950a).

On 3 July a mixed colony of Glaucous and Iceland Gulls was discovered on a near-vertical cliff facing the fjord, 4 km south-east of Niaqorssua. Although it was impossible to see the whole of the 200 m cliff face, an estimated population of 30 pairs of Glaucous Gulls was thought to be present. The adult birds spent much time roosting on the mudbanks below the cliff or making regular feeding flights westwards down the fjord. When the Gullery was visited on 2 August many juveniles had already fledged, though some could still be caught and eleven were ringed.

Two pairs nested away from the colony, on Niaqorssua itself. One pair was on a broad ledge 150 m up the 300 m west face of the headland; the other pair raised two young to fledging on the top of a large (6 m high) rock on the shoreline of the south face.

There were only three sightings away from the immediate area of the colony. On 28 and 29 May a single adult was observed flying across Kûk Marshes at a height of approximately 3 m, as if searching for food; on 6 August an adult glided slowly down Goose Valley from DZ. There were no records of immature, non-breeding birds.

E23 GREAT BLACK-BACKED GULL (*Larus marinus*)

A. P. Fowles

In western Greenland the Great Black-backed Gull is found in the low arctic only, breeding from Kap Farvel to Upernavik. In the summer it favours coastal waters where there are suitable islets, but it is also found in the fjords. Ringing recoveries have shown that it is sedentary in Greenland, frequenting the open water of the inshore zone during the winter months.

There was only one sighting in Eqalungmiut Nunât. An adult flew up South Valley past Kûk Marshes on 7 May.

E24 BLACK GUILLEMOT (*Cepphus grylle*)

A. P. Fowles

The Black Guillemot is found along the greater part of the Greenland coast and breeds as far north as open water occurs in summer, i.e. the entire west coast up to Washington Land and as far north as Scoresby Sund on the east coast. Salomonsen (1950a) considers it to be by far the most common seabird in Greenland.

A single colony was located on the southern side of Niaqorssua amongst the crevices of a 30 m cliff face. During the first visit (3 July) a single nest containing two eggs was discovered 1 m from the top of the cliff and approximately 0.6 m into the crevice. On 3 August this nest contained two large chicks and a further four nests were found (mainly by watching adults as they flew back into crevices to feed their young). The following day an attempt was made to catch these birds but the chicks had apparently fledged the previous night. Indeed, as the ringer abseiled down the cliff, a chick leapt out past him and fluttered down to the fjord. A maximum of 28 adults was observed on the water below the colony on 16 July.

E 25 SNOWY OWL (*Nyctea scandiaca*)

A. P. Fowles

In Greenland, the breeding range of the Snowy Owl is restricted to the high arctic region inhabited by the Collared Lemming. It does not breed outside this area, but small numbers regularly visit the west coast, most frequently in winter. The usual winter range is to the north of Disko Bugt but invasions following "Lemming Years" extend far south along the west coast. "Subsequent to an invasion the Snowy Owl may stay one or more years in south-west Greenland and consequently it is possible to encounter the owls there at any time. The odd wanderers to the west coast are usually met with in the interior" (Salomonsen 1950a).

On 17 July, an adult male was observed roosting on a boulder above Echo. The bird was asleep for five minutes and then woke, preening for a further eight minutes before flying off in a westerly direction.

Steen Malmquist (pers. comm.) observes Snowy Owls as almost annual summer visitors to Søndre Strømfjord Air Base.

E26 SHORT-EARED OWL (*Asio flammeus*)

A. P. Fowles

Short-eared Owls are occasional visitors to low arctic Greenland and by 1967 there had been 37 authenticated records from the west coast (Salomonsen 1967a). Salomonsen believes that Icelandic birds are responsible for the records south of the Nûk District, whilst further north it is thought that American birds are involved. It is possible that the owls from Eastern Labrador overshoot on their spring migration, continue to follow the coast up to southern Baffin Island, and then cross the Davis Strait by following the ice-border.

On 20 June a single bird was flushed from a clearing amongst willow scrub near Aberchar. Although very similar to the European race it was felt that this bird was rather more rufous and heavily marked than the mustard-brown colouring of British birds. The following day the bird was flushed again from the same area. In July a Short-eared Owl primary was picked up from near Aberchar.



E27 WHEATEAR (*Oenanthe oenanthe*)

J. Madsen

The Wheatear breeds in low arctic west Greenland, extending north as far as Qânâq District, arriving during the first half of May and leaving Greenland from the middle of August onwards.

The first Wheatear was observed in the lowlands on 7 May, although subsequently the species was largely restricted to plateau areas, probably as a result of the lack of suitable nest sites at lower altitudes.

Up to 15 birds in flocks of two to four were seen on the DZ slopes during a blizzard on 31 May, probably driven down from the plateau to where the snow cover was not complete.

Due to observer coverage being largely restricted to the lowlands during May and early June, relatively few Wheatear nests were found. This fact, together with the relative inaccessibility of many nests gave little information on the timing and breeding success of nesting pairs. Nest building was witnessed between 22 May and 14 June (5 pairs) and nestlings were ringed between 7 and 15 July, although hatching probably commenced up to a month earlier judging from nest-building dates.

Nest sites were exclusively in rock faces in crevices up to 0.5 m deep; southerly aspects (south-east to south-west) were favoured in 11 out of 13 nests, presumably linked to increased temperatures and/or better feeding sites on southern-facing slopes and cliffs.



E28 RAVEN (*Corvus corax*)

A. P. Fowles

The Raven is common in the low arctic and southern high arctic regions, more frequently encountered in the interior than on the coast.

Ravens were present in Eqalungmiut Nunât when the expedition arrived and breeding pairs kept such a low profile that only three nests were located. However, non-breeders were conspicuous as they frequented look-out points throughout May. Considerable movement was noticed in the early evenings as they presumably sought a communal roost; a maximum of 58 were recorded on 24 May heading south-east down Goose Valley.

The tendency of families to remain in the vicinity of the nest after the fledging period was evident and suggested that pairs bred at the following sites: Omphalis cliffs, Needle Cairn Heights, False Eyrie Crags and Eqalungmiut nuât. The whaleback at Aberchar attracted regular concentrations (up to 16) but had no suitable nest-site. Only three sites were confirmed as being definitely occupied: Ímajuitsoq, Raven Chasm and a cliff 250 m from Gyrfalcon eyrie B. The high proportion of old nest-sites suggests that Greenlandic Ravens share the habit of European birds in utilising four or five nest-sites within their territory over a period of years.

The sight of 48 Ravens on the ground together on 23 June was unprecedented. Although the majority were clustered into an area of some 100 m^2 there did not seem to be any carrion there to account for the gathering. Numbers in that area dwindled over the next few days and the aggregation had apparently left Goose Valley by 27 June.

The concentration of Ravens throughout the season in Goose Valley did not seem typical for the region as a whole. Observer coverage was biased (section B4) but nonetheless very few birds were seen away from the valley apart from a handful of sightings of individuals on the plateau. A 54 km walk on 3 July covering the western corner of the region failed to record a single Raven. Similarly, a 30 km walk in the north-eastern quarter failed to produce any sightings on 27 July.

Ravens were often observed turning over vast amounts of *Aulacomnium turgidum* moss mat, presumably in search of insects and, more specifically, pupae which were in great abundance. Ravens are opportunistic omnivores and tend to exploit locally common food sources as they become abundant. For example, several old pellets collected from below the nest at Ímajuitsoq (containing at least two downy young on 21 May), consisted almost entirely of seeds of *Empetrum nigrum*. Two Mallard eggs were found that had been smashed open by a Raven and on 1 July a Raven was seen flying with a passerine's egg held in its bill. On 3 June a Lapland Bunting's nest was found below False Eyrie Crag and measurements were taken of the clutch of five eggs. By the time of the return visit on 12 June the nest had been predated and several Ravens feathers were caught amongst the surrounding vegetation. It is to be presumed that the Ravens present at the False Eyrie Crag had observed our activities and destroyed the nest as soon as we left the vicinity.

REDPOLL (*Carduelis flammea*)

A. D. Fox

The Greenland Redpoll is a very common breeding species throughout the low arctic regions of Greenland, nesting on the west coast from Kap Farvel to Melville Bugt. It is largely restricted to the interior and is practically absent from coastal areas as a breeding species.

In Eqalungmiut Nunât, the Redpoll commonly bred in *Salix glauca* scrub from 0.5 to 2.0 m high, particularly on the warmer south-facing slopes and in sheltered stream beds where the *Salix* forms a denser scrub. The birds were noted foraging in many habitats and were heard calling above the peak of 627 m, although they generally avoided bare rocky areas and the dry barrens of the tops.

Observations were complicated by the presence of the two colour morphs amongst cock Redpolls as described by Salomonsen (1928). Although the white form was seen throughout the four-month stay, brown males made up the majority of observations (ratio 9.2:1). In contrast to the findings of Salomonsen (1950a), the white morph birds generally possessed considerable areas of pink on the breast and head and were conspicuous and handsome birds. None of the white cocks was shown to be paired to nesting female Redpolls, although during a twenty-four hour observation period at one nest, a white male twice alighted near to the incubating female. Each time, the cock bird dropped rapidly down to alight close to the nest, giving the subdued call note; the incubating female looked at the male, but did not assume the begging posture which formed the usual response to the arrival of the attendant brown male.

ARRIVAL AND DISPERSAL

Redpolls were present on arrival in Eqalungmiut Nunât on 5 May and Salomonsen (1950a) gives the arrival date of the species as the latter half of April. The species tended to be restless and wide-ranging, but migration through the area occurred throughout May and possibly into early June, with birds flying over generally north and east. Such movements were particularly noticeable up Goose Valley during the period 9 to 14 May and again from 26 May to the end of the month. The plateau regions were rarely visited during the early part of the project, but it seemed that the general pattern was followed with regard to altitude, with early arrivals restricted to the lowlands freed from snow cover, but gradually moving to the higher parts later through May.

Newly fledged young tended to remain in the immediate vicinity for four to five days after leaving the nest, moving away from the nesting areas after this. Around Base Camp where detailed observations were made, the young of the year were noted around the nest site for only two days after fledging. The implication is that the young birds can move up on to the plateau where the amelioration of conditions produces a burst of production to be exploited by juvenile birds away from the main breeding areas. Although groups of young Redpolls were seen on the uplands during June and July, large numbers of juveniles were not noted until August. Small parties of juveniles amongst patches of willow became a common sight towards the end of July, but from 31 July, larger groups began to move down off the plateau, following the wet runnels and *Salix glauca* streams past Base Camp. By 3 August, the movement had become more noticeable and by 11 August had become a substantial flow with flocks of up to 120 individuals involved. This heavy passage continued up to the time of departure on 20 August, although declining after 15 August.

BREEDING

Song flight and courtship were rarely observed, although cocks were seen throughout Goose Valley delivering song display to a female often flushed close at hand. This was especially common in mid-May, but such encounters never corresponded to nest sites found later. Three apparently male birds were watched fighting on the slopes below False Eyrie Crags on 19 May.

Salomonsen (1950a) states that egg-laying takes place from the latter part of May, a pattern followed in Eqalungmiut Nunât. Figure E29.1 gives the distribution of first egg laying dates; those of incomplete clutches were calculated on the basis of one egg laid per day. Clearly sample size restricts the validity of interpretation, but the bimodal nature of the distribution hints at two distinct phases underlying the data, with initial egg laying taking place in late May and early June and later clutches initiated during mid-July. The pattern is complicated by late nesting birds, but the suggestion is that either sequential breeding or double-brooding occurs in the population. Records suggest that the plateau birds nested later than birds at lower altitudes, with earliest nesting pairs breeding on the sunny slopes below False Eyrie Crags and on DZ slopes. Indeed, the first fully fledged young Redpolls were seen on 11 June below DZ, suggesting a first laying date of at latest 21 May, although as the young were well developed with no attendant adults, it seems likely that the first egg would have been laid as much as five days before this date. The final clutch was commenced on 21 July, giving a breeding season of two months duration, longer than that of any other species in Eqalungmiut Nunât, and further evidence of the possibility of sequential breeding or double-brooding.

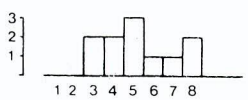


Figure E29.1. Distribution of first egg-laying dates of Redpoll (*Carduelis flammea*) from nests around Base Camp (see Figure E29.2), based on five day intervals starting from 10 May, 1979.

Some of the *Salix glauca* scrub areas in the wet runnels about Base Camp were watched on a regular basis, and a study of nesting Redpolls was undertaken here. With hen Redpolls flushing from the nest at 1-5 m range and the nest sites being so conspicuous, it was possible to locate the majority of nests within the study area. Details of nests and positions of sites are shown in Figure E29.2.

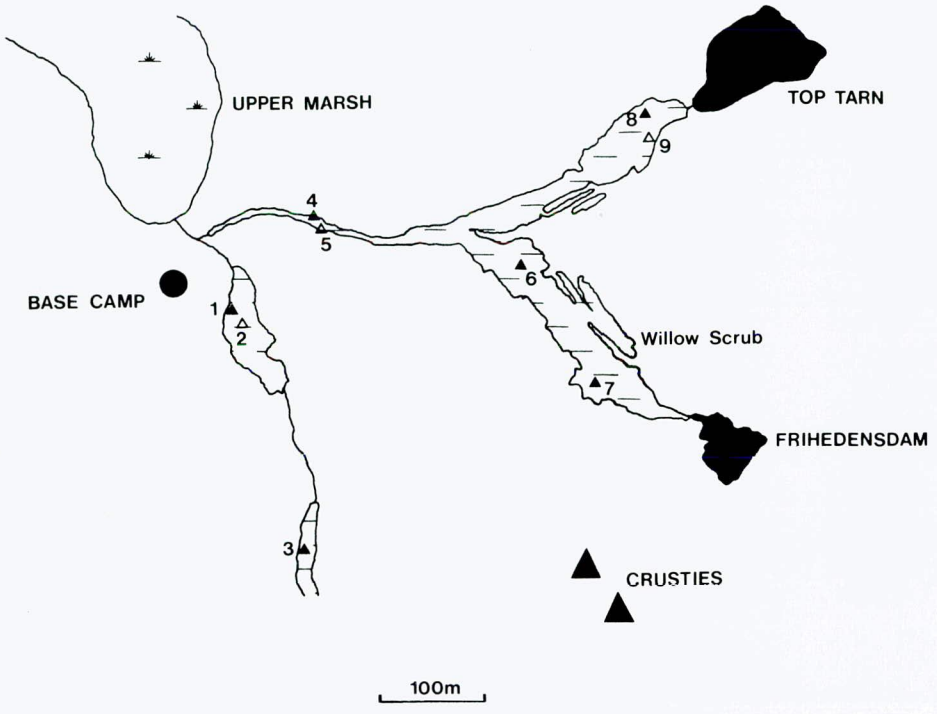


Figure E29.2. Distribution of Redpoll (*Carduelis flammea*) nests around Base Camp, Eqalungmiut Nunât 1979. Open triangles indicate suspected second broods.

Nests and Nest Sites

All nests located were found in the forks of *Salix glauca* scrub with one notable exception at "Brain Coral Mud" where an occupied nest was found on a bank of dry mud with no vegetation for considerable distances around. With this exception, all nests were constructed of dry grass with pieces of rootlets and small twigs woven into the structure. In one nest, substantial amounts of the lichen *Alectoria sp.* were incorporated, but generally the lining consisted of *Salix arctophila* down, Caribou hair and, especially in the later nests, Ptarmigan feathers.

All nests were between 0.4 and 1.2 m above the ground, excepting the ground based nest. Most of the early eggs hatched before the *Salix glauca* had burst bud, so many of the nests were situated below the upper branches, concealed within the canopy. However, at least three nests were positioned at the very top of plants, and with the pale linings were extremely conspicuous, although none of the followed nests was predated.

Incubation

Incubation was carried out by the female Redpoll, and although fed by the male at the nest, she made frequent feeding flights out of the area as well.

Clutch Size

No predation was observed at any of the sites. Clutch size ranged from five to seven; the distribution amongst size classes is given in Figure E29.3, the modal class was five eggs, the mean 5.46. No trends in clutch size with respect to time can be seen in such a small sample, but there seems considerable scope for an investigation of this aspect with respect to temperature and day-length. Infertile eggs were removed by the adults within hours of the hatching of the brood.

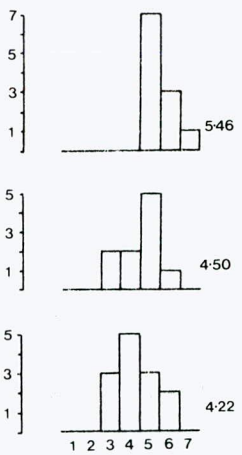


Figure E29.3. Distribution of clutch size (*top*), brood size (*centre*) and fledging success (*lower*) of all located Redpoll (*Carduelis flammea*) nests, Eqalungmiut Nunât, 1979.

Post-incubation

It was hoped to undertake a study of Redpoll diurnal rhythms similar to that of Asbirk and Franzmann (1978). In the event, it proved impossible to complete the study, but the results of a single twenty-four hour watch are summarised in Figure E29.4 . The watch was carried out on 10 June when the pulli were two days old, hatching commencing on the morning of 8 June.

On every occasion, the arrival of the feeding male produced a begging response in the female with fluttering wings, bowed back and open gape while uttering a piping call. On all but three occasions (93% of occurrences) the cock fed the female which later fed the nestlings after the departure of the male. The exceptions were when the female was absent from the nest when the male bird was observed feeding the young directly.

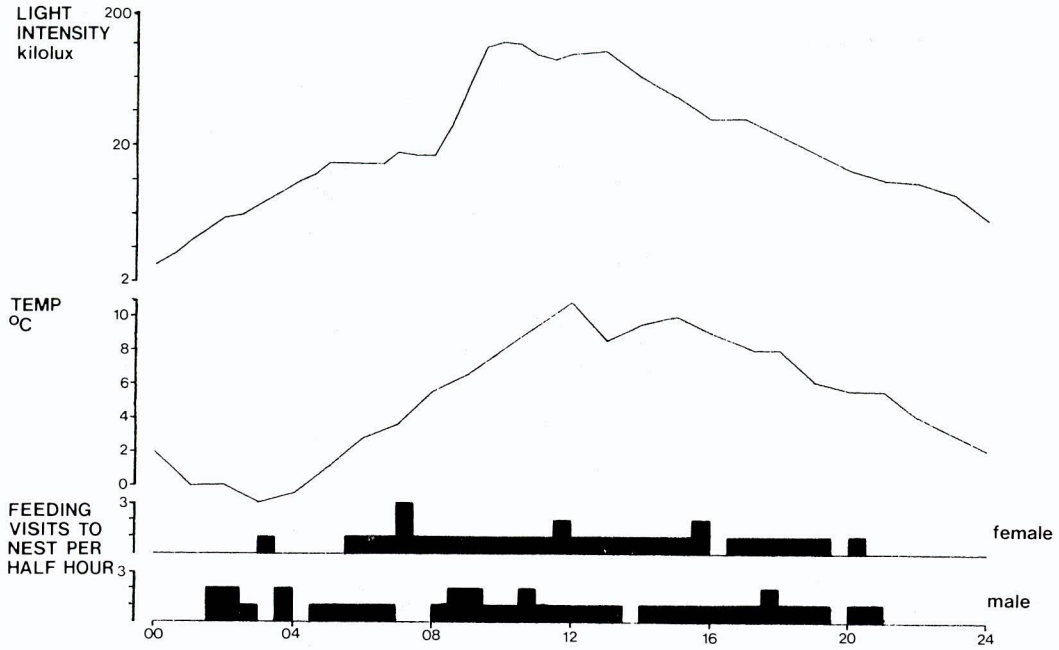


Figure E29.4. Activity of Redpoll (*Carduellis flammea*) parents at nest 4 (Figure E29.2).

Breeding Success

An estimate of breeding success in terms of the proportion of eggs giving rise to fledged young was possible for a few nests. In respect of bringing at least one egg to flying fledgling, all nests were successful. Mean percentage hatching success was 76.3% (n=7) and nest success rates are plotted with respect to laying dates in Figure E29.5. Incubation lasted 10-11 days, fledging taking nine days, considerably shorter than in other parts of the range of the Redpoll (Harrison 1975).

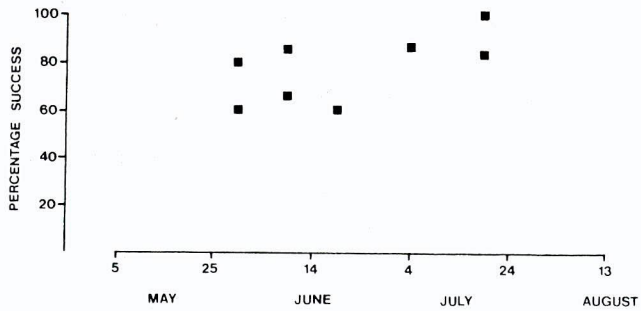


Figure E29.5. Breeding success rates of Redpolls (*Carduellis flammea*) with time, Eqalungmiut Nunât, 1979.

Egg Measurements

Mean measurements of 19 Redpoll eggs were 18.09 x 13.26 mm

Chick Development

The pulli of two clutches were weighed to determine rates of development. The results show a rate of growth in both broods very similar to that found by Grimmell (1943) in Churchill, Manitoba, and the plots of growth are shown in Figure E29.6.

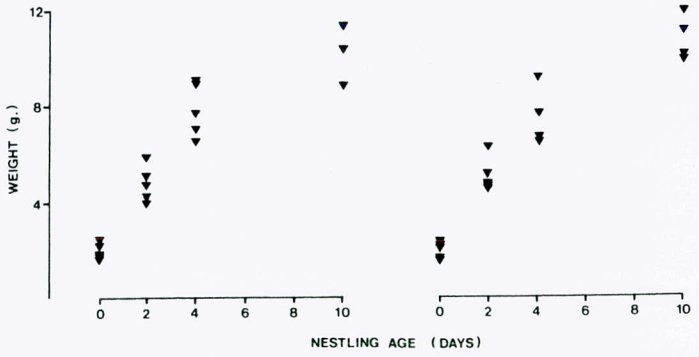


Figure E29.6. Growth rates of pulli Redpoll (*Carduellis flammea*) from two nests in Eqalungmiut Nunât, 1979.



E30 ARCTIC REDPOLL (*Carduelis hornemanni*)

J. Madsen

According to Salomonsen (1967a) the Arctic Redpoll breeds in high arctic west Greenland, but has recently been found in Upernavik and Umanaq Districts where it is believed to breed. It winters in low arctic Greenland and passage takes place from mid-April to late May in spring and during late August in autumn.

There were four sightings of this species relating to six birds, all in May:

11 May - A single bird above Kûk Marshes, flying off north-east.

12 May - A single bird above Manx Lake, flew off north-east.

22 May - A pair rested briefly by the peak of the Crusties, later moving off in an easterly direction.

25 May - A pair together on the southern side of east Eqalungmiut tasia.

The dates suggest that these birds were passage migrants.

E31 LAPLAND BUNTING (*Calcarius lapponicus*)

J. Madsen

The Lapland Bunting breeds commonly in west Greenland, from the extreme south as far north as the Qânâq District. In Eqalungmiut Nunât it was the most abundant bird, with densities highest below 400 m on south-facing slopes (see section E34).

A full discussion of the timing of breeding, reproductive success and their relation to prey abundance is given in Madsen (in prep.).

ARRIVAL AND DISPERSAL

The first birds seen in Eqalungmiut Nunât were a pair on 7 May, although peak arrival occurred a week later, the males arriving 2-3 days before the females. By 20 May the sex-ratio was approximately equal and most birds appeared to be already paired.

Juveniles started to move off the upland areas during mid-July with up to 230 birds in the willow scrub leading down from Top Tarn to Upper Marsh and a visible passage of as many as 40 birds per minute passing Base Camp during early mornings in August. This passage resulted in large, localised concentrations, with up to *c.*90 juveniles feeding on the seed of dense *Puccinellia deschampsioides* stands at Kûk Marshes and *c.*30 feeding on set seeds of *Poa spp.* at Aberchar in mid-August.

BREEDING

Throughout the breeding season a total of 70 nests was regularly visited. Where clutch initiation dates were known, eggs were measured and weighed using 5 gm Pesola balances. In four lowland and two upland nests, individual young were marked and then reweighed at regular intervals.

The start of breeding was defined as the date when the first egg in the clutch was laid, this being estimated by:

i) direct observation;

ii) calculation from dates of laying of subsequent eggs, based on one egg laid per day (Hussell 1972);

iii) length of incubation period;

iv) hatching date;

v) size and development of nestlings.

When the number of eggs remained constant for at least two days the clutch was considered to be complete. The time from hatching to independence of young is given as 25 days by Custer and Pitelka (1977).

In order to relate changes in nest site distribution with vegetation phenology, a leaf development index was used, grading from unburst buds (0.00) to fully developed leaves (1.00). Data were pooled from 10 plants of *Salix glauca* and *Betula nana*, and on each of these 90 buds and leaves were measured at 4-5 day intervals from 27 May to 23 July.

Nesting Habitats

The highest breeding densities were encountered on lowland south-facing slopes, particularly where covered with dense *Salix glauca* scrub (as at DZ and False Eyrie Crag slopes). At higher altitudes, densities were lower and nesting was restricted to local patches of low *Salix* or *Betula* scrub.

Figure E31.1 indicates that most located nests were found on slopes orientated between the west and south-east, with south-westerly aspects preferred. On these slopes, the sun thawed the soil earliest resulting in the first emergence of invertebrates which comprised the principal food of the Lapland Buntings. In addition, the slopes offer good nest cover of dense *Calamagrostis purpurescens* sward with numerous tussocks and a dense scrub of *Salix* and *Betula*.

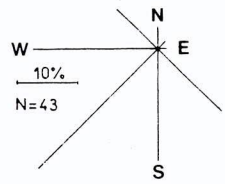


Figure E31.1. Aspect of all Lapland Bunting (*Calcarius lapponicus*) nests located in Eqalungmiut Nunât, 1979.

All nests were situated on the ground below bushes or tussocks, but nest concealment ranged from none to complete, with one nest (subsequently predated) found on an open rock surface, whilst other nests were buried deep below the grass litter of the previous season. In one instance, a nest was totally concealed under a roof of dead grass, with the entrance placed at the end of a tunnel beneath the litter.

Nest site selection changed as the season progressed, with *Calamagrostis purpurescens* slopes being the preferred habitat amongst the earliest nesting pairs, but dense scrub later becoming increasingly frequented. This change was correlated with the development of the leaves of *Salix glauca* and *Betula nana* (Figure E31.2). The scrub afforded greater concealment of nests and increased the complexity of the foraging enviroment, and indeed Furrer (1980) found a similar change from conifers to deciduous tree species as favoured nesting habitat in Fieldfares.

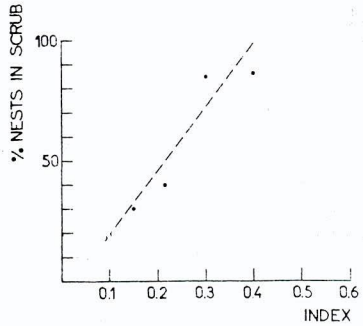


Figure E31.2. Correlation of nest site selection index of Lapland Bunting (*Calcarius lapponicus*) with leaf development in *Salix glauca*. (see text for details).

Nest Construction

Of 40 located nests, all were composed of dead grasses, occasionally with twigs in the outer layers. Thirty-four nests (85%) were lined with feathers - mostly Ptarmigan, twenty-four (60%) with Caribou or Arctic Hare fur and five (12.5%) with mosses. Only five (12.5%) were unlined. These linings have also been found previously (references cited in Rowell 1957), although unlined nests seem to be unusual.

Measurements of inner cup width were on average 63.5 ± 8.9 mm (n=25) and depth 42.0 ± 9.0 mm (n=22).

Chronology of Nesting Season

The events of the breeding season are shown in Table E31.1. Incubation averaged 12 days (range 11-13, n=10), mean fledging period 9 days (range 7-12, n=13).

TABLE E31.1. Phenology of the breeding season in Lapland Buntings (*Calcarius lapponicus*).

DATE	EVENT
14 - 16 May	Major arrival of males
17 - 18 May	Major arrival of females
24 May - 26 June	Laying of first egg
9 June - 8 July	Hatching
17 June - 17 July	Fledging
4 July - 2 August	Independent young

In the majority of lowland pairs, clutch initiation commenced 2-3 weeks after arrival (Table E31.1), with most starting about 7 June (n=49). However birds nesting on the DZ slopes started to nest significantly earlier than elsewhere (mean 1 June, n=14, χ^2 $p < 0.001$). The early start in the DZ area was probably caused by favourable microclimate conditions, since *Salix* and *Betula* growth commenced earlier there than anywhere else and an early mass emergence of *Eurois occulta* caterpillars (section H1) gave the egg-laying female buntings a potentially abundant high protein food supply. This enabled the newly arrived birds to begin egg-laying as quickly as was physiologically possible after pairing and mating. In contrast the colder weather on the higher altitude plateau probably caused a delay in arthropod production there and forced the birds to delay nesting.

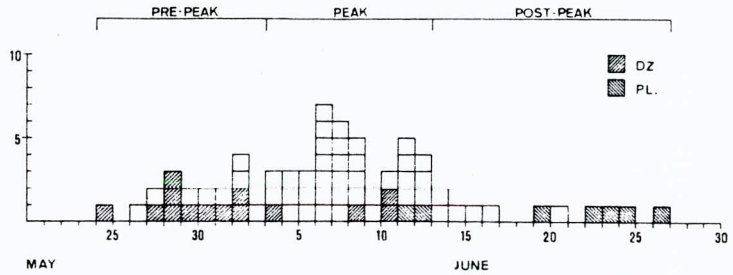


Figure E31.3. Distribution of first egg-laying dates of Lapland Bunting (*Calcarius lapponicus*), Eqalungmiut Nunât, 1979.

Clutch Size and Egg Measurements

There was no evidence of pairs producing more than one clutch, although second attempts following nest losses during egg-laying early in the season might have occurred and been included in the sample. The overall mean clutch size was 5.18 (range 3-7, n=70), although clutch size decreased towards the end of the season (Table E31.2), a phenomenon well documented in many bird species (Perrins 1965), including the Lapland Bunting (Hussell 1972).

TABLE E31.2. Seasonal reproductive success in Lapland Buntings (*Calcarius lapponicus*). The three categories of initiation times are explained in Figure E31.3. * and ** adjacent to figures indicate a significant difference between the means, at 5% and 1% levels respectively, and the means of the peak period (χ^2 test).

	Time of initiation		
	pre-peak	peak	post-peak
Clutch size ± SE	5.41 ± 0.20	5.30 ± 0.15	4.10 ± 0.25*
n	18	41	11
Eggs hatched ± SE	3.78 ± 0.46	4.70 ± 0.21	3.00 ± 0.60*
n	16	37	9
Young fledged/nest ± SE	3.65 ± 0.49	4.63 ± 0.23	2.89 ± 0.57**
n	15	36	9
Percent of nests successful	82.4	96.9	77.8
Percent of eggs which produce fledged young	67.5	87.4	70.5

Egg measurements are shown in Table E31.3; reweighing of some eggs show a mean daily weight loss of 0.021 gm (n=13). The weights are corrected to weights of eggs at the beginning of incubation.

TABLE E31.3. Measurements and weights of Lapland Bunting (*Calcarius lapponicus*). eggs.

	MEAN	S.D.	RANGE	SAMPLE SIZE
WEIGHT (gm)	2.6	0.3	2.0 - 3.2	67
LENGTH (mm)	20.9	0.9	19.1 - 22.9	76
WIDTH (mm)	15.4	0.7	11.0 - 16.3	76

Reproductive Success

The seasonal change in breeding success is included in Table E31.2. The pooled success rate was 4.13 young fledged per female. The peak period was the 'safest' in which to lay eggs and rear young because of more favourable weather conditions. Eleven out of the 14 pairs found in the DZ area started egg-laying in the pre-peak period and on average these pairs were more successful than the pre-peak pairs elsewhere. The DZ pre-peak birds raised 82% of the eggs laid (4.55 per female) against 55% (3.00 young per female) elsewhere, however sample sizes are too small to show significances. The high fledging success in the DZ area was probably due to the superabundant food supply. At several nests piles of dead caterpillars were seen, ensuring food during cold periods.

Of 254 eggs laid the total egg loss was 31.1%. Hatching failures contributed 11.8%, predation 7.5%, abandonment 6.3%, flooding of nests 3.9% and starvation of young 1.6%. Egg predation is possibly enhanced by the behaviour of the female when the nest is approached. On the approach of a predator to about 1-2 m the female flies conspicuously from the nest leaving it uncovered (90% of all nests in the sample were located in this fashion). After hatching the female ran crouching to 2-3 m from the nest before flying up, making the nest more difficult to find.

Compared to the reproductive success of the Lapland Buntings in Canada and Alaska where 1.7 - 2.31 young/nest and mean clutch sizes of between 4.3 - 5.06 have been found (Custer and Pitelka 1977; Williamson and Emison 1971), the fledging success in Eqalungmiut Nunât was high. This is partly due to a high predation rate in the New World, especially by Arctic Skuas. Another possible reason is that the longer breeding season in Greenland gives the birds more flexibility to choose the optimal time for egg-laying and the possibility of renesting if a nest is lost early in the season.

Nestling Food Items

Throughout the season caterpillars were the main diet of the nestlings in the lowlands, and pairs were seen flying long distances to the DZ area to catch prey where the caterpillars had the highest abundance. On the plateau where caterpillars had a lower density, adult Diptera were most important for the young. On two occasions young were seen being fed with the sporophytes of mosses, especially *Polytrichum* spp.

Table E31.4 shows the food items brought to the nestlings by the adults at nests in both the lowland and plateau areas, however the dietary composition is atypical in lacking caterpillars.

TABLE E31.4. Observed Lapland Bunting (*Calcarius lapponicus*) nestling food items. Observations made with binoculars or telescope. Unusually this sample does not contain caterpillars (see text).

	Valley		Plateau	
PREY	Number	Percentage	Number	Percentage
Adult Diptera	8	11.8	49	79.0
Diptera larvae	52	76.5	6	9.7
Aranea	8	11.8	5	8.1
Plant material	0	0	2	3.2

Growth of Young

Figure E31.4 shows the growth of individual young from four lowland and two plateau nests. In all nests egg laying was initiated in the peak period and hatching occurred between 24 and 28 June. The mean growth rate was 2.3 gm per day in the lowlands and 1.8 gm per day on the plateau. From the fourth day after hatching to fledging the mean weights of young are significantly higher in the lowland (t-tests, $p<0.05$ for all daily samples). Although no quantitative measures are available from the plateau, arthropod production was lower there than in the lowlands. This probably meant that the adults had to spend longer searching for food, which ultimately meant a reduced rate of growth of the young.

Usually young fledged nine days after hatching, although there was often one day's interval between the departure of the biggest and the smallest chicks from the nest (Figure E31.4). In one nest (nest 6 in Figure E31.4), it was noticed that in good weather the biggest young were always on the top in the nest, where presumably they would be fed first, whilst in bad weather they were sheltered from chilling in the bottom. On 6 July there was a snow fall on the plateau, and only the three biggest chicks survived from this nest. It is believed that such a feeding hierarchy was established by the parents, investing energetically in the young most likely to survive, and that this is an adaptation to critical conditions where the alternative might have been the total loss of the brood. Cullen (1957) noticed that similar "peck-orders" among Kittiwake siblings were only evident during periods of food shortage.

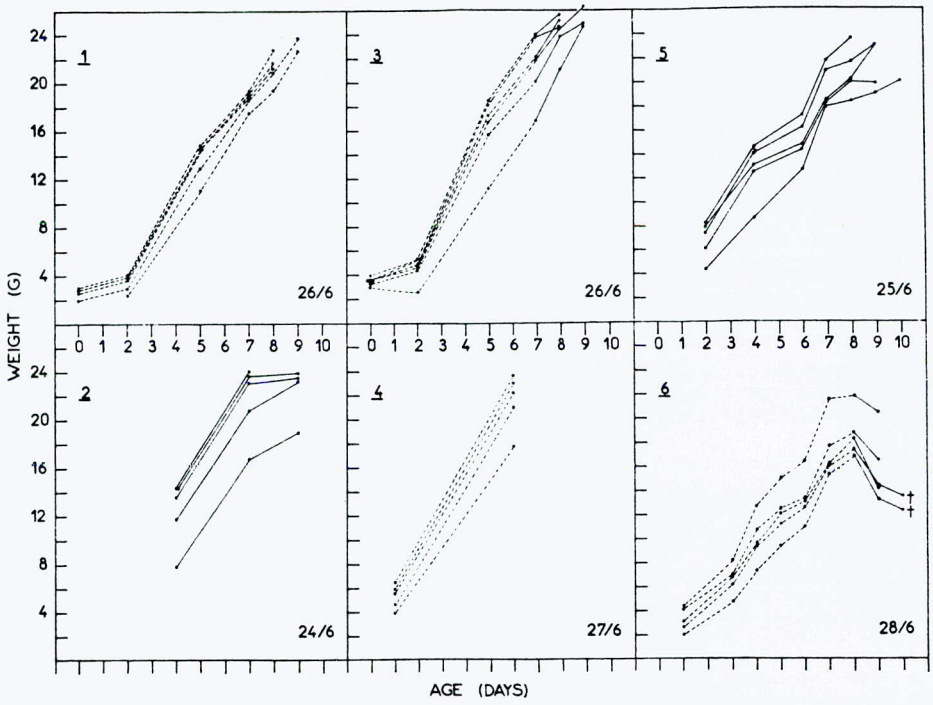


FIGURE E31.4. **Growth rates of nestlings from six Lapland Bunting (*Calcarius lapponicus*) nests, Eqalungmiut Nunât, 1979. Crosses indicate nestling death, dates indicate hatching dates.**

E32 SNOW BUNTING (*Plectrophenax nivalis*)

A. D. Fox

The Snow Bunting is the most abundant and widespread of Greenland birds, breeding from the far south to the extreme high arctic areas of the north.

In Eqalungmiut Nunât, the Snow Bunting was less numerous than the Lapland Bunting at altitudes below 200 m, but on the plateau region, it was by far the most numerous passerine. Its distribution was largely determined by the availability of nest sites and it was seemingly able to breed amongst high concentrations of Lapland Buntings wherever suitable rock crevices were available for protection of the nest.

ARRIVAL AND DISPERSAL

Male Snow Buntings were present on our arrival on 5 May, with summer-plumaged cock birds defending territories in the lowlands; only a very few birds were noted on the periphery of the uplands. Bertelsen (1932) gives dates of arrival on the west coast of Greenland (Table E32.1). The first female in Eqalungmiut Nunât was seen on 10 May, slightly later than reported by Tinbergen (1948) from Tasiusaq (Angmagssalik) and expedition members had seen female Snow Buntings at Søndre Strømfjord Air Base on 3 May 1979.

TABLE E32.1. Mean arrival dates of male Snow Buntings at different latitudes on the west coast of Greenland (Bertelsen 1932).

LATITUDE	MEAN ARRIVAL DATE
60°	31 March
64°	4 April
67°	30 March
71°	8 April
74°	12 April
77°	29 April

Early territories on lowland lichen mat areas often formed the basis of later breeding territories, while others appeared to be transient feeding territories before the occupants followed the thaw to higher altitudes. As many as three cock birds were showing vehement territory defence in early May in the unstable areas where Afon Char fed Manx Lake, yet all were later abandoned.

Males were occasionally observed flying strongly north and east during May, especially during the early observation period at Kûk Marshes but there was a far more dramatic passage of hen birds with a few males towards the end of the month in Goose Valley.

After fledging, young birds remained close to the nest to feed and roost during the "night" period between 23.00 and 04.00 hours in late July. This pattern continued for a week to ten days, the young remaining with the parents and the entire family group often roosting close to the original nest site. After this, young birds aggregated into flocks of wandering juveniles, conspicuous from 21 July when up to 16 young birds were together around the Crusties and 25 at the west end of Atanârssuk ten days later. Subsequently, large numbers of young birds with some moulting males and occasional hen birds were encountered all over the plateau, with a maximum of *c*.65 near Spaceman on 27 July, although family groups, presumably late nesters, persisted until at least 29 July.

Once juveniles had formed large roaming bands, it appeared that the departure from Eqalungmiut Nunât proceeded rapidly such that by 10 August, a walk from Base Camp to the Wallbanger area produced only one sighting of an adult male from prime Snow Bunting habitat.

BREEDING

From 7 May, cock birds in their territories spent much of the mornings singing, quickly attracting females on their arrival; the two birds then fed in close association. During these early days, copulation was frequently observed. The pairs within the lowland sites were all prospecting for nest sites by 23 May, and the pair by Aberchar began building a nest during the afternoon of the same day. The first egg at this nest was laid in the early morning of 28 May, this being the first egg-laying of the season. Breeding commenced first at lowest altitudes, with later nests situated on the south-facing slopes of the Crusties. Birds started nesting on the uplands in early June, continuing through the month until the last nest at Mistwater, where the first egg was estimated as being laid about 28 June. Despite the early start to the breeding season at lower altitudes, the sites at Aberchar and around Kûk Marshes were deserted by early August and in no situation was double brooding suspected.

Nest and Nest Sites

The Aberchar nest was built on a basis of mud and moss gathered from a *Polytrichum* hummock some 1.5 m from the nest crevice, with construction continuing through until 26 May. The female almost exclusively constructed the nest, although the cock bird occasionally brought material, but did not contribute to the structure, generally only accompanying the female in her exploits or singing from a small *Salix glauca* bush above the nest entrance. After the base had been formed, grass and twigs were brought throughout 24 and 25 May to be lined with Ptarmigan feathers and hare down on 26 May.

Other nests were similarly constructed, but the site of the nest crevice proved extremely variable. It had been hoped to link nest site position to nesting success, and although this proved impossible, the results summarise something of the range of nest sites utilised (see Table E32.2).

TABLE E32.2. Summary of nest position parameters from 22 nests, Eqalungmiut Nunât, 1979.
(All values are means ± standard deviation)

Crevice Orientation	Vertical	± 45°	63.6%
	Horizontal	± 45°	36.4%
Site	Rockfall		40.9%
	Rockface		59.1%
Height above nearest break in slope		10.7 ± 19.6 m	
Depth of nest into crevice		61.3 ± 23.6 cm	
Distance from nearest open water		251 ± 220 m	

Sizes of territories based on regularly utilised song-posts noted on two dates at least ten days apart were mapped out. The areas of defended territory estimated in this way from six pairs were found to range from 10 700 m^2 to 12 800 m^2, increasing with altitude but decreasing with time, at least at the Aberchar site. It should be mentioned that all mapped territories were in situations where nest sites were not limiting, and the territories all abutted others for much of their border. In the absence of other breeding males, birds held far larger territories than at higher breeding densities. After hatching, adults collected food from outside the defended area, and at Ptarmigan Gorge, one pair regularly flew to pools some 600 m away to collect emergent chironomids for young in the nest.

Incubation

Incubation was carried out exclusively by the female and she was fed by the male as well as leaving to feed herself. It is interesting to note that during the day of laying of the last egg and the following day the female was away from the nest for long periods.

Clutch Size and Breeding Success

No predation was noted at any of the nests followed. From three nests, mean clutch size was 5.67, with a modal class of six. All followed nests were successful in bringing at least one of the eggs to a fully fledged young; however, considerable mortality was experienced by the plateau families during the early part of July when the snow and low temperatures were doubtless responsible for the many dead nestlings found in or around nests at this time. The mean hatching success was 4.22, with a modal value of four, but the mean fledging numbers fell to 2.88 (modal class 3) with several birds producing only one nestling.

FEEDING

The onset of the cooler weather during early July had not only a profound direct effect on hatched young, but also affected the availability of insect food. It seemed that birds fed spiders and Tipulids to the young early on, but after the arrival of the snow showers and lower temperatures, large numbers of semi-emerged chironomids were taken from the strand lines above the lakes and pools of the uplands. In this respect, it seemed that birds within close flying distance of open water had a considerable advantage over other birds. It would appear that, as with many other passerines, the nesting period coincides with maximum insect production and availability, but that during the subsequent decline of insect numbers after the emergence of fledged birds, the young birds, in large roaming flocks, change to a seed-eating diet, with seeds of *Polygonum viviparum* particularly favoured. Adult birds also utilised plant foods on arrival and later, after breeding, birds were again noted feeding on seeds, especially amongst late snow lie and on many occasions the sporophytic parts of *Polytrichum juniperinum* were eaten.

E33

RINGING REPORT

P. J. Belman

INTRODUCTION

The ringing party, consisting of a BTO A Permit holder (PJB) and two C Permit holders (PCD and PAIE), joined the expedition in Eqalungmiut Nunât on 25 June. The catching of Greenland White-fronted Geese during moult (first week of July to the second week of August) was given priority over the ringing of other species, and while some time was available for ringing pulli in this period, there was little time for mist-netting. Goose ringing is described in Section D10 and will not be discussed further here.

Many watercourses in Eqalungmiut Nunât develop tall dense *Salix glauca* scrub (section I1). This woody vegetation attracts all passerines except Snow Buntings and is suitable for the use of single-panel mist-nets. This habitat was netted irregularly during the goose round-ups, but more or less continuously until 4 July and after 7 August.

The expedition left Eqalungmiut Nunât on 20 August and arrived in Sisimiut on 21 August. The tundra there lacked tall woody vegetation, but passerines were mist-netted in gardens in the town until 26 August. The expedition spent 27 August - 1 September at Søndre Strømfjord Air Base and an area of *Salix glauca* at Keglen was netted continuously until our departure.

METHODS

All birds except geese were caught in single-panel mist-nets or hand-nets, or ringed in the nest. Clap-nets for catching some non-passerine species on the nest or at bait were taken but not used. Special techniques were used to catch moulting and pulli Mallard which could not be induced to leave a lake by threat, but, if a ringer waited quietly, they would sneak into cover on an opposite bank where they crouched and could be hand-netted. Red-necked Phalaropes were caught using the method of Kagarise (1978), by leaving a hand-net over the nest and returning after a short interval to flush the bird. The adult did not always come back to incubate under the net, and the catching attempt was then abandoned. Many nests of Snow Buntings and Wheatears were in deep rock crevices and radio aerials were used like chopsticks to lift out and replace young.

RESULTS

Totals

A total of 1691 birds of eleven species was ringed, comprising 935 full-grown and 269 pulli in Eqalungmiut Nunât, 140 full-grown in Sisimiut and 347 full-grown at Søndre Strømfjord Air Base. The species totals are listed in Table E33.1. Some ringing was carried out on all but five days, with catching prevented only occasionally by rain, snow or wind.

Eqalungmiut Nunât

The only seabird colonies were at the Gullery where a few Iceland and Glaucous Gulls were ringed, and at Niaqorssua where there was a small colony of Black Guillemots, although none was caught. A single Ptarmigan was unwary enough to be hand-netted at Base Camp.

Mist-netting was carried out intermittently near Base Camp and a few other sites until 7 - 19 August when continuous netting took place at Lakesmeet. A large dispersal of juvenile Lapland Buntings was noted on 23 - 25 July (but little netting was possible just before and after these dates) which involved recently fledged birds in body moult. Flocks of Redpoll were conspicuous from early August and those caught at Lakesmeet were mainly juveniles, as were most Wheatears trapped at this time.

Sisimiut

Redpolls were numerous in the town and all those caught were juveniles. Snow Buntings were feeding avidly in gardens on introduced *Stellaria media*; again all caught were juveniles.

Søndre Strømfjord Air Base

Redpoll passage was heavy at Keglen, and involved mainly adults nearing completion of wing moult. The high proportion of adults contrasts with the situation earlier in August at Lakesmeet, and with their complete absence from gardens at Sisimiut. Two juvenile Arctic Redpolls were netted on 31 August. Most Lapland Buntings caught were adults that had, or had nearly, completed wing moult. These were the only passerines found to be carrying large amounts of subcutaneous fat.

TABLE E33.1. Ringing totals in Eqalungmiut Nunât, Sisimiut and Søndre Strømfjord Air Base, 26 June - 1 September 1979.

	FG	EQALUNGMIUT NUNÂT Pull	SISIMIUT	SØNDRE STRØMFJORD AIR BASE	TOTAL
White-fronted Goose (*Anser albifrons*)	67	29			96
Mallard (*Anas platyrhynchos*)	4	3			7
Ptarmigan (*Lagopus mutus*)	1				1
Red-necked Phalarope (*Phalaropus lobatus*)	3	8			11
Iceland Gull (*Larus glaucoides*)		9			9
Glaucous Gull (*Larus hyperboreus*)		11			11
Wheatear (*Oenanthe oenanthe*)	89	15	1	4	109
Redpoll (*Carduelis flammea*)	246	5	106	310	667
Arctic Redpoll (*Carduelis hornemanni*)				2	2
Lapland Bunting (*Calcarius lapponicus*)	524	152		31	707
Snow Bunting (*Plectrophenax nivalis*)	1	37	33		71
TOTAL	935	269	140	347	1691

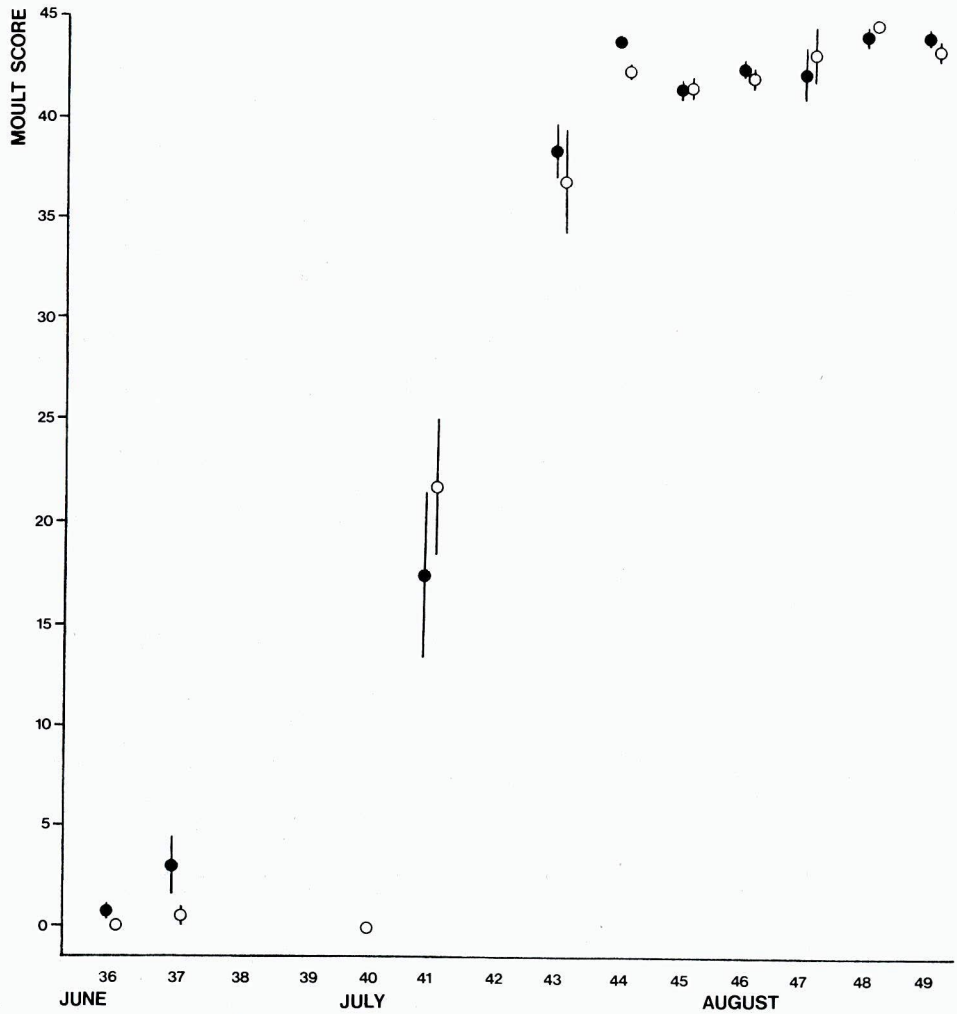


Figure E33.1. Primary scores of Lapland Buntings (*Calcarius lapponicus*) by 5-day periods. Means ± 1 S.E. are plotted with solid circles for males and open circles for females. All unmoulted and fully-moulted birds caught are included.

TABLE E33.2. Measurements (mm) and weights (g.) from West Greenland, 26 June - 1 September 1979. Adult wing and tail lengths were all measured before the moult, and juveniles caught before August are excluded. Weights of retraps are included. Data are listed in the format: Mean ± S.D. (*n*) Range, or in full for small samples.

	SAMPLE	WING (maximum)	TAIL	TARSUS	BILL	WEIGHT
Anas platyrhynchos	Ad ♂♂					1330, 1340, 1410, 1620
Lagopus mutus	Ad ♂	210				525
Phalaropus lobatus	Ad ♂♂	103, 109, 109	46, 48, 50	19.0, 19.5, 20.0	21.0, 21.0, 21.5	29.2, 29.6, 32.9
Larus marinus	1Y	466, 518	185, 202	67, 79	56, 57	1640, 2040
Rissa tridactyla	Ad	304	122, 124, 129	34, 34, 34	34, 35, 36	420, 430, 445
	2Y		114, 121, 125	31, 31, 31	31, 33, 34	365, 370, 390
	1Y	303, 310	119, 119	32, 33	31, 32	355, 360
Oenanthe oenanthe	Ad ♀♀	100.25±0.96(4)99-101	55.00±1.41(4)54-57	28.33±0.68(6)27.5-29.0	17.83±0.61(6)17.0-18.5	27.80±2.94(6)23.1-30.8
	1Y	102.10±2.14(87)97-109	58.51±2.12(82)53-64	27.61±1.14(83)24.0-30.0	16.82±0.56(83)15.5-18.0	28.84±1.85(89)23.6-33.7
Carduelis flammea	Ad ♂♂	79.68±1.86(19)76-83	59.72±1.99(18)56-63	16.13±0.55(23)15.0-17.0	12.52±0.41(23)12.0-13.0	17.97±1.05(70)15.6-20.0
	Ad ♀♀	76.40±2.03(15)73-80	58.43±2.28(14)55-64	15.77±0.55(26)14.5-17.0	11.94±0.48(26)10.5-13.0	17.34±1.12(76)14.9-19.6
	1Y	77.75±2.15(146)71-83	61.12±1.60(58)58-65	15.80±0.49(58)15.0-17.0	11.63±0.43(58)10.5-12.5	17.00±1.23(158)13.9-20.0
Carduelis hornemanni	1Y	83, 84	68, 68	16.0, 16.0	12.0, 12.0	17.00, 18.9
Calcarius lapponicus	Ad ♂♂	96.35±2.06(31)93-101	63.03±1.70(31)60-66	21.52±0.65(32)20.5-23.0	14.19±0.55(32)13.5-15.5	30.08±2.50(80)20.8-37.4
	Ad ♀♀	90.32±1.89(50)86-96	59.08±1.97(48)55-64	21.07±0.65(53)19.5-22.0	13.50±0.42(53)12.5-14.5	27.67±2.19(109)23.2-34.9
	1Y ♂♂	96.67±1.83(24)94-100	66.35±1.77(17)62-69	21.68±0.56(17)21.0-22.5	13.44±0.43(17)12.5-14.5	30.15±1.62(26)27.5-33.9
	1Y ♀♀	91.58±1.84(19)89-96	63.06±1.92(18)61-67	21.03±0.58(18)20.0-22.5	13.00±0.38(18)12.5-13.5	27.63±1.14(21)26.0-29.3
Plectrophenax nivalis	1Y ♂♂	110.07±1.62(15)108-114	69.80±2.54(15)65-74	21.17±0.72(15)20.0-22.5	13.70±0.53(15)12.5-14.5	40.09±2.18(15)37.5-45.4
	1Y ♀♀	103.58±2.01(19)101-106	64.22±1.93(18)61-68	20.81±0.52(18)20.0-21.5	13.36±0.33(18)12.5-14.0	36.98±2.04(19)31.4-40.3

Measurements and Weights

Measurements and weights are summarised in Table E33.2. All adult wing and tail measurements were taken before moult and, because of the effects of wear, are minima for the populations concerned. The first-year samples exclude juveniles caught before August, but can be expected to include a few birds that were not fully grown. The Great Black-Backed Gulls and Kittiwakes were shot birds measured in Sisimiut.

Lapland Bunting Moult

Lapland Bunting was the only species caught in reasonable numbers throughout the moult. Primary scores are plotted by international 5-day periods (Berthold 1973) in Figure E33.1. Females commenced moult later than males, but both sexes completed the moult at the same time.

MOVEMENTS

Three ringed birds showed local movement within Eqalungmiut Nunât. A Wheatear pullus ringed at Axewater on 7 July was netted at Lakesmeet (5 km SE) on 8 August. A male Lapland Bunting pullus ringed near Doodle on 17 July was netted at Lakesmeet (13 km E) on 9 August, and a juvenile female ringed near Base Camp on 24 July was caught at Lakesmeet (2 km SE) on 9 August.

Only one distant recovery has been reported; a Mallard pullus ringed in Eqalungmiut Nunât at Lake 66 (67°36'N, 50°47'W) on 3 August was shot on 2 April 1980 at Atangmik, Sukkertoppen at 64°48'N, 52°12'W. This recovery fits the pattern of movements of Greenland Mallard (Salomonsen 1967a).

DISCUSSION

The primary aim of the expedition was to study Greenland White-fronted Geese and Eqalungmiut Nunât was chosen for its high goose density (section D1). It presented only limited opportunities for ringing other non-passerine species. The priority of catching geese during the moult, and our departure from Eqalungmiut Nunât on 20 August and from Greenland on 1 September, before most passerines started fattening for migration, affected both the continuity and extent of the mist-netting that could be carried out. Nevertheless, few Redpolls or Arctic Redpolls have been ringed in Greenland and our catch more than doubles the national total for 1946-74 for both species (Salomonsen 1979a). The Lapland Bunting figures are also a useful contribution to the national total.

ACKNOWLEDGEMENTS

Dr Finn Salomonsen arranged the supply of rings from the Zoologisk Museum, Copenhagen, which forwarded recoveries. Steen Malmquist arranged for us to net at Keglen, and I thank him for his exceptional kindness in air-dropping extra rings to us in Eqalungmiut Nunât. The other members of the expedition relieved the ringers of routine work to enable us to mist-net.

E34 BREEDING BIRD CENSUS

A. P. Fowles, A. D. Fox & D. A. Stroud

INTRODUCTION

Although the planned 9 km^2 transect of Goose Valley had to be abandoned (Figure E34.1), census visits were made to two of the 1 km^2 squares during June. This information is insufficient to qualify as a full census, but it is felt that a reasonably accurate estimate of the breeding population was made. The lack of census data from this region of west Greenland and the high densities of Lapland Buntings make such a project a future priority.

METHODS

Wooden 50 cm stakes were used to mark out a census grid of five different coloured lines. The stakes were placed at the intersections of the lines and the unique two-colour combination on each post gives its position on the grid (BTO 1977). Nine grids were prepared covering most of the valley from Kûk Marshes to Lake Hotel, with stakes placed at 250 m intervals delimiting nine 1 km^2 squares. The stakes were prepared without prior knowledge of the terrain and proved inadequate for the task - the *Salix glauca* thickets in parts of the valley were up to 2 m high and the posts were soon lost from sight. Ideally, 2 m poles would be required with the identification combination painted in vivid 'day-glo' colours.

The census was undertaken by mapping the predominant features of the grid, particularly areas of open water and the most distinct plant communities (Figures E34.2 and E34.3). The whole of Grid 1 on Kûk Marshes was surveyed in this manner, but only three 0.0625 km^2 squares were surveyed on Grid 5 on George Eliot Marsh. This process took six hours on Kûk Marshes for the entire kilometre square.

Two visits were made to Grid 1 on 16 and 24 June, three visits were made to each 0.0625 km^2 unit of Grid 5 on 19, 20 and 21 June. On each occasion, positions and activities of all birds present were plotted in accordance with the BTO Instructions (1977). From these plots, a composite picture of nesting territories was built up using the criteria of BTO (1976).



Figure E34.1. Map showing extent of intended vegetation/breeding bird census mapping, shaded area indicates grids censused for nesting birds.

LOCATION AND HABITAT

Grid 1 was situated 3 m above sea level in the centre of Kûk Marshes, and its southernmost edge was approximately 100 m from the dune system (Figure E34.1). The grid straddled Manx Lake such that 22% (0.13 km^2) of the land surface within the grid was separated from the rest by a distance of at least 250 m across open water. The habitat composition of the study area is outlined in Table 34.1. Open water covered 43% of the grid area, whilst the remainder was mainly composed of short tundra heath (less than 25 cm high) and heath-herb communities, with dry land accounting for 0.57 km^2. Of the available nesting area, 54.4% consisted of a dense cover of *Vaccinium uliginosum* and *Ledum palustre* - a community only noted at this site and at Pass of Jennings Dunes (see Figure E34.2).

Grid 5 was a further 2 km up the valley from Grid 1 covering George Eliot Marsh, but including the *Salix glauca* scrub below False Eyrie Crag and the *Salix glauca-Betula nana* heath-herb slopes to the Aberchar whaleback. The major habitat types are shown in Figure E34.3, with the majority of the 0.1875 km^2 heath or scrub vegetation and hence Lapland Bunting habitat. The habitat composition is tabulated in Table E34.2.

METHODS

(i) Kûk Marshes are lowland areas thawing earlier than much of Eqalungmiut Nunât and hence form a staging post for many birds as they arrive on spring migration. The resulting long growing season gives rise to lush vegetation and high insect production. Consequently, flocks of Mallard, Long-tailed Duck and Red-necked Phalaropes persisted throughout the season and made population estimates difficult. A lack of exposed rock in the grid square accounted for the absence of Snow Buntings and Wheatears, while the lack of *Salix glauca* scrub gave little nesting habitat for Redpolls.

A total of 11.25 hours was spent censusing the grid on 16 and 24 June. Four species (Mallard, Long-tailed Duck, Red-necked Phalarope and Lapland Bunting) were confirmed as breeding, while a Snipe was observed drumming for two consecutive days and a Red-throated Diver was regularly present on Manx Lake.

Mallard

Non-breeding flocks which gathered on the larger pools of the grid confused the status of the breeding population. The behaviour of these birds suggested only two breeding pairs, and on 24 June, a female was seen with nine very young ducklings. A total of five Mallard broods was present on Kûk Marshes in mid-August, giving a density of one successful pair per 0.8 km^2.

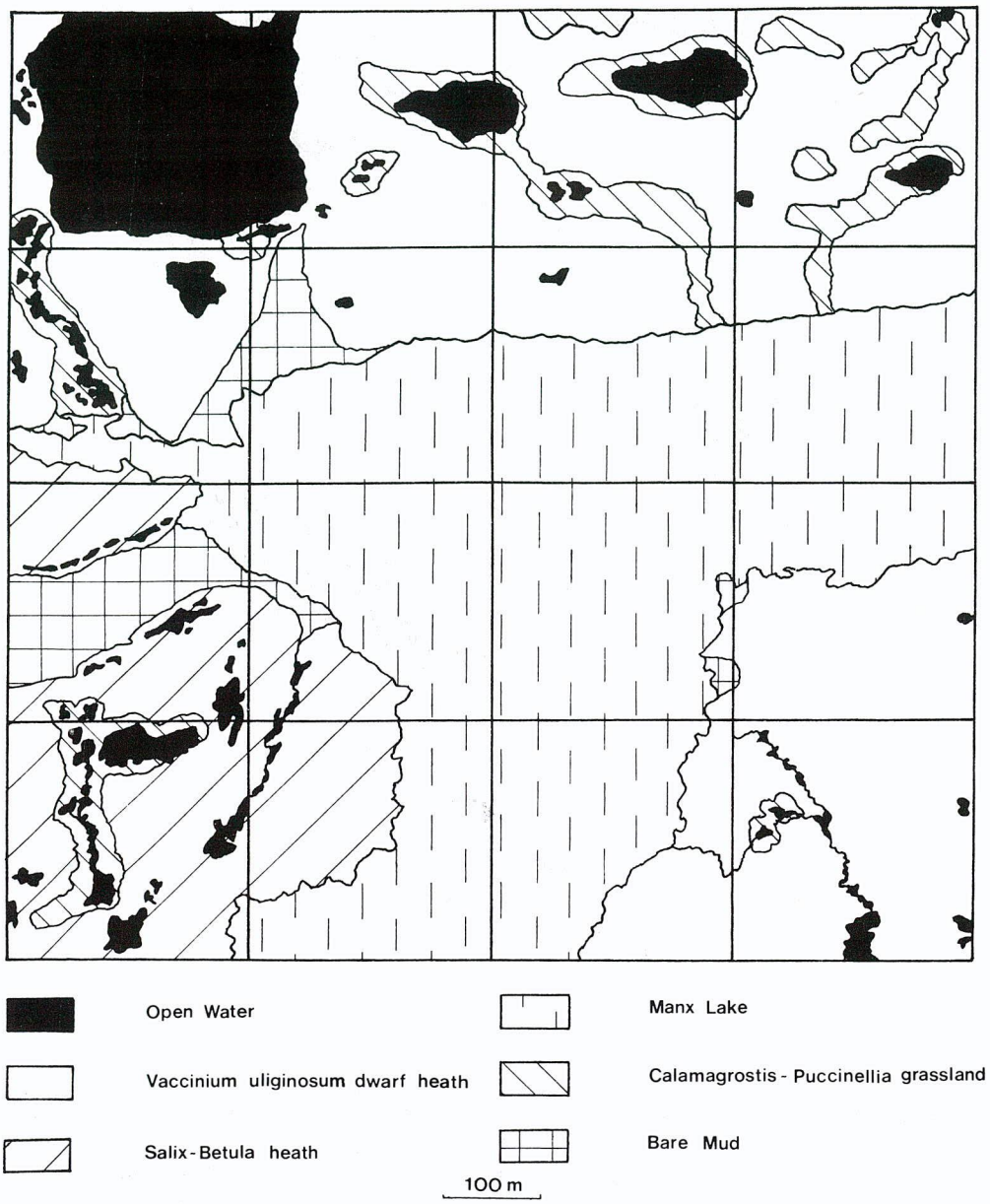


Figure E34.2. Generalised vegetation map of grid 1, Kûk Marshes, Eqalungmiut Nunât.

Long-tailed Duck

Long-tailed Duck also congregated in large flocks on Manx Lake and Long-tail Pool, and although drakes were often observed displaying, only one brood of ducklings was seen on Long-tail Pool on 14 August.

Red-necked Phalarope

Up to 27 Phalaropes congregated on the pools of Kûk Marshes through the summer. Birds of both sexes spent the day in small flocks on the larger pools and it is most likely that the majority of these did not breed in the grid. Nevertheless, the terrain was ideal breeding habitat and although only two nests were located, it seemed likely that there were some four breeding pairs present.

Lapland Bunting

An estimated 26 pairs were found, which in the 0.57 km^2 of available habitat equates to 46 pairs/ km^2. However, only six nests were found and the presence of breeding pairs was inferred from the territorial behaviour of adult birds, especially singing males. Sixty males and 26 females were found in the grid, a greater proportion of males than was found at higher altitudes in Baffin Island (Watson 1963). Several small groups of unattached males (three or four birds) were present in the grid and appeared to be tolerated by breeding birds. The higher proportion of unmated birds is unusual in the absence of a super-abundance of food, apart from mosquitoes, to sustain such a non-breeding population. Four of the located nests were found in depressions under *Vaccinium uliginosum* and this habitat held the highest densities (0.0155 km^2/pair) in this area. The remaining two nests were discovered beneath *Salix glauca* bushes. Clutch initiation in the area appeared to begin during 1 - 10 June, corresponding to the peak period demonstrated in Section E31; this is somewhat surprising in view of the early thaw of the site.

TABLE E34.1. Habitat composition of Kûk Marshes census area. (1 km^2)

HABITAT	ESTIMATED SURFACE AREA	%
All open water	0.43 km^2	43
(Pools less than 5000 m^2)	(0.09 km^2)	9
Bare mud	0.04 km^2	4
Puccinellia deschampsioides community	0.04 km^2	4
Heath-herb community	0.18 km^2	18
Vaccinium uliginosum dwarf heath	0.31 km^2	31

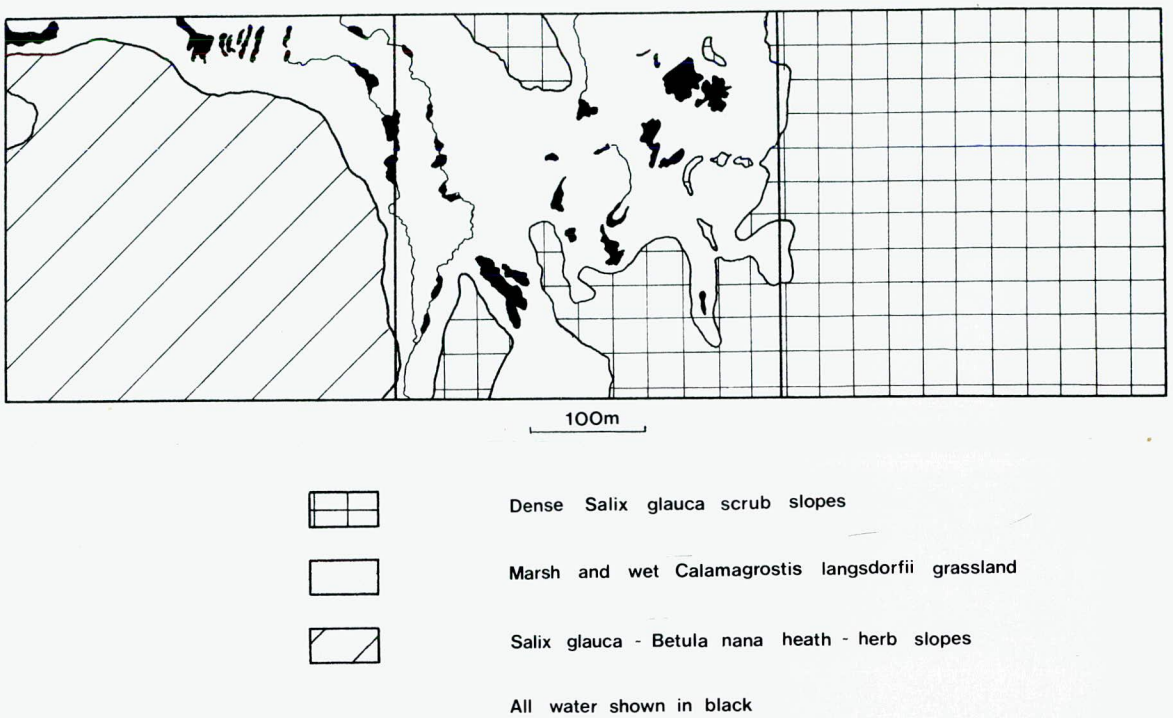


Figure E34.3. Generalised vegetation map of part of grid 5, George Eliot, Eqalungmiut Nunât.

(ii) George Eliot Marsh was not censused over the complete 1 km^2. The site was below 200 m and hence subject to a long growing season. On the south facing slopes below False Eyrie Crags, the steep valley sides were covered in *Salix glauca* scrub up to 2 m high, suitable habitat for Lapland Bunting and Redpoll, with a few areas of rock exposures providing nest sites for Wheatear. The small amount of open water (1.6% of the area) provided suitable habitat, together with the marshy areas, for Phalaropes and Mallard.

A total of 12 hours was spent censusing Grid 5 on 19, 20 and 21 June. Only one species of bird (Lapland Bunting) was confirmed breeding, while four others were noted in the grid (Mallard, Red-necked Phalarope, Wheatear and Redpoll) and a Snipe was seen drumming over George Eliot at various times (see Section E16).

Mallard

Non-breeding flocks of Mallard collected on George Eliot, and although no confirmed breeding cases resulted from the census, there were three family broods on the marsh later in the season.

Red-necked Phalarope

One pair and a single female were consistently flushed from the same sites in the census area on two dates, but no further confirmation of breeding was obtained.

Redpoll

A pair was disturbed feeding from the dwarf *Salix* scrub in the marsh on 20 June, but apparently they were not breeding within the census plot.

Lapland Bunting

In the three 0.0625 km^2 plots, four, four and eight 'paper' territories were drawn from census maps, although only three nests were found in all three areas together. This gives a range of densities from 64 pairs/km^2 in the north-facing heath-herb slopes to 128 pairs/km^2 on the dense scrub of the south-facing slopes below False Eyrie Crags. Twenty-nine males and 20 females were counted on the census, which represents a similar ratio of birds present to estimated paper territories found on Kûk Marshes. As at the Kûk site, there were several non-breeding birds present in the area, but these were not included in breeding density estimates.

TABLE E34.2. Habitat composition of George Eliot Marsh census area. (0.1875 km^2)

HABITAT	ESTIMATED SURFACE AREA	%
Open water	0.004 km^2	2
Marsh (generally *Calamagrostis langsdorfii*)	0.051 km^2	27
Salix-Betula heath-herb slopes	0.049 km^2	26
Dense *Salix glauca* scrub	0.084 km^2	45

TABLE E34.3. Breeding and non-breeding bird populations of Kûk Marshes census data.

SPECIES	MAXIMUM NUMBER OF ADULTS	ESTIMATED BREEDING POPULATION (PAIRS CONFIRMED IN (..)) IN 1 km^2	ADJUSTED NEST DENSITY (pr/km^2)*
Red-throated Diver	2	0	0
Mallard	9	2 (1)	0.5
Long-tailed Duck	10	1 (1)	1.0
Snipe	1	0	0
Red-necked Phalarope	27	4 (2)	0.25 (0.14)
Lapland Bunting	86	26 (6)	0.04 (0.02)
TOTAL	135	33 (10)	

* Densities of Red-necked Phalarope and Lapland Bunting comparing numbers of pairs to available nesting habitat given in brackets.

TABLE E34.4 Breeding and non-breeding bird populations of George Eliot Marshes census area.

SPECIES	MAXIMUM NUMBER OF ADULTS	ESTIMATED BREEDING POPULATION (PAIRS CONFIRMED IN (..)) IN 1 km^2	ADJUSTED NEST DENSITY (pr/km^2)
Mallard	1	0	0
Snipe	1	0	0
Red-necked Phalarope	4	2 (0)	10.7
Wheatear	1	1 (0)	5.3
Redpoll	2	0	0
Lapland Bunting	49	16 (3)	85.3
TOTAL	58	19 (3)	
TOTAL FOR 1 km^2	309	203 (16)	

CONCLUSIONS AND DISCUSSION

The breeding census in Eqalungmiut Nunât had been envisaged as a subsiduary project, but to have obtained accurate census data as many as six field workers would have been needed throughout May and June to survey the full nine 1 km^2 squares. The densities of Lapland Buntings was such that any census was considerably more time-consuming than an equivalent survey in Britain. Furthermore, it would be advisable to combine the census with colour-marking methods to facilitate individual recognition of birds during the census period.

The dense *Salix* thicket present on the lowland sunny slopes (as below DZ, above George Eliot and around Aberchar) hold unusually large concentrations of breeding Lapland Buntings. The estimates of densities in these areas exceed those of Joensen and Preuss (1972) (29-37 pairs/km^2 from Sarqaqdalen, Nugssuaq, a coastal site further north in west Greenland) and those of Custer and Pitelka (1977) (74-94 pairs/km^2 from Barrow, Alaska). The maximum recorded numbers appear to be those of Williamson and Emison (1971) where localised densities of up to 198 pairs/km^2 were encountered. Densities based on census data and rough approximations of located nest densities in the *Salix glauca* scrub suggest concentrations in excess of 100 pairs/km^2 over substantial tracts of the lowlands.

In view of these very high densities of Lapland Buntings, a future survey would be extremely useful in linking the high arthropod production (particularly the larval stages of the moth *Eurois occulta*, see Section E31) to productivity of the passerines in different habitats within the lowland area.

SECTION F MAMMAL OBSERVATIONS

F 1 CARIBOU (*Rangifer tarandus groenlandicus*)

D. A. Stroud

INTRODUCTION

The Caribou of the west Greenland coast (*Rangifer tarandus groenlandicus*) are thought to have first come from Baffin Island across the Davis Strait some time before the first Greenland Caribou culture (about 1400 BC) (Vibe 1967, Remmert 1980). The herds now occupy about 60 000 km^2 of central west Greenland and numbers in March 1980 were estimated to be about 7 000 - 9 000. This is a considerable decline from the population peak of about 100 000 around 1970 (Thing pers. comm.). From an aerial survey of Ipiutârssup Nunâ, Ugssuit Nunât and Eqalungmiut Nunât in 1978, about 700 were estimated to be present, mainly in Eqalungmiut Nunât (Strandgaard 1979). This compares with numbers over a wider area shown in Figure F1.1.

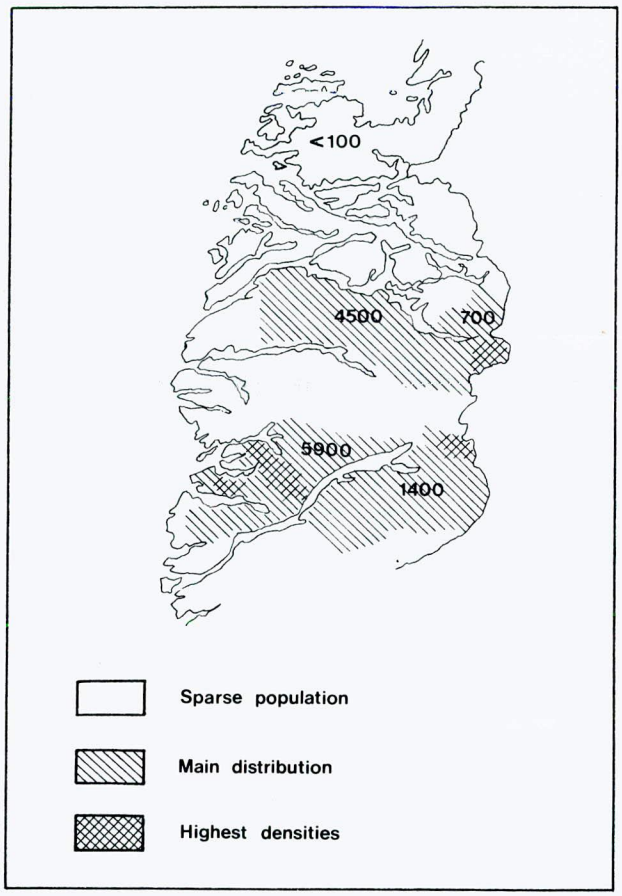


Figure F1.1. The present day range of the Caribou (*Rangifer tarandus*) in central west Greenland (from Strandgaard 1979).

Caribou were commonly seen in Eqalungmiut Nunât throughout our stay. During May and June not all observations were recorded, but those seen thereafter enable a pattern of movements to be built up. The following account is based on records of 904 individuals seen over a period of 77 days. We found it difficult to distinguish females from immature males, so these records were usually combined. Immature males can be distinguished by the absence of urine stains below the tail.

MORTALITY

There was no evidence of the cause of death for the majority of dead Caribou found, although hunting mortality seems to be of some importance. Only three carcasses were found of recent origin (less than one year old and barely decomposed), all at the western end of Eqalungmiut Nunât. One had fallen down amongst the boulders of an old rock-fall and was firmly wedged upside down,caught by its pelvis. Many skeletons were found at the base of cliffs particularly those to the south of Yankee and Doodle and along the base of Gormenghast Mountain. At the western end of this knife-edge ridge seven skeletons were found in a 200 m stretch. On the side of Manx Lake is a camp regularly used by hunters (see Section F4). The identifiable marks of hunting (bullets lodged in bone, antlers sawn off) become more common nearer the camp. Caribou antlers are collected by the small boys of the summer camps and sold via the KGH for the Asian aphrodisiac market. The collection of antlers for sale is a fairly recent phenomenon, and antlers are now sawn off old skulls, although large sets of antlers have no doubt always been collected for aesthetic reasons and for carving.

The state of disintegration of a skeleton is influenced by both hunters and Arctic Foxes. Heads without bodies are probably due to the former, whilst the scattering of long bones is certainly due to foxes. A cache of limb bones was found in a small cave on the north face of Imajuitsoq, which contained the remains of seven limbs of at least four different animals together with many scats.

MOVEMENTS

In order to show Caribou distribution, Eqalungmiut Nunât has been divided into six areas of varying size. The areas C, E and F (Figure F1.2) cover most of the plateau regions (200 - 630 m) whilst the areas A, B and D include all the lowland regions (less than 200 m) to the south, but including the Angmat (428 m) and Imajuitsoq (614 m) range of hills. The northern edge of areas A, B and D is the edge of the plateau running from Eqalungmiut nuât through the Crusties and as far as Hookwater. The three areas are arbitrarily centred on sites of regular Caribou attendance; respectively Kûk Marshes, George Eliot and Ridgeway Marshes. Within each of these areas herds would stay for several days, although there were no major habitat differences between them.

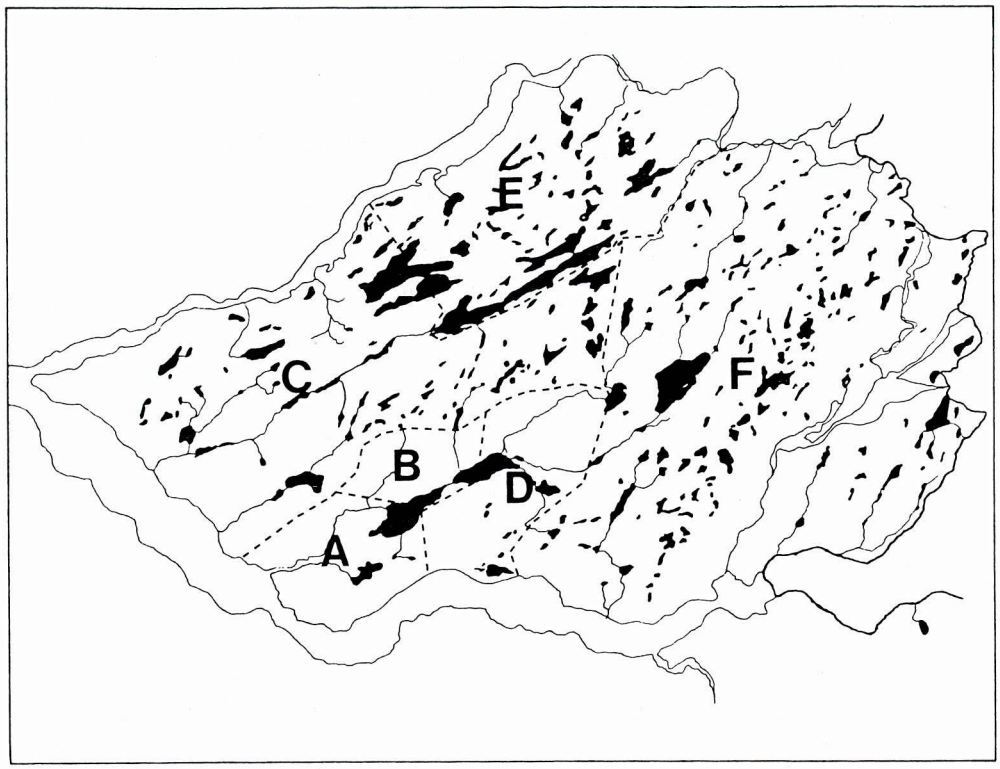


Figure F1.2. Divisions of Eqalungmiut Nunât used in Caribou (*Rangifer tarandus*) distribution data (Figure F1.3). See text for full explanation.

Area E is bounded by North Valley and Atanârssuk although its western and eastern boundaries are arbitrary. Area F comprises a large area of plateau bordering the ice-cap and the South Valley draining Inugpait qûat. The southwestern boundary is a range of cliffs. Area C includes the northwestern section of Eqalungmiut Nunât.

Observer coverage of these areas was extremely variable and is quantified in Section B4. Immediately on our arrival and during May most animals were seen in the lowland areas (Figure F1.3) and only a few on the plateau, although numbers were seen near 627 m and the Crusties. They were most frequently seen on Kûk Marshes, Angmat and the lowland marshes. During June the number of sightings of Caribou in area A declined and none at all was seen there during July. In area B roughly the same numbers were seen in June as in May. Several groups of up to 11 animals approached quite close to Base Camp in June; however Caribou were only recorded in B on two days at the beginning of July.

During the second half of June and July there was a noticeable movement of Caribou away from the lowlands. The second trip to the glacier Inugpait qûat (13-17 June) and subsequent visits there and to the ice-cap produced sightings of large herds in area F. These were much larger than any seen further west. Coverage of areas E and F was scant and the three periods when Caribou were reported in F were when trips to the ice-cap were made. The lack of sightings at other times is not significant.

The absence of animals from the lowlands during July and August was striking as they remained abundant on the plateau throughout the four months. Whether or not those that moved out of the lowlands went as far as the ice-cap, or just up onto the plateau, is not known. The Caribou hunters said we had driven the Caribou away from area A. Large numbers in areas rarely visited (E & F) and a possible move away from plateau regions with much human activity lends credence to this.

Pruitt (1978) suggests that Caribou move to more exposed and wind-swept sites in summer to avoid mosquitoes. Although the tops of hills usually had a slight breeze that kept biting insects at bay, the plateau below the tops (300 - 450 m) had similar numbers of biting insects to the lower areas. The movements observed were more likely to be determined by the phenology of plant production as discussed below.

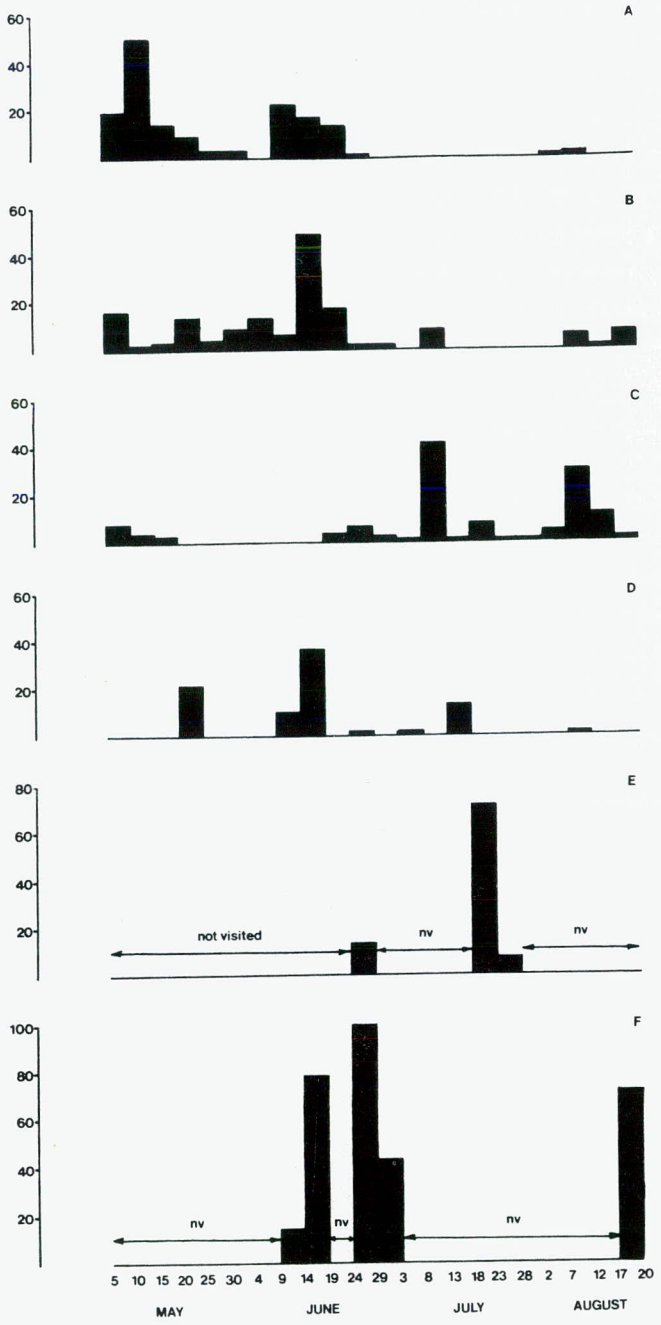


Figure F1.3. Sightings of Caribou (*Rangifer tarandus*) by area and five day period. Observer cover in areas E and F was sporadic.

Many regularly used trails were found, usually around some physical obstacle but also to drinking places where considerable erosion occurred. Particularly well used trails were found along the base of Ímajuitsoq, along the edge of South Valley and north-south around the east end of Atanârssuk. We observed a party of fifty-four animals moving south on this path on 27 July. Trails were also found around much smaller obstacles and indicated the easiest routes. In winter there is some interchange with animals from neighbouring areas, and fresh tracks across the frozen sandur were seen in early May; in summer however, the highly thixotropic silts form an impassable barrier. Several animals were seen in Amitsuarssuk in June, presumably trapped there all summer.

FEEDING

Caribou show considerable seasonal dietary change as different plants become available (Skogland 1975, 1980; Thing 1980). The temporal change in nutrient quality of emergent forage species allows the Caribou to graze optimally by selection between species and feeding sites (Whitten & Cameron 1980). Thus the change in distribution we saw in Eqalungmiut Nunât could in part be due to changing grazing patterns; subjectively it correlated with the thaw of the plateau soil. For details of diet see Thing (1980).

The few animals which we saw feeding were usually in or around damp areas, although they seemed to avoid the wettest parts of the marshes. Their regular presence in George Eliot and the quantity of old droppings found both there and around Upper Marsh indicate important feeding sites.

Seasonal movements are well known, and many northern Eurasian peoples base their nomadic way of life upon the animal migration of their semi-domesticated herds. In Greenland there has been a traditional dependence on the Caribou as is shown by the succession of Caribou cultures on the west coast (Gad 1970). As Vibe (1967) has shown, the fortunes of these were closely linked to the size of the Caribou population, in turn affected by the long-term climatic changes altering the feeding conditions. The range of movements of Caribou in west Greenland is much less than in America and Eurasia, affected as it is by numerous barriers to north-south travel. Additionally environmental gradients, such as winter snow cover, are far more east-west orientated than on the vast taigas and tundras of the larger continents. No northerly spring movements following the thaw have ever developed in Greenland, thus there has never been the need to domesticate Caribou for use as beasts of burden, as the Lapps have done for following the wild herds north each spring.

MOULT

Moulted hair was widespread and formed an important material for lining passerine nests. On 27 June a group of about 50 were seen near the ice-cap shaking out fur in great clouds. The colour of the animals suddenly became darker as the moult progressed and by early June all had finished moulting and were uniformly dark.

CALVES

The first calf was seen on 13 June near Inugpait qûat. Several others were seen in the following days until a month later when about a quarter of all females were accompanied. However because of the problems we had in distinguishing females from immature males it is not really meaningful to calculate the mean number of females with young. Growth of calves was rapid, and by mid-August it was becoming difficult to tell calves from small females at a glance, indicating high quality grazing in this area. During mid-August calves became more independent of their mothers and were often seen sleeping on gravel areas sheltered by large rocks.

RESPONSE TO MAN

As the summer progressed the Caribou grew bolder, often standing and staring or even advancing up to a certain distance as we approached; then they would run off as before. This apparent change of behaviour started about the time of the birth of the calves. During the second ice-cap trip (27 -30 June) when large herds were approached, the females with calves would run off first leaving the large antlered males behind to bark. However this response is more likely to be due to curiosity than to any aggressive or protective function (Thing pers. comm.). Early in August JF was approached by a waist high calf which he had disturbed sleeping at about 10 m distance. Once on its feet it seemed to be confused, but ran at John barking, grunting and baring its teeth, finally stopping about 15 cm from his hip. When shouted at it ran off, not looking back in sight. Another similar encounter with a calf occurred to WH and JB on their ice-cap trip. Rather than being aggressive in nature these seem to be cases of mistaken identity, since human beings are often mistaken for female Caribou by young calves. The calls and grunts are normal behaviour in seeking the mother, and the baring of the teeth is not analogous to a snarl but rather anticipatory suckling movements of the lips (Thing pers. comm.).

ANTLERS

Male Caribou cast antlers in late autumn after the rut and growth resumes in spring. The females retain antlers over the winter giving them dominance over the antlerless males. Thus the females and calves (which assume the rank of the mother) have an advantage in competition for winter food, whilst males avoid the physiological stress of antler growth at a period of limited food supply and the danger of frostbite in the growing antlers. Calves develop antlers before the first winter (Chaplin 1977). Females in west Greenland drop their antlers around calving time but there is no difference in time of shedding between pregnant and non-pregnant females as there is elsewhere. Only about 55% of females in the Søndre Strømfjord Air Base region (aged two years or more) have antlers, the rest being naturally antlerless. About 15% have only one antler (Thing pers. comm.). Large antlers were seen on stags from 7 May onwards, always in velvet. New antler growth in females was seen from June onwards but no sign of velvet shedding was seen at any time. Near Søndre Strømfjord Air Base mature bulls start to shed velvet at the beginning of September and a little later in females, immature males and calves (Thing pers. comm.).

HERDS

Caribou differ from most deer in being found in mixed age and sex herds throughout the year. Figure F1.4 gives a breakdown of sightings by group size. As far as possible the same animals were not counted twice in any day. The figures represent the sum of the daily totals of each herd size over the four month period. There were no seasonal changes in the frequency of different group sizes when the data was analysed by month.

Rutting occurs in autumn once antlers have hardened, and in the build up to this there is a great deal of sparring and fighting to establish rank orders (Chaplin 1977). One of these bouts of fighting was witnessed north of Hookwater on 12 August. About 50 males, females and young were present, both as individuals and in groups of up to ten. Within the group there was much running about and barking, although it was not clear what was happening. This area was covered in footprints in late June so it is possible that it is a regular rutting area.

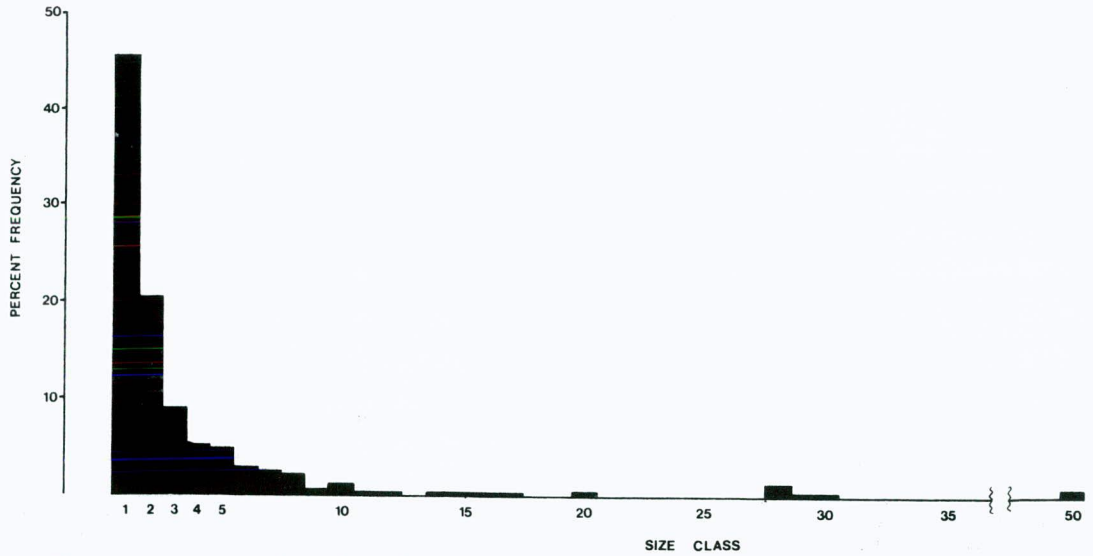


Figure F1.4. Group size of Caribou (*Rangifer tarandus*). Histogram represents percentage frequency of all sightings (n=297) by herd size.

ACKNOWLEDGEMENTS

Members of the expedition kindly furnished their sightings and gave many constructive suggestions. Dr N Leader-Williams and Mr H Thing replied to many letters and extensive enquiries, the latter also reading a draft and providing much information about the Caribou near Søndre Strømfjord Air Base.

F 2 ARCTIC HARE (*Lepus timidus groenlandicus*)

D. A. Stroud

Arctic Hares were seen at many locations (Figure F2.1) and occur frequently at several of these giving an impression of local abundance. They were particularly common on hill-tops and rocky outcrops. Solitary hares and pairs were most frequent, but three, four and five hares were occasionally seen together. It is possible that as many as five animals were present on the rock outcrops near Aberchar, although no more than three were ever seen there at one time.

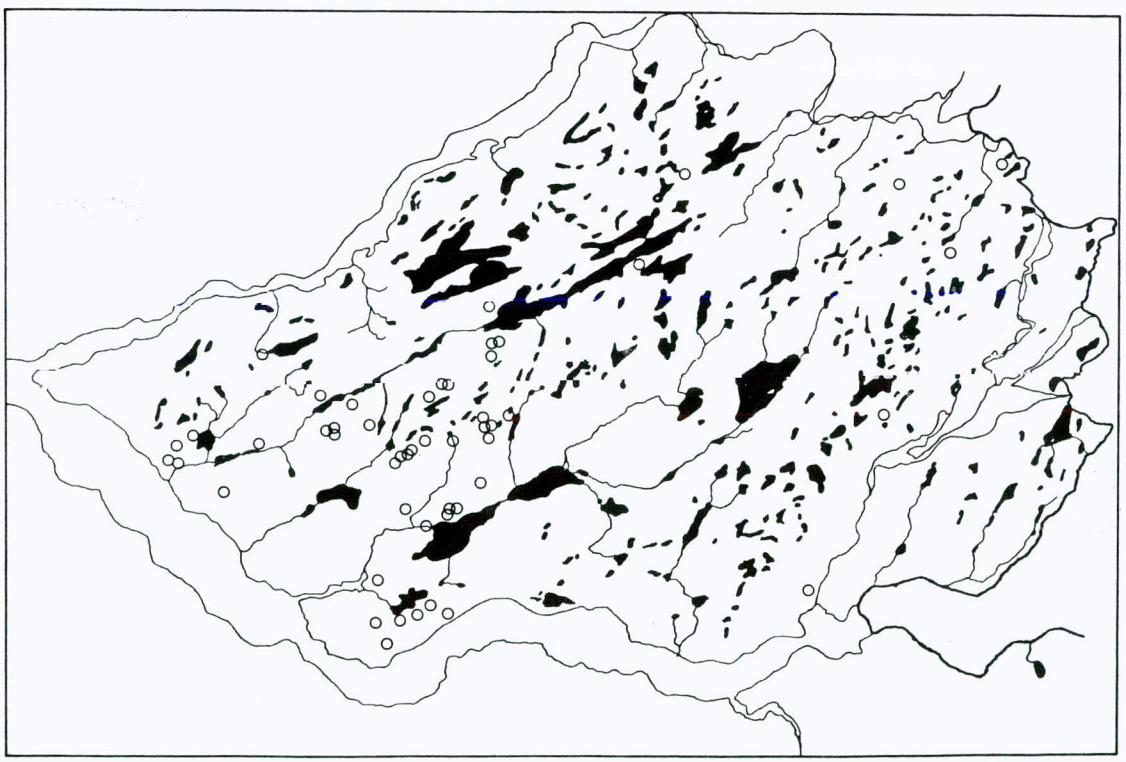


Figure F2.1. All sightings of Arctic Hare (*Lepus timidus*), Eqalungmiut Nunât, 1979.

Hares were most often seen feeding or sleeping in fell-field habitats (Bocher *et al.* 1968), equivalent to the open mat or moss-mat communities of Trapnell (1933), either on the higher ground such as hill ridges or in the lowland areas associated with rock and boulder outcrops. Individuals were also seen in *Salix glauca* scrub. Adults tended to be more conspicuous in fell-field habitats than the smokey grey leverets.

Four individual leverets were seen between 9 July and 2 August. They were all noticeably bolder than the adults, and usually permitted approach to within 10-20 m, whereas adults ran off at distances of more than 50 m. As they ran off they usually stopped at least once to sit upright and look back at the observer, in marked contrast to the European Hare which sprints away when disturbed, not pausing at any time in its zig-zag course.

Only one animal was heard to make any sort of vocalisation. This was an adult flushed from a 'form' in late May which made a strange hissing noise when it was startled.

Most animals began moult during the last two weeks of May when hares were seen in various bedraggled states. Two of the five seen together on 22 June were moulting and the last seen in such a state was apparently half-way through moult on 11 July. Thus there seemed to be a two month moult period, although no doubt individuals moult through in a shorter time. There was no significant colour change between summer and winter coats.

Droppings were found in areas not frequented by Arctic Hares in summer: this was particularly so with droppings found in valley bottoms. Whether this is indicative of a wider winter distribution or a different distribution is not known.

In May, hares were notably crepuscular. When continuous observations were being made of the geese at Kûk Marshes (9-12 May), one animal would appear regularly in the same area each night, between 20.45 and 20.50 hours, roughly corresponding to sunset at that time. Late in May animals at Aberchar emerged an hour or so earlier, although in late July and early August a pair appeared later at 'night'. They would emerge regularly near the summit of 612 m between 23.00 and 02.00 hours. In July and August we tended to disturb a lot of animals whilst they were sleeping during the day which rather obscures any diurnal behavioural changes.

F 3 ARCTIC FOX (*Alopex lagopus*)

D. A. Stroud

The Arctic Fox is a circumpolar species, found from the timberline to at least 85°N on the pack-ice of the Arctic Ocean (Nansen 1897). It is the only mammalian predator in west Greenland, and was commonly seen and heard during our stay in Eqalungmiut Nunât.

RACES

The systematics of the Arctic Fox have long been the subject of study, aided by the often extensive collection of the animal's pelt in most parts of its range. Braestrup (1941) differentiated between "coastal foxes" largely dependent on marine and littoral environments for their winter food, and "lemming foxes" found inland and throughout the range of lemming species (*Lemmus* and *Dicrostonyx* spp.). Vibe (1967) separated them more practically on the basis of colour as well as ecology into two biological races: the White Arctic Fox, *Alopex lagopus lagopus*, and the Blue Arctic Fox, *A. l. caerulescens*. Whereas Vibe suggests that the two phases of Arctic Fox are sympatric sub-species, earlier classifications regarded them as morphs of allopatric races, sub-species or species (see Larson 1960). Vibe (1967) suggests that each race has a favoured biotope and as these seem to be affected by climatic changes so the relative abundance and distribution of each race in any area will change with the climate. When they meet they hybridise to produce a Fox with a grey coat which is apparently ecologically inferior to either of the two morphs/races and soon disappears when the climate stabilises, favouring one or other of the parent races (Vibe *loc. cit.*). In west Greenland today there appears to be "an astonishing individual variation, making it difficult to separate races" (Braestrup 1941), a fact attributed by Vibe to the present unstable climatic conditions resulting in "lively bastardisation and the creation of mixed populations which prevail nearly everywhere in coastal regions today".

In Eqalungmiut Nunât the ubiquitous rock flour possibly affects fur colour, and moult further complicated field separation of the races/morphs. The Blue race remains a uniform brownish-grey throughout the year becoming slightly bluer in winter, whilst the White Fox turns dull brown on top in summer. Both races were seen, as well as a bewildering variety of intermediate forms. Pure White Foxes were seen between 7 May and 30 May and one moulted animal was seen in August. Those seen after 25 May had noticeably started to moult. Brown coloured Foxes, probably including both Blue and White moulted Foxes were seen from May until August. Blue race Foxes were seen in June and July. In addition several intermediate animals were seen: one (perhaps more) had a distinctive brown coat and pale ears and tail. This Fox was seen over a wide area in June and July. Two animals were described as 'pied' and another dark brown Fox had sparse pale marking on its limbs and face. These were all seen at the beginning of June and the odd colourations may be due to late or incomplete moult.

Without photographs of animals seen, or the use of standard colour charts when describing coat colours, it is not really possible to interpret our sightings in any meaningful way.

DISTRIBUTION

Arctic Foxes were seen over a large area from Angmat to Atanârssuk. Estimation of numbers present in this area is made difficult by not knowing the range of movements of individuals. Longstaff (1932) quotes a figure of one pair in 20 km^2 of similar habitat at Godthaab Fjord. It is thought that three pairs make up the bulk of our sightings; one near Angmat and Kûk Marshes, one near Eqalungmiut nuat and Rimwater, and one near Crusties and Cornerstone. One of the latter pair

had a distinctive pale tail and was seen at Aberchar, Ptarmigam Gorge, DZ and north of Foxtrot, an area of at least 30 km^2. In May animals ranged across the ice of Eqalungmiut tasê and seemed frequently to use the lake-ice as a means of fast travel. No animals were ever seen swimming and several times Foxes were apparently trapped on the ice, having got on at night and then found the edge strip thawed by the time they reached the other side. In these cases it seemed they would rather walk around the entire edge of the lake (often several km) looking for an ice-bridge, than swim the 1.5 m to the edge.

No dens were found, but a young very dark Fox was seen at Lakesmeet on 26 June. Old Fox traps were found on the fjord edge along the south shore of Niaqorssua. Large flat stones were placed to form a tunnel about 60 cm long, 30 cm wide and 23 cm high. Stones were heaped over this to form a small cairn. When in use, a trapdoor made of a flat stone would be erected at the open end and this would fall down and seal the trap when the Fox took the bait inside (Gad 1970, p.274). The traps were placed roughly every 100 m along the shore for about 2 km and were placed on the top of raised rock areas commonly frequented by resting Foxes. They are not currently used by the Greenlanders visiting the area.

DIURNAL ACTIVITY

The vast majority of calling Foxes were heard in May and June. From 24 hour watches it seemed that most barking occurred from 17.15 to 18.20 hours, and then again from 19.00 to 22.00 hours, 65% of all records being between 16.00 and 23.00. Barking at 'night' was rarely heard. In May and June animals seemed to bark and patrol their territories from 17.00 to 19.00 hours perhaps in two discrete phases, interrupted by a bout of feeding and grooming. Combined records of timed sightings and calling records are shown in Figure F3.1. Records of Fox sightings (Figure F3.2) in different phases of goose activity shows a more 'nocturnal' trend in July and August. In view of the possible link between the cycle of activity of Foxes and the behaviour of prey species (see especially Section D6), much more work, preferably involving radio-tracking, is needed to elucidate the diurnal cycle of the Arctic Fox in continuous daylight.

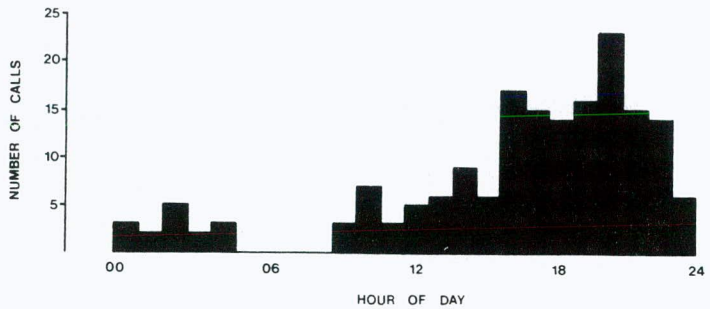


Figure F3.1. Hourly frequency of all timed Arctic Fox (*Alopex lagopus*) calls (n=176) May-August, 1979.

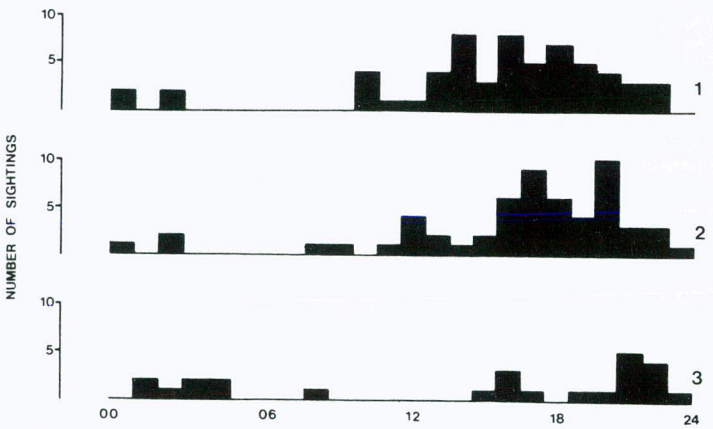


Figure F3.2. Hourly frequency of timed Arctic Fox (*Alopex lagopus*) sightings in three periods of goose activity: 1 pre-breeding (7 May-6 June), 2 breeding (7 June-30 June), 3 fledged (1 July-20 August).

RESPONSE TO MAN

We had been warned to expect trouble from Foxes raiding food dumps and camps. Their apparent fearlessness has been frequently commented on by travellers in Greenland (e.g. Freuchen & Salomonsen 1958; Ferns 1978) and many settlements have numbers of animals largely subsistent on

scavenging. However, despite the food dump at DZ being left unattended for long periods, we came across no evidence that it had been interfered with by Foxes. Other than the occasional hunting party which might visit a small area at most two or three months in the summer, the Foxes of the inland regions of west Greenland have no contact with man and seem to retain their natural wariness.

FOOD

The items of food known to have been taken by Arctic Fox in Eqalungmiut Nunât include Caribou carrion, Greenland White-fronted Geese (Section D3), Snow Bunting chicks, Lapland Bunting eggs, Mallard eggs and Ptarmigan. Ptarmigan would seem to constitute a large part of the winter diet since many piles of white primaries were found all over the area in May, none, however, with any remains of the carcass. Only a very few of these were attributable to raptors. Ptarmigan and Arctic Hare are the only available vertebrate prey for Foxes in winter in Eqalungmiut Nunât. On one occasion a Fox was seen approaching a Raven's nest containing at least two chicks, but it saw the observers and ran off before reaching the nesting ledge.

In May and June large areas of tundra were strewn with chunks of moss torn up from the frozen ground. Both Foxes and Ravens were seen clawing and pulling up moss in this fashion, presumably to obtain overwintering larvae and insects from below the surface.

Descriptions of attacks by Foxes on geese are to be found in Section D3.

MOBBING

Arctic Foxes were seen being mobbed by both Snow Buntings and Greenland White-fronted Geese. On 22 May, Snow Buntings were seen following a white Fox some distance behind it, and mobbing it. Late on 8 July, a pair was seen mobbing the same animal as it ran down Ptarmigan Gorge with a dead chick that had been ejected from the nest.

On 9 June, in the evening, eight geese took off and flew from Upper Marsh to the slopes of Needle Cairn Heights. A minute later they were seen standing very alert and lungeing with flapping wings in the direction of a pale Fox which they were facing. The Fox ran off up the hill and shortly afterwards the geese flew back to the marsh. On 16 June the Crusties Fox was observed being circled by two calling White-fronts as it ran below the Crusties peak.

ACKNOWLEDGEMENTS

Members of the expedition recorded sightings of Arctic Foxes and all predators in an extensive log; all provided much helpful criticism especially APF.

F 4 MIDDEN REMAINS AT MANX LAKE

D. A. Stroud

At the north-east tip of Manx Lake is a 3 m high bank. Most of this is glacially derived sediments, but the top 25 cm is highly humified and contains many bones, very probably associated with the Greenlanders' summer camp close by on the edge of the lake (Figure F4.1). The camp has probably come about due to the site being the furthest inland that a boat can be taken without having to portage, and thus it seems likely that this spot has historically been used as a camp site for this reason. During our stay in Eqalungmiut Nunât the Greenlandic hunting party established camps on the south side of the fjord near Qerqertaq and at the east end of east Eqalungmiut tasia. Although not apparently used as a 'permanent' camp, the Manx Lake site was used in transit between the two, as was evident from the large quantities of litter left there. There are no remains of permanent structures there except for three pits used for smoking Char, described and illustrated by Hertz (1977). Similar pits were seen in use at the active camp on the south side on the fjord (Section C20), but judging from the growth of vegetation in those at Manx Lake they did not seem to have been used for some considerable time.



Figure F4.1. Location of Greenlanders 'transit camp' (see text) and midden. Shaded area represents the extent of exposed banks of sediments, x marks the collection site.

The bank had eroded at the edge of the lake, and numerous bones were either projecting or had fallen out and were being re-covered by the lake silts. A representative selection of the latter (but not an accurate sample) was collected and the bones have since been identified (Table F4.1). There are several indications that the remains are from a midden rather than being a natural assemblage.

The innominate (pelvic) bones of the seals have been roughly chopped apart, and some seal vertebrae (not collected) were found to have been sawn in half. The Caribou metatarsus and other long bones (not collected) show evidence of butchery. In particular they are spirally fractured, a feature which Bonnichsen (1979) has shown is caused only by human breakage of bones with implements. Unfortunately, few Caribou long bones were brought back to Britain; however examination of further material from this site should show a high frequency of spiral fractures. The broken bones are stained equally on both the inside and outside surfaces, showing that they were broken before deposition - an indication of human activity (Bonnichsen 1979). Although not good evidence in itself, the rather curious species assemblage would suggest human agency.

DISCUSSION

The high proportion of ribs and vertebrae present in the sample (see Table F4.1) is entirely due to sampling bias. Unfortunately, the data here presented do not allow estimation of the relative importance of the different species to the occupants of the site. An objective sample would be required for this. However, the following observations may be of note.

TABLE F4.1 Faunal remains identified from Manx Lake midden site.

Species	*Number of bones*	*Type of bone*
AVES		
White-fronted Goose	4	humeri
	1	ulna
	1	femur
	1	tarso-metatarsus
	1	furcula
Cormorant	1	femur
MAMMALIA		
Arctic Hare	1	tibia
	1	humerus
Common or Harbour Seal	1	mandibular ramus, adult
	1	pelvic bone, adult
	3	scapulae; 1 adult, 1 subadult, 1 juvenile
	2	femora, adult
	1	humerus, adult
	1	ulna
Common Seal or Bearded Seal	1	bulla region of skull
Ringed Seal	1	pelvic bone, juvenile ?
Ringed Seal or Harp Seal	1	incomplete skull, juvenile
Harp Seal	1	bulla region of skull, adult
	1	sacrum, adult
Seal spp.	6	vertebrae, adult
	3	vertebrae, subadult
	8	vertebrae, juvenile
	20+	ribs
Caribou	4	atlas vertebrae, adult
	1	axis vertebra, subadult
	2	incomplete scapulae
	1	mandibular ramus, juvenile
	2	metacarpi, adult
	6	incomplete innominate bones; 3 adult, 3 subadult
	2	calcanea; 1 adult, 1 subadult
	1	proximal end of metatarsus, adult
	25+	ribs

Caribou vertebrae	Cervical	Thoracic	Lumbar
12 Adult	-	6	6
5 Subadult	3	1	1
32 Juvenile	5	16	11

The presence of White-fronted Goose bones is of great interest as this indicates that they have been hunted here in the past, although not at present. These bones are being radio-carbon dated. Geese seem to be generally unimportant as part of the diet of past Greenlandic peoples.

Common and Ringed Seals are both found in the fjords of west Greenland, and the latter were of great importance to the settlements of the Greenland Thule culture (Møhl 1979; Staab 1979). Ringed Seals are frequently found at the innermost end of Kangerdlugssuaq, and although we did not see them, there is no reason to suppose that they should not come a similar distance inland to the head of Nagssugtôq. Harp Seals and Bearded Seals are more surprising finds. Both species (especially Bearded Seal) are restricted offshore animals and are found only on the outer coast. The presence of their remains may therefore indicate the transportation of their carcasses up the fjord by the occupants of the site. The skin of the Bearded Seal is highly valued because of its strength and is cut into thongs and used for the soles of kamiks (Møhl 1979), thus it may have been easier to bring the whole body from the coast (with bones) rather than dried meat (off the bone).

F5

FORM AND GROWTH OF CARIBOU ATLAS VERTEBRAE

N. W. Hardy & D. A. Stroud

INTRODUCTION

Caribou skeletons were frequently encountered in Eqalungmiut Nunât in all states of disintegration . A collection of atlas vertebrae was made with four major aims:

1) As a simple count of the total number of skeletons found.

2) To investigate the age at death of the animals, although when this was planned it had not been appreciated how important hunting was in Eqalungmiut Nunât.

3) To look at the non-metrical variation of the foramena of the bone, and to compare this with other populations, attempting to use it as a measure of the genetic divergence (section F6).

4) It was thought possible to use atlas vertebrae morphological parameters to investigate growth and structure of the bone, as well as to provide information about the population of skeletons from which they were taken. Being easy to collect, they might prove useful in future comparisons of populations of Caribou and Reindeer from different geographical areas.

Characterisation of the Parameters and their Relationships

The major problem of using such a sample of bones to give information about the population of animals from which they have come is that they may represent a growth sequence. The present sample is very obviously a growth sequence, and need not be comparable with other smaller samples from populations where, for instance, mortality and recruitment are different. Recent reproductive success of the population may alter the distribution of a variable, and differences in overall mean size of different age/sex classes need not necessarily be indicative of population divergence. The use of ratios would not eliminate the problem, since, in addition to statistical objections to their use, allometry would be present in a growth sequence. Ratios would be biased by the age distribution of the samples.

One possibility would be to take measurements from bones only at a certain defined developmental stage, but a fully grown state cannot be readily identified from the data (see below) possibly due in part to sexual dimorphism. Alternatively the time of dorsal suture fusion might be chosen. Any such policy however, would discard many bones in each sample and would conflict with the aims of the exercise.

A growth sequence sample however, may be exploited; measurements of allometry for samples can be made and these used as data for contrasting populations. Allometry has been used in taxonomy, Fishithal (1979) provides a recent example in work on trematodes, and it is discussed by Gould (1966).

Allometry may be thought of as investigating changes in proportion with increasing size. Isometry is the relatively rare case where two growth parameters maintain a constant ratio. Positive or negative allometry is the more common case; 'shape' or proportion changes with size. The rate of change of shape with size might well differ between populations just as adult size and shape does. This approach has been investigated for the present data set.

METHODS

Collection

Although the search was by no mean exhaustive, 160 vertebrae were collected from the *c.*50 km^2 thoroughly covered. Approximately 80% of skeletons had skulls and atlases still attached, the remainder having been removed by either Greenlanders or Arctic Foxes. The conspicuousness of skeletons varied considerably according to the habitat in which the Caribou had died. Whole skeletons could be inconspicuous on grass slopes or amongst willow scrub, whereas a few bleached bones could be seen on moss-mat from some distance, and any attempt to count all dead animals in future would have to take this into account. Sixteen further vertebrae were collected from in and around Sisimiut, but because of their unknown provenance they are not included in this analysis.

Measurement

An atlas vertebra from a mature male is shown in Figure F5.1, and a young bone illustrated in Figure F5.2. Measurements were taken with calipers to the nearest 0.1 mm and are shown in Figures F5.1, F5.2 and Table F5.1. All bones were weighed soon after collection with Pesola spring balances. It proved difficult to age or sex many of the skeletons found: the obvious males could be distinguished from others, but it was not possible to separate most of the remainder into females and immature males. Various complementary skull measurements were taken whenever possible, but are not presented in the analysis. In the absence of any direct measurement of the time since death, bones were placed into four catagories:

VERY RECENT (n=2)	-	Animal thought to have died in the year of collection
RECENT (n=113)	-	Shreds of flesh, ligament or cartilage still attached to bone
OLD (n=48)	-	Either clean white or discoloured by algae, mosses or lichens
SUBFOSSIL (n=5)	-	Taken from the midden at Manx Lake (section F4) buried in a peaty substrate, on collection the bone was soft and brown

It is not possible to give accurate dates for these periods, but it is thought that most *recent* bones were less than 10 years old. There was no significant difference between the sizes of the bones in the different categories, so hereafter they have been treated together.

The state of the dorsal suture (fused or open) was recorded as a simple measure of age.

The transverse processes of the vertebrae are the first part of the bone to get damaged after death, thus only unchipped or very slightly chipped bones have been used in most analyses.

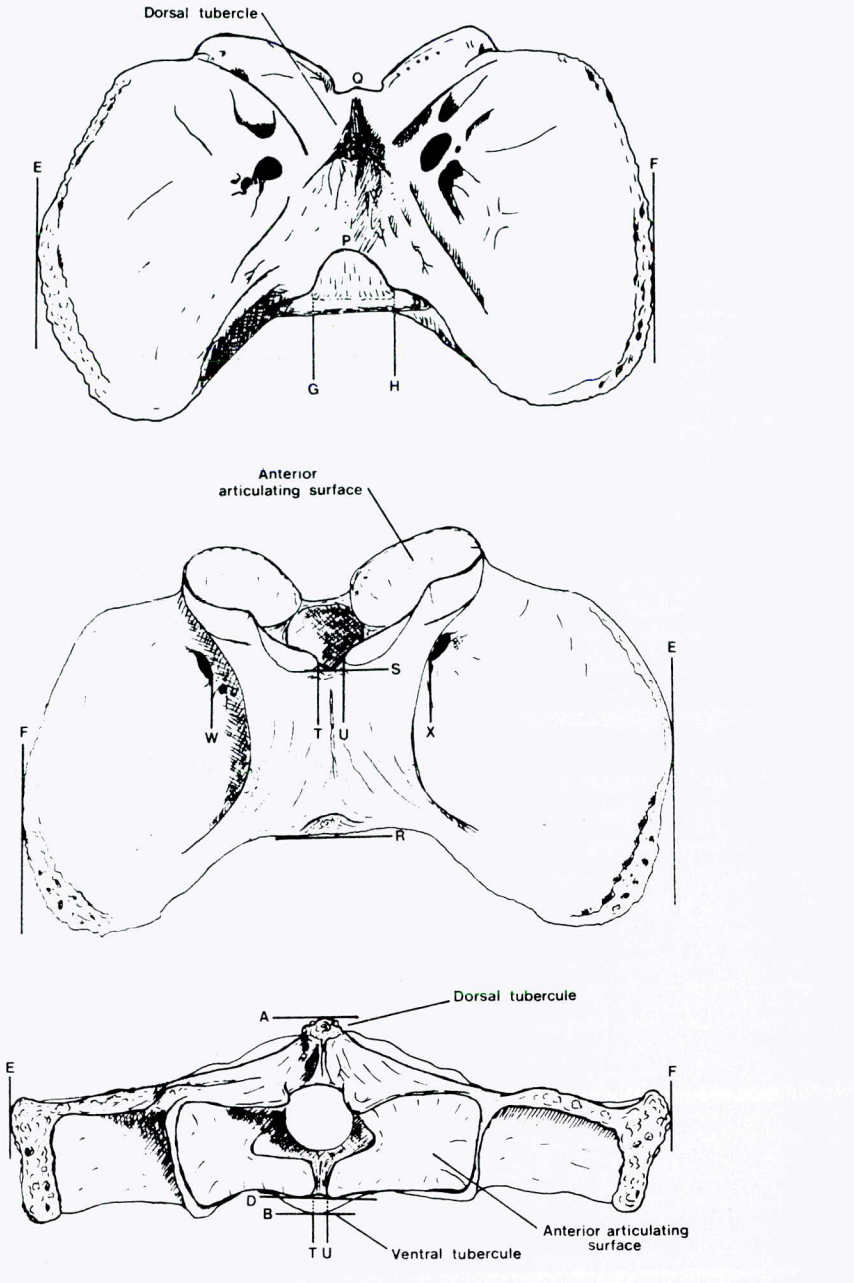


Figure F5.1. Mature male bone.



Figure F5.2. Juvenile Bone.

TABLE F5.1. Description of measures taken on Caribou atlas vertebrae.

FEATURE	ABBREVIATION USED
Absolute height (dorsal to ventral tubercle)	AB
Height of neural canal (anterior)	CD
Height of neural canal (posterior)	KJ
Absolute width across transverse processes	EF
Width of neural canal (posterior)	GH
Depth of ventral surface (ventral tubercle to ventral surface of neural canal)	JB
Depth of dorsal surface (dorsal tubercle to dorsal surface of neural canal)	KA
Length of dorsal midline	PQ
Length of ventral midline	RS
Width between anterior and ventral articulating surfaces	TU
Distance between ventral foramina	WX
Weight (g)	

Osteological deformities

Each skeleton found was briefly examined for deformities, and although trivial changes may have been overlooked, no major deformation of calf skeletons such as those described by Guiness *et al.* (1978) were found. Only one abnormal atlas vertebra was found in which the left-hand transverse process was shortened and bent vertically upwards by about 3 cm. This was a bone from a mature animal and the deformity unlikely to have been the cause of death.

Weight

Fresh weights of bones ranged from 12-203 g. A large number of small (12-20 g) bones were found, but only a few large bones (Figure F5.3). The suture along the dorsal surface of the bone, forming the flattened neural crest did not form until the bone weighed some 16 g. This, and the fact that there were no bones smaller than about 12 g suggests that these derive from still births or calves dying shortly after birth. Associated with the open neural spine was a gap between the parietal and frontal bones of the skull in every instance where the atlas was found with the skull.

Allometry

Gould (1966) in his review makes some criticisms of the use of "mass data" for the investigation of ontogenetic allometry. Small individuals, dying young, possibly due to stabilising selection, may not provide a typical sample at the small end of the range. The calculations given here for allometry in the sample do not fall into one of Gould's classes of allometry, being neither ontogenetic allometry (=heterauxesis) nor intraspecific allometry (individual allometry) since they are attempting to show changes of proportion with time (growth) as population parameters rather than for an individual. It must be said that the approach differs from ontogenetic allometry only in application.

Whilst the principles of the common approach to allometry are agreed upon (*viz.* the fitting of a straight line to logarithmically transformed variates to estimate the parameters of the relationship $y = \beta x^{\alpha}$), some debate continues as to the best method for fitting the line. The reduced major axis of the bivariate distribution is now commonly used. It has an intuitive and theoretical appeal as well as having the practical advantages of being independent of scale and not too difficult to calculate (see Kidwell and Chase 1967 for a comparison of fitting methods). One drawback is the lack of statistical tests associated with the line. Recent work (Clark 1980) has provided tests for the comparison of sample gradients. In the current analysis all possible least squares regressions with errors in one variable were performed (i.e. 11 x 11 = 121, less 11 self comparisons = 110) and the usual analysis of variance test of significance of each regression performed. Allometric constants were, however, calculated as the gradients of the reduced major axes. A full 11 x 11 matrix of these results thus has reciprocals in its upper and lower halves.

Other methods of investigating allometry in a multivariate data set have been suggested. Some were investigated and the results briefly mentioned.

Univariate data and the segregation of the sample

As already stated this data set is a growth curve sample and its make up and biases are unknown. It would however be foolish to discard what information we do have on its make up. Fusion of the dorsal suture divides the sample unequivocally into two classes, based broadly on age, though the possibility of variation in the timing of fusion exists. Sexual dimorphism is a likely cause of variation, especially amongst larger bones. There are two other small data classes - known males (n=5) and known females (n=2). In this sample the classes *dorsal suture unfused*, *known males* and *known females* are non-overlapping and this is likely to be the case in any sample collected from wild skeletons.

The data were therefore analysed using the four classes:

Dorsal suture not fused,

Known males,

Known females,

Remainder,

or as a single class.

Multivariate analysis

A multivariate analysis of these data was expected to help in identifying the relationships between the classes. A principal component analysis of the variance/covariance matrix of centred, logarithmically transformed data was performed. This particular method was chosen as it was to be used in further analyses. Other variants of PCA gave broadly similar ordinations of the objects however. The logarithmic transformation tends to remove the effects of scale from the matrix (as would be the case in a correlation matrix (Jolicoeur 1963)), and standardisation of data produced a very similar result.

In this analysis the data set was treated as a single statistical population but the four classes are distinguished on the ordination.

RESULTS

Univariate analysis

In univariate distributions the ranges of the two sex classes fall within that of the remainder, and this is found in general (Figure F5.3). Typically the known males lie in the upper tail of the distribution and the known females in the lower, as might be expected if sexual dimorphism is apparent in the bone.

Figure F5.3 shows there to be considerable overlap between the classes *suture not fused* and *remainder* for all variables. The incomplete vertebrae are typically at the small end of the spectrum but for no character does there appear to be a distinct size at which fusion occurs.

Single classification ANOVAs using the four classes as treatments gave significant F values ($P<0.001$) for 11 characters, whilst character GH (posterior width of neural canal) was significant only at the $P<0.05$ level. Ranking of the means of the four classes gave the expected order *males* > *remainder* > *females* > *suture not fused* for eight characters. The exceptions were the posterior width of the neural canal (GH), the depth of the dorsal surface (KA) and the distance between the ventral foramena (WX), where the *suture not fused* class was greater than that of *known females*, and the width between the edges of the anterior articulating surfaces (TU), where the order was reversed from that of the majority. This gap narrowed with growth and thus it is not anomalous but fits with the known growth pattern of the bone, and might thus be expected to stand out in further analyses. The other characters (GH, KA & WX) appear to reflect real features of the growth pattern despite the fact that there are only two *known females*. Characters GH and WX show rather little change during growth as can be seen from Figures F5.4 and F5.11 there is relatively great overlap of the classes. Character KA appears to show a thinning with age, possible as the suture fuses, followed by further thickening after this (Figure F5.5). It was noted that prior to fusion the lips of the suture were somewhat thickened compared to newly fused bones, thus it might be that ablation of the bone occurs on fusion. Alternatively the phenomenon may be an artifact due to difficulties in standardising the parameter KA between the unfused and fused classes. A multiple comparison or multiple range test was not seen as useful with such small sex classes. T-tests on the difference of means between the classes *suture not fused* and *remainder* were highly significant ($P<0.001$) for all characters except for WX which was significant at $P<0.01$ and KA which failed to reach significance.

Principal Components Analysis

A log (eigenvalue) v. eigenvector plot from the analysis (Farmer 1971) (Figure F5.6) indicates that the first three principal components have significant variation. The loadings on the first two axes were used to produce the character ordination in Figure F5.7 to help in interpreting the object ordination in Figure F5.8. Axis 1, as expected, reflects overall size from the small bones with unfused sutures up to the large known males. Axis 2 indicates a divergence from the fairly uniform small bones to a range of large ones. The data give some indication that this might at least be associated with sexual dimorphism. It is to be expected that dimorphism would be evident in the adult bones. Axis 3, if considered to be coming perpendicularly out of the page in Figure F5.8 raises the small unfused bones and the large known males up on the point of a V with the smallest fused bones at the base and the others spread out on the arms. This pattern is on a scale about one half that of axis 1. Thus it can be seen that axes 2 and 3 together particularly reflect these characters where *suture unfused* is not the class of smallest sized individuals. It therefore seems that our growth series might be summarised as an actual increase in size, accompanied by a divergence of shape in the adults, possibly associated with sexual diamorphism and a slight change of form around the time of suture fusion.

Allometry

Some reciprocal pairs of least squares regression coefficients showed a wide divergence but the reduced major axis (RMA) produced a single gradient for the comparisons.

ANOVA tests of the least squares regressions of all possible pairs showed them all to be individually very highly significant with the exception of 4, and all involved TU. This character, already noted as showing a trend of decreasing size, failed to give significant regressions with absolute width (EF) and depth of ventral surface (JB), whilst that with WX was significant only at $P = 0.052$, and that with the length of the dorsal midline (PQ) at $P = 0.013$. Thus, with the exception of TU, all parameters show significant regressions with all others. The reduced major axes are shown in Table F5.2. These now provide sample estimates of population parameters which are, we hope, little affected by sampling bias in age or sex. They may be used to compare this with any further samples of *Rangifer* atlases. Values of α for each pair of characters could be compared between populations, and possibly a few pairs showing particularly different allometries singled out.

A second possibility is that a synthesis of the values in Table F5.2 might provide a picture of the development of the bone within the population which might be contrasted with another population. Two methods are suggested here.

Firstly, calculating the sum of deviations from 1.0 (isometry) for each row of Table F5.2 would give a value to each parameter reflecting its overall positive or negative allometry. An ordination of the parameters would then be possible. The result of this approach may be seen in Table F5.3 and Figure F5.9a, and is somewhat brutal compared with Table F5.2.

The second approach involves searching for pairings of parameters within Table F5.2 on the basis of their isometry. Using Clark's (1980) method of testing a sample gradient against a given value, the null hypothesis $\alpha = 1.0$ can be tested separately for each fitted line. A matrix of probablities is thus formed and data from this is shown in a simplified form by asterisks in Table F5.2. Using these

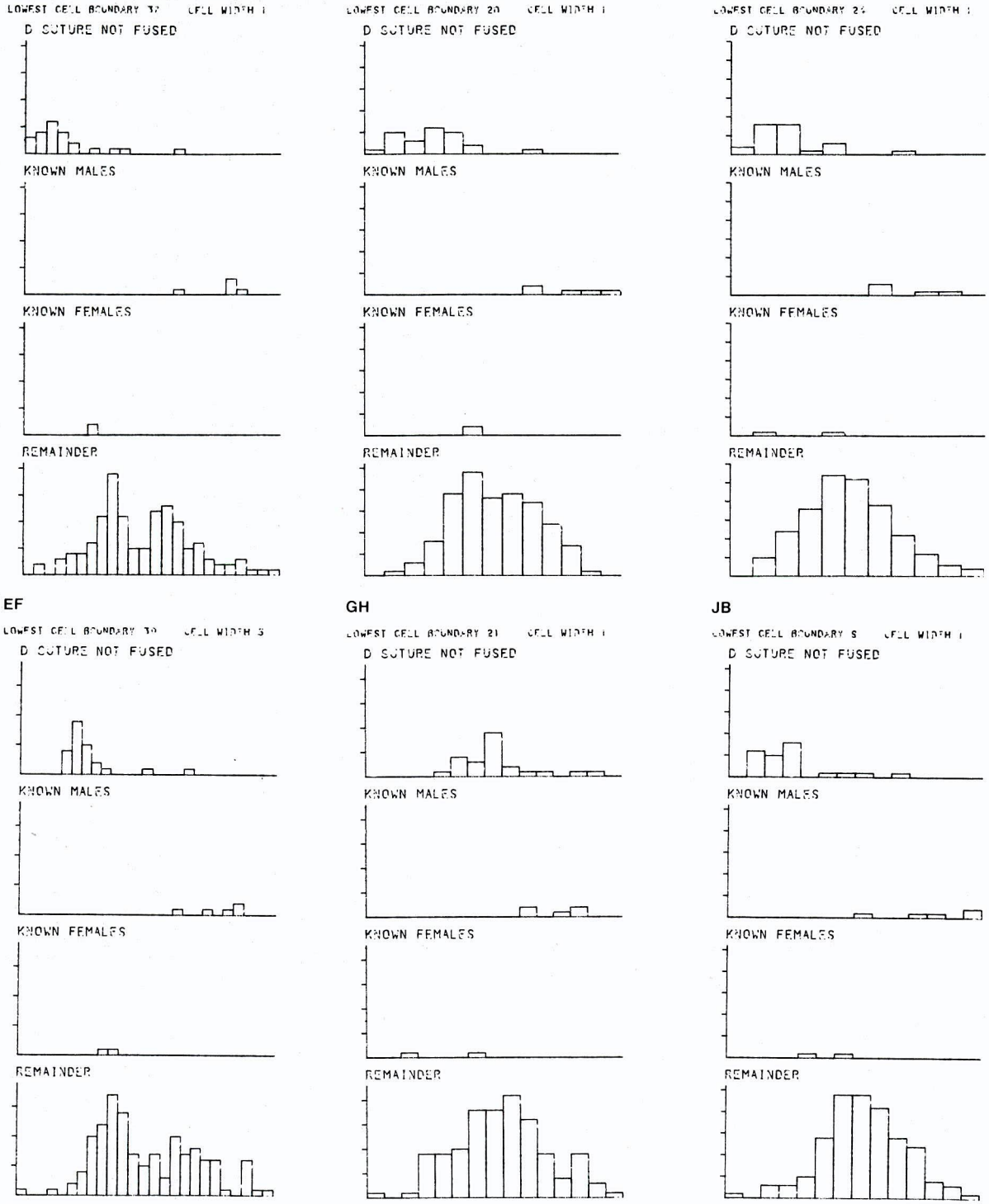


Figure F5.3 Absolute frequency distributions for all attributes



Figure F9.3. Absolute frequency distributions for all attributes.

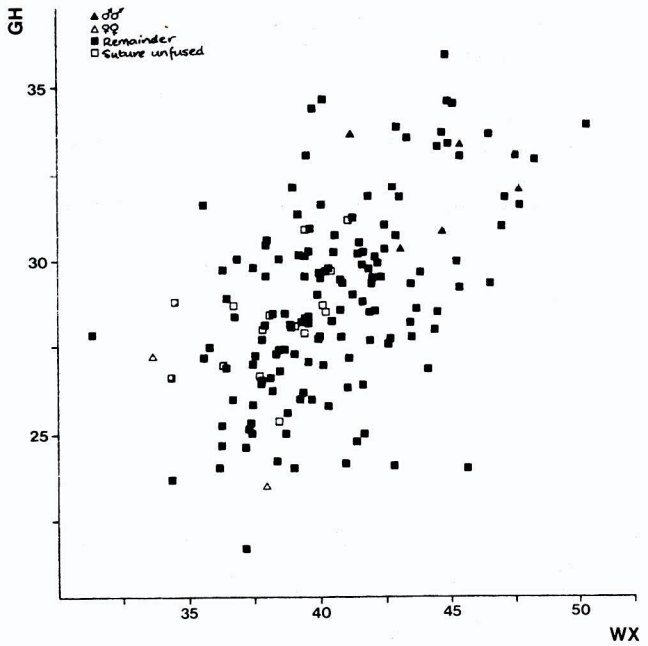


Figure F5.4. Bivariate scatter diagram of character GH against WX.

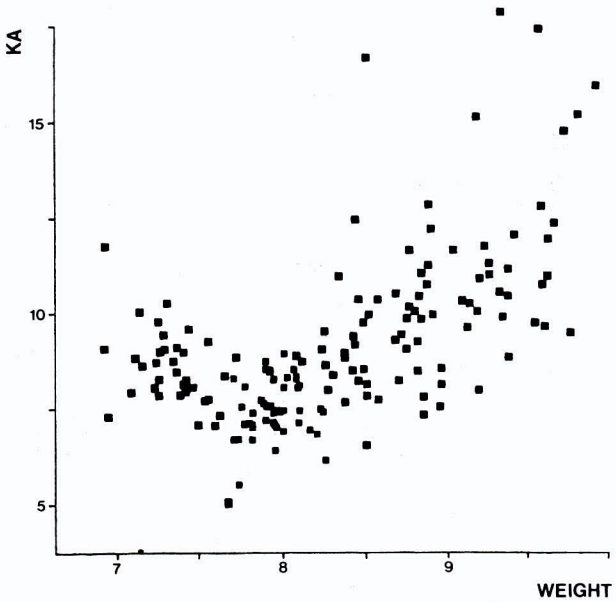


Figure F5.5. Bivariate scatter diagram of character KA against the logarithms of weight (as a suitable general size indicator).

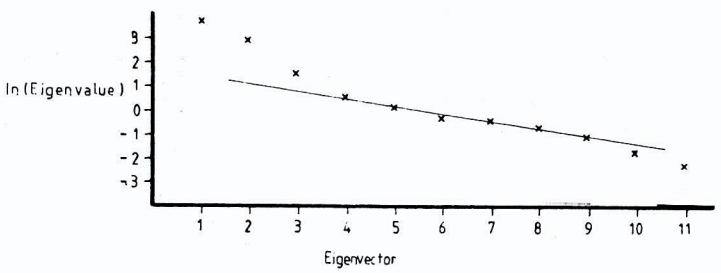


Figure F5.6 A plot of the logarithm of the eigenvalue against the eigenvector number for the principal component analysis (Farmer 1971). The line is fitted by eye.

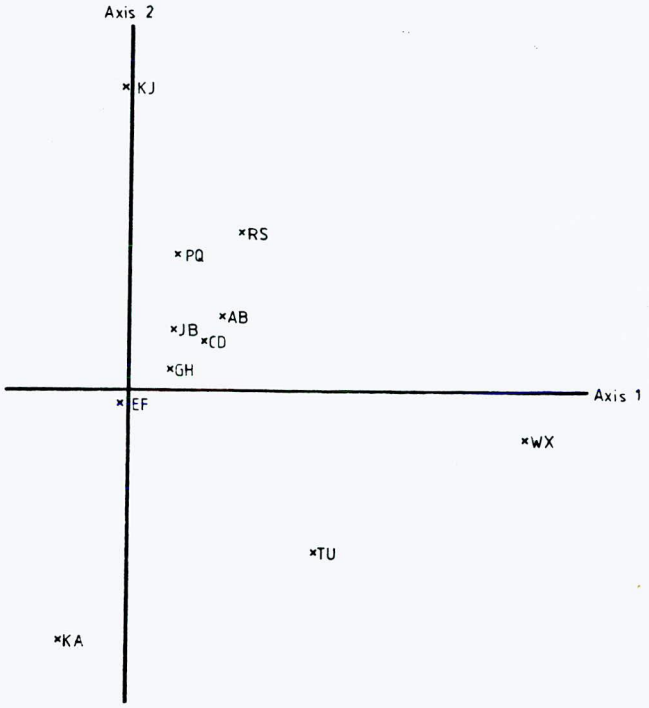


Figure F5.7. An attribute ordination based on the eigenvector loadings for the first two principal components (both axes on the same scale).

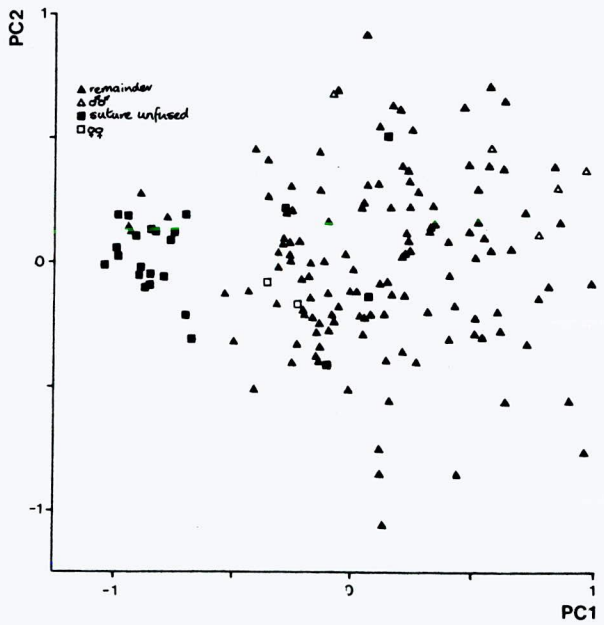


Figure F5.8. An object ordination on the first two principal component axes.

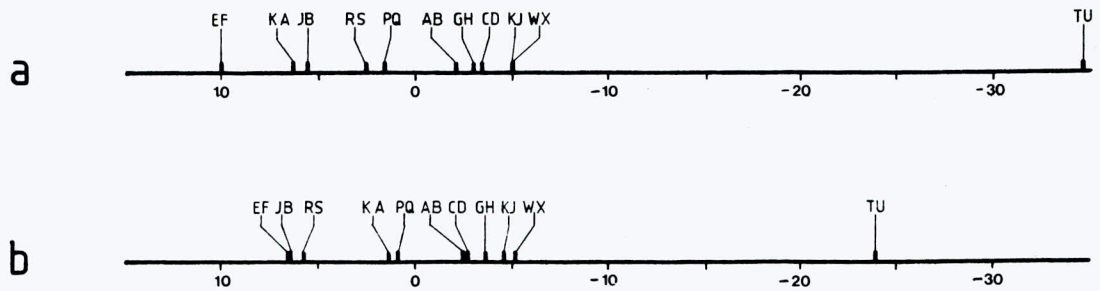


Figure F5.9. Ordinations of the attributes according to the sums of deviations from isometry,
(a) based on all bones
(b) based only on bones with unfused dorsal sutures.

TABLE F5.2. A table of the gradients of the reduced major axes.

X-AXIS VARIABLE

		AB	CD	EF	GH	JB	KA	PQ	RS	KJ	TU	WX
Absolute height	AB	-	1.184	0.427***	1.178	0.577**	0.518***	0.710	0.661*	1.500*	-0.280***	1.508*
Height of neural canal (anterior)	CD	0.845	-	0.360***	0.995	0.487***	0.437***	0.600**	0.558**	1.267	-0.236***	1.274
Absolute width, transverse processes	EF	2.344***	2.774***	-	2.762***	1.351	1.214	1.664**	1.550*	3.516***	-0.655*	3.535***
Width of neural canal (posterior)	GH	0.849	1.005	0.362***	-	0.489***	0.440***	0.603**	0.561**	1.273	0.237***	1.280
Depth of ventral surface	JB	1.734**	2.053***	0.740	2.043***	-	0.898	1.231	1.147	2.601***	0.485***	2.616***
Depth of dorsal surface	KA	1.931***	2.286***	0.824	2.275***	1.113	-	1.371	1.277	2.897***	-0.540***	2.913***
Length of dorsal midline	PQ	1.408	1.667**	0.601*	1.659**	0.812	0.729	-	0.931	2.112***	-0.394***	2.124***
Length of ventral midline	RS	1.512*	1.790**	0.645*	1.782**	0.872	0.783	1.074	-	2.269**	-0.423***	2.281***
Height of neural canal (posterior)	KJ	0.667*	0.789	0.284***	0.785	0.384***	0.345***	0.473***	0.441**	-	-0.186***	1.005
Width between articulating surfaces	TU	-3.577***	-4.234***	-1.526*	4.214***	-2.062***	-1.852***	-2.540***	-2.365***	-5.365***	-	-5.394***
Distance between ventral foramina	WX	0.663*	0.785	0.283***	0.781	0.382***	0.343***	0.471***	0.438***	0.994	-0.185***	-

Y-AXIS VARIABLE

Asterisks indicate the probability of incorrect rejection of the null hypothesis "gradient = 1.0" for each case

*** $P < 0.001$

** $P < 0.01$

* $P < 0.05$

Underlining indicates the probability of significance of the least squares regression of the same pair

═══ $P < 0.05$

——— $P < 0.001$

i.e. underlined comparisons indicate regressions which failed to reach significance

TABLE F5.3. Summed deviations from isometry ($\alpha = 1.0$) for each attribute. Data for all bones.

ATTRIBUTE		$(\Sigma slope_{ij}, i \neq j)-10$
Absolute height	AB	-2.017
Height, neural canal (anterior)	CD	-3.412
Absolute width	EF	10.055
Width, neural canal (posterior)	GH	-2.901
Depth, ventral surface	JB	5.549
Depth, dorsal surface	KA	6.346
Length, dorsal midline	PQ	1.650
Length, ventral midline	RS	2.587
Height, neural canal (posterior)	KJ	-5.012
Width between anterior ventral surface	TU	-34.700
Distance between ventral foramina	WX	-5.004

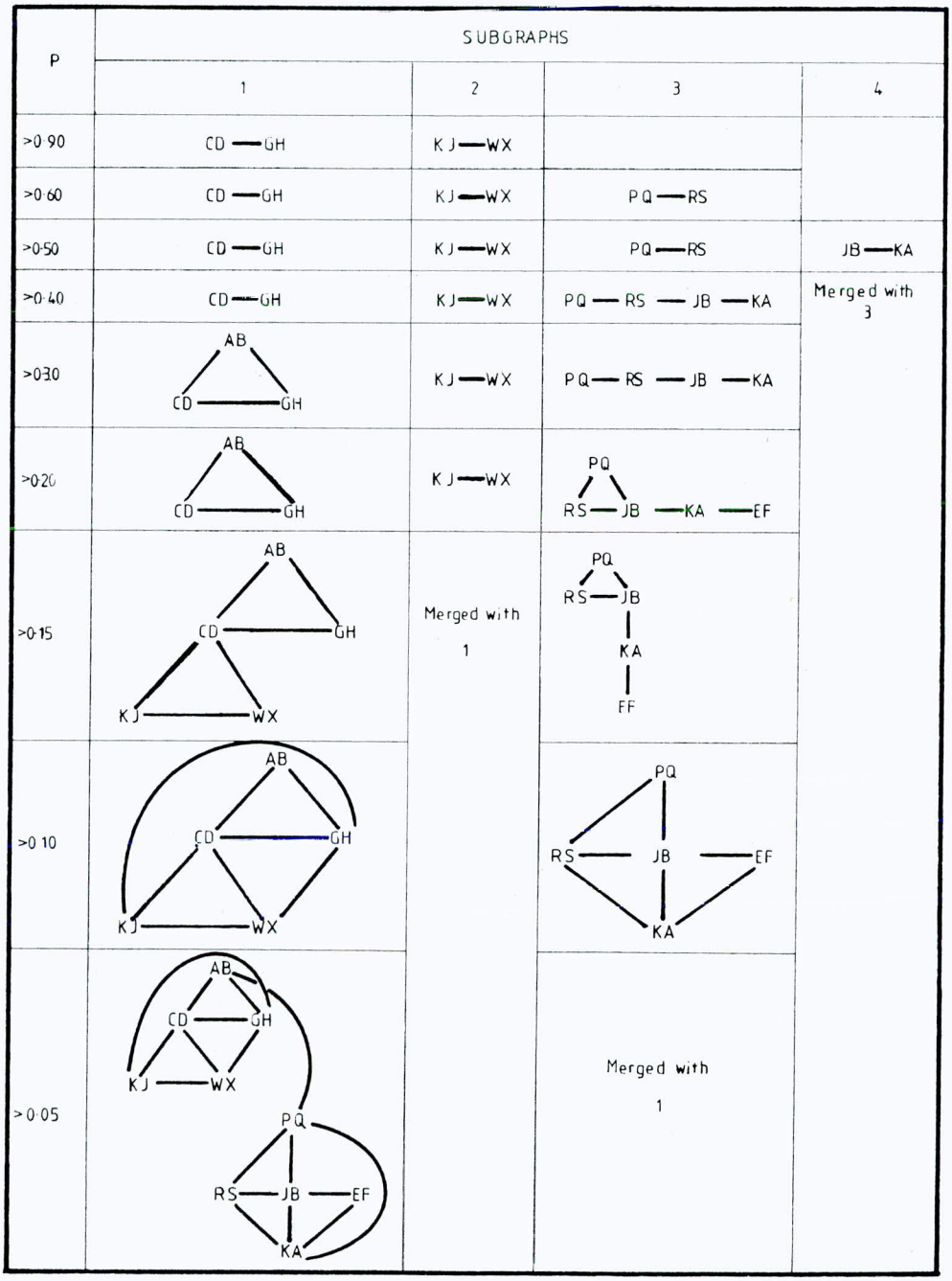


Figure F5.10. A graph theory clustering of the attributes based on the probability (P) of incorrect rejection of the null hypothesis of isometry. Data for all bones.

as a measure of association between the parameters, a graph theory approach can be used. Figure F5.10 shows this with parameters linking at a series of probabilities down to the level at which the null hypothesis of isometry might be rejected. All parameters, except TU (which was tested for negative isometry), have clustered by this level.

It may be noted that these two methods - of ordination and clustering - produce similar results and some broad conclusions may be drawn from the data of Table F5.2.

1) The status of TU which is 'negatively growing' is uncertain. It seems to alter little with age, though the gap does narrow. (It shows poor correlations with other parameters).

2) Characters WX and KJ, noted as having less alteration during growth show considerable negative allometry and thus become relatively smaller with age. (See Figure F5.11 for WX).

3) Characters AB, EF and GH cluster well and show some negative allometry. They thus become relatively a little smaller with age.

4) Characters PQ and RS show some positive allometry. They cluster with characters JB and KA which show somewhat greater positive allometry.

5) Total width, EF, shows a high positive allometry and clusters last. The high relative growth of this parameter is obvious from inspection of the bones (see Figure F5.11).

6) The parameters show two clusters at P>0.15, *viz* those with positive and those with negative allometry. We thus have a cluster of parameters associated with the nervous system and core of the vertebra which show relatively less growth than the more structural parameters which reflect the total growth of the bone to a greater extent. Total width, EF, contrasted with the height of the neural canal and the distance between the ventral foramina represent the extremes, with the length of the dorsal midline, PQ, and the length of the ventral midline, RS, falling between the two. Thus we have characterised a not unexpected developmental sequence: that neural and vascular characters, which change little in size or volume over the life of the individual, change little in relative size, whereas those characters associated with muscular and structural systems show a relatively greater change as the animal grows larger.

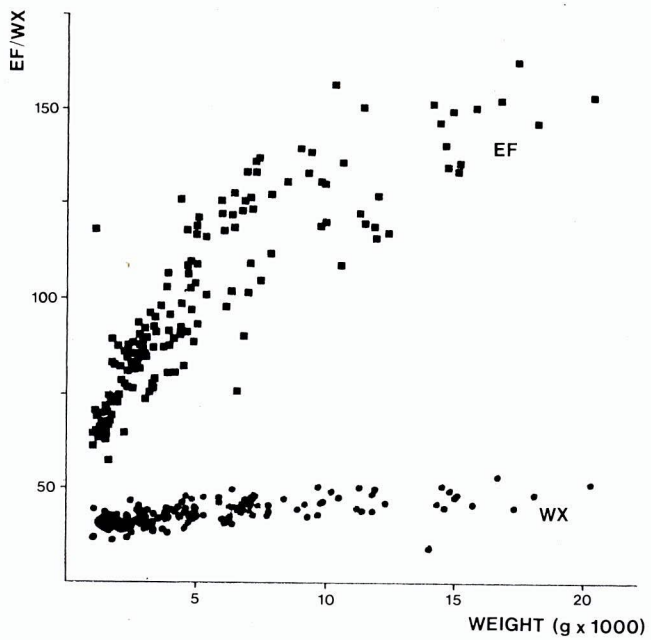


Figure F5.11. Scatter diagram of attributes EF and WX against weight (as a general size variable).

As a brief example of comparing matrices of a values we might consider the sample consisting solely of bones with un-fused sutures. Figures F5.9b and F5.12 show the clustering and the ordination. The two methods are in poorer agreement this time, as might be expected since the sample is small and has a small size range for all parameters. Many of the least squares regressions fail to show significance and many gradients cannot be distinguished from 1.0. However as a broad outline we again see AB, EF and GH forming a tight cluster, joined later by KJ and WX relating to the core of the bone and thus showing less growth. Characters EF, JB and RS are the cluster showing most relative growth, suggesting possibly that the ventral wall is still being laid down in the largest unfused bones collected. The dorsal parameters KA and PQ show negative allometry.

Thus in descriptive terms, we may contrast the two populations (or in this case population and subpopulation).

Various methods have been proposed for the investigation of allometry in multivariate data sets. The use of the scores of individuals on the first principal component as a variable against which to measure the allometry of all the observed variables was tried. This gave a single set of 11 allometric constants which ordered the variables in the same way as shown in Figure F5.12.. The use of this method in contrasting populations would seem inappropriate however, since the first principal component would be different for each.

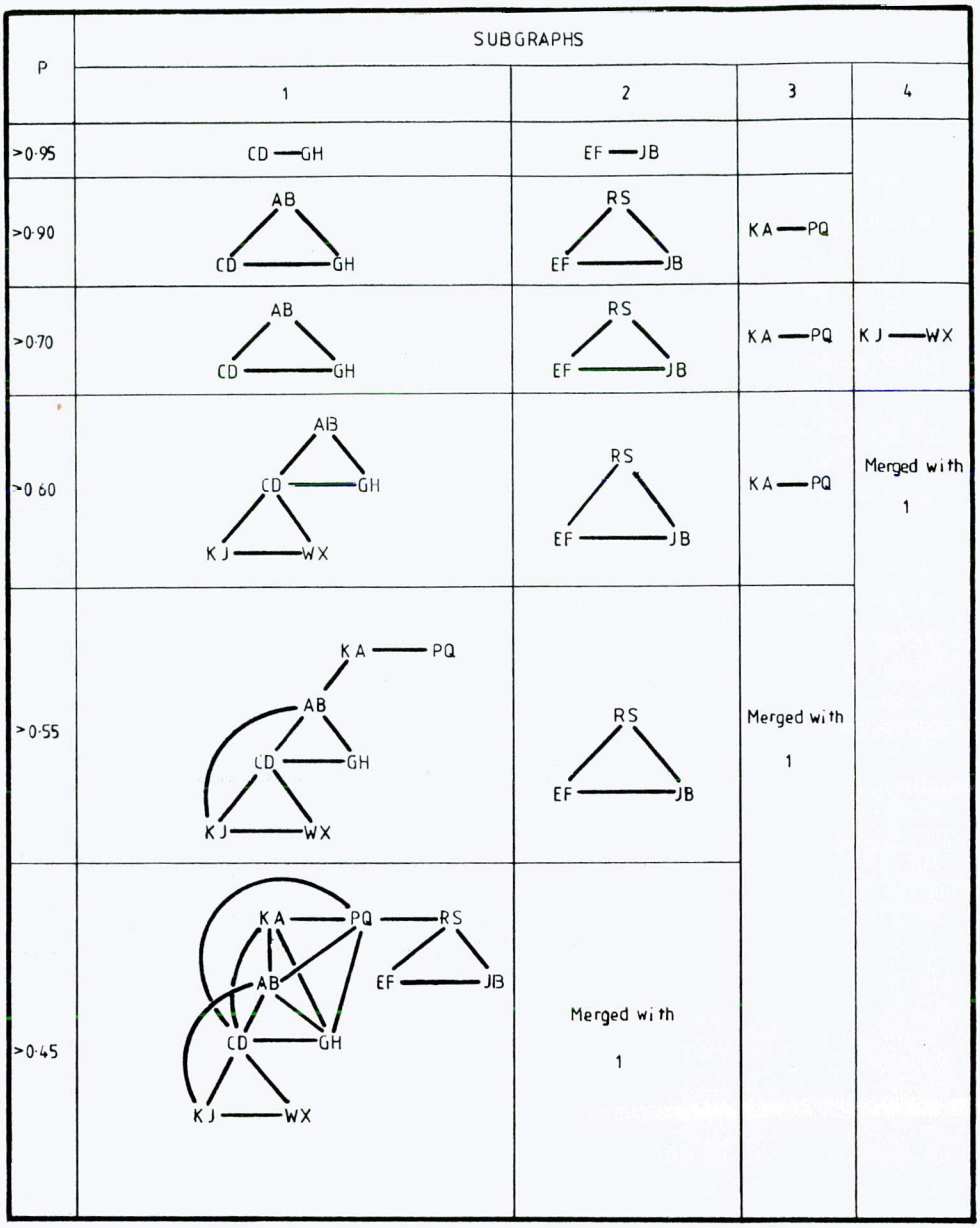


Figure F5.12. A graph theory clustering of the attributes based on the probability (P) of incorrect rejection of the null hypothesis of isometry. Data only for bones with unfused dorsal sutures.

Jolicoeur's (1963) method also involves principal component analysis. The pairwise comparison of all loadings for the first axis which he suggests produced a very different set of allometric results. However, the first axis was thought to represent a simple increase in size and these relationships might reflect patterns less affected by sexual dimorphism and any sudden change in the pattern of growth around the time of birth. If the constitution of the sample were better known such hypotheses could be investigated, but this falls outside the current study.

CONCLUSIONS

A well defined pattern of development can be illustrated from these data, and it seems likely that samples could be contrasted usefully, either on the basis of certain allometric constants or by the overall pattern of development. No truly multivariate approach yet tried seems suitable.

ACKNOWLEDGEMENTS

We would like to thank all those who collected bones in Greenland, particularly Phil Davies for diligence beyond the call of duty.

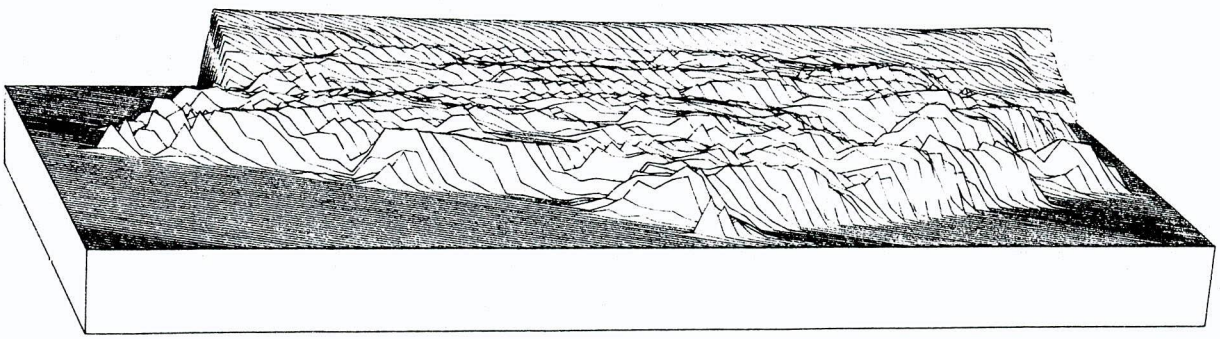
F 6 NON-METRICAL VARIATION OF THE CARIBOU ATLAS VERTEBRAE

D. A. Stroud

During the collection of Caribou atlas vertebrae, it was noted that there was a high degree of variation in the structure and number of foramen on the dorsal (and to a lesser extent ventral) surface. Although it has not been possible to show conclusively that this is non-metrical in origin, it seems quite probable that this is so. Non-metrical variants of the skeleton (or epigenetic polymorphism) are caused by the interaction of a number of gene loci during the development of an individual. "Non-metrical variants provide a useful way of comparing gene frequencies in different populations (since each variant is determined by a number of loci, and the occurrence of any one variant tends to be poorly correlated with the occurrence of any other)" (Berry 1977). Thus by comparing the frequency of a number of variants of several populations, it is possible to obtain a rough estimate of the 'genetic distance' or degree of divergence of those populations. This has been done with considerable success in investigations of island populations of mice around Britain (Berry 1968, Berry, Evans & Sennitt, 1967) and in investigations of past human populations (Berry 1974). Although most work of this nature has tended to concentrate on the non-metrical variation of the cranium (e.g. the above references), the infracranial skeleton has also been used with some success (Finnegan 1978, Saunders 1978).

The Caribou atlas vertebra is a convenient bone for this type of investigation since it can be collected in large quantities from the tundra in most arctic habitats where present day Caribou are found. Additionally, it can be found in many middens since *Rangifer* has been traditionally an important part of the diet of circumpolar peoples. Thus it is possible not only to compare the frequency of non-metrical variants between present day populations but also with past or extinct races (e.g. *Rangifer tarandus eogroenlandicus* of north-east Greenland). The material from Eqalungmiut Nunat has been scored for several variants, bones have been collected from South Georgia and at present material from other populations is being sought prior to detailed analysis.





SECTION G OBSERVATIONS OF FRESHWATER FISH

G 1 THREE-SPINED STICKLEBACK (*Gasterosteus aculeatus*)

A. D. Fox & D. A. Stroud

INTRODUCTION

The Three-spined Stickleback occurs in west Greenland as far as Upernavik (73°N) and in east Greenland it is sometimes found as far north as Mestersvig, 72°19'N (Cotton 1971). Some of these populations are of the *semiarmatus* and *trachurus* forms (see Wootton 1976), while many are permanent residents of freshwater with high proportions of the *leiurus* morph. The population of west Eqalungmiut tasia consisted of the *leiurus* form with 3-7 lateral plates along each flank.

Sticklebacks were an important component of the freshwater fauna of Eqalungmiut tasê, forming part of the diet of the Arctic Char and Red-throated Diver and the major part of the diet of the Red-breasted Merganser. The Three-spined Stickleback probably also contributed to the diet of the Great Northern Diver and Long-tailed Duck, but for further details on avian predation see especially Bengston (1972), Gross (1978) and Reimchen (1980).

In Eqalungmiut Nunât, sticklebacks were first seen on 21 May around the edge of Eqalungmiut tasia, and subsequently large numbers were always to be found there. Activity of the fish around the edge of the thawing lakes was largely dependent on weather conditions; the shallower water around the periphery was forsaken for deeper water on windy or cloudy days, a response similar to that of feeding *Lepidurus arcticus* in north-east Greenland (Crook & Greenwood 1978). On still, warm, sunny days, sticklebacks were very active and numbers approaching several hundred per metre of lake bank could be commonly encountered. No fish were captured that showed any sign of breeding colouration on the body, although a very few individuals showing irridescent blue colours on the iris were present in the two samples taken in June.

METHODS

A simple mark-recapture procedure was attempted to assess the local densities of fish in shallow waters. Fish were caught from a 25 m length of the shore of west Eqalungmiut tasia and marked as shown in Table G1.1. Measurements of total length were taken with a steel rule from the tip of the tail to the end of the head, and fish were weighed to the nearest 0.05 g using a 5 g Pesola spring balance.

TABLE G1.1. Marking of Sticklebacks

10 June	103 captured, weighed and measured, left pectoral spine clipped
18 June	151 captured (no retraps), right pectoral spine clipped
12 August	30 captured (no retraps), length measured
15 August	325 captured (no retraps), length measured
16 August	50 captured (no retraps), length measured, then preserved in 4% formalin

RESULTS

(i) *Capture/Recapture*

The simple capture/recapture method of estimation of population size relies on the basic premise that there is no immigration or emigration in the population and no mortality between the sampling dates. At least two marked fish were recovered dead from the lake edge, and it seems likely that the weather dependent movements of the fish involved a substantial flux of individuals into and out of the surrounding shallows. Thus the method is invalidated on both assumptions and the sample size marked clearly needs to be several orders of magnitude greater to accommodate these factors.

(ii) *Size Class Distribution*

The length frequency data from sampling in June and August are shown in Figure G1.1. When plotted as a cumulative frequency (after Cassie 1954), the length class data suggests that there are three age classes present in the June catch (Figure G1.2a). One age class is of fish that are less than 30 mm long, the next contains fish between 30 and 60 mm long and the third, consisting of a very few individuals in excess of 66 mm. Later, the August sample (Figure G1.2b) shows the smaller fish to be absent. The smallest fish in the June catch were fry hatched in 1979, which by August had grown larger than 30 mm. This interpretation is suggested by the bimodal frequency distribution between 34 and 66 mm, which consists of both fish that have overwintered and the fast-growing young of the year. In both samples, there are a few fish larger than the main overwintering size class and these may represent a third age class of fish in their second breeding summer.

(iii) *Length-Weight Relationship*

The relationship between length and weight of the fish caught in June was found to be:

$$\ln(\text{weight}) = 2.64 \ln(\text{length}) - 10.46 \qquad F = 1105 \ (P < 0.001)$$

(iv) *Plate Number*

There appears to be a relationship between the number of lateral plates and age (as interpreted from length data) as shown in Figure G1.3, with older fish having more lateral plates. Such a situation is unusual in *Gasterosteus aculeatus* and whether this results from the effects of selection or ontogeny clearly requires further investigation.

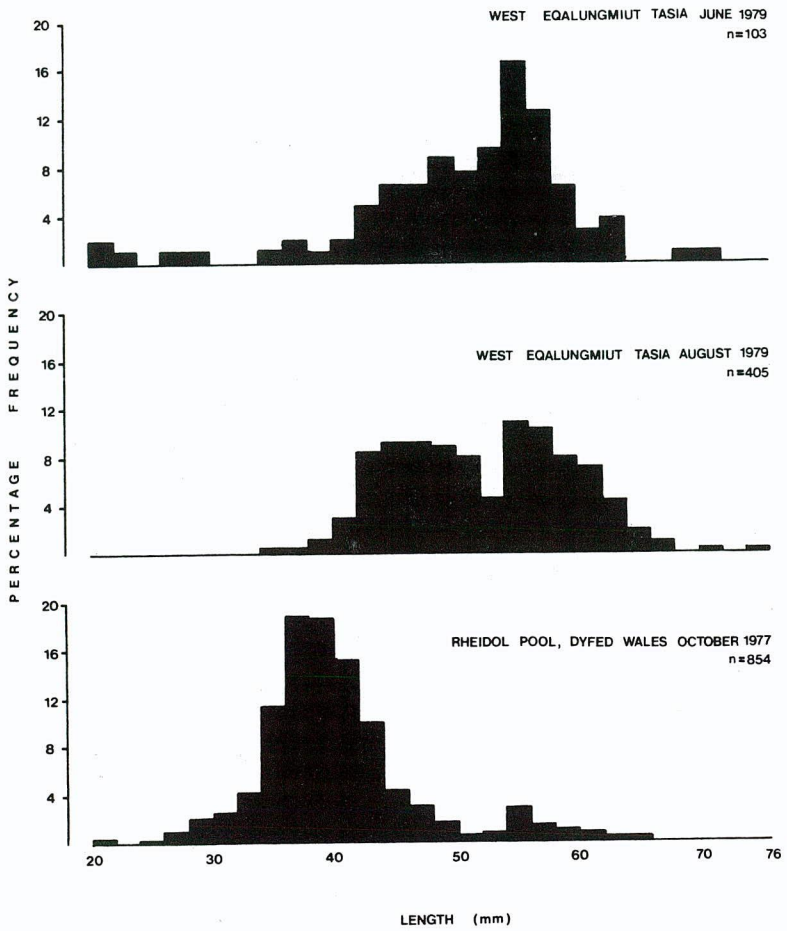


Figure G1.1. Size frequency data from catches of Three-spined Sticklebacks (*Gasterosteus aculeatus*) from west Eqalungmiut tasia during June and August, 1979. Data from a catch of 854 fish caught in Dyfed, Wales (October 1977) is also presented. Whilst caught at a later date, the later data demonstrate the size difference between the two populations.

DISCUSSION

The length frequency data suggest that Greenland Sticklebacks have a remarkable rate of growth during the season of hatching. Sequential sampling of the Eqalungmiut tasê populations in the same pattern as undertaken by Greenbank and Nelson (1959) for Alaskan populations would lend further evidence of fast development during the first year of arctic sticklebacks. This development is sufficiently fast to enable fry to attain a similar size to over-wintering individuals by August. In work carried out in Alaskan populations, successive samples throughout the summer showed that the young of the year grew rapidly, with a slower growth of one and two year old fish. It is likely that a similar situation prevails in the west Greenland population where fish are able to exploit the dramatic increase in arthropod production which occurs between late June and August in freshwater ecosystems. Samples from stomach contents from Alaska listed in Greenbank and Nelson (1959) showed that Chironomid larvae and pupae formed the major part of the diet in a similar arctic habitat, although various copepods (also numerous in west Eqalungmiut tasia) were also heavily predated.

With high production over a short summer, it would seem that selection would be most severe during the winter when freezing of the lakes forces fish to greater depth as growth rates drop drastically. Larger fish might be expected to survive the winter better than the smaller ones and to this end, it may be significant that the Greenlandic fish were generally larger than fish from Mid-Wales (Wootton 1976). The larger body size of many arctic animals (poikilotherms as well as homotherms) is, of course, well known and Dunbar (1968) attributes the cause, at the ultimate level, to be due to the advantage of greater fecundity and possibly the greater efficiency of the use of food resources. Since large body size and low metabolism are often related, this would give large overwintering fish an advantage in those periods when food was at a premium.

In view of the *leiurus* nature of all fish examined and the difficulty of regular migration up and down the Afon Char, the Eqalungmiut tasê stickleback population is apparently land-locked. Unfortunately, the population in Manx Lake, in slightly brackish water, was not sampled but it would form the basis of an interesting future comparision.

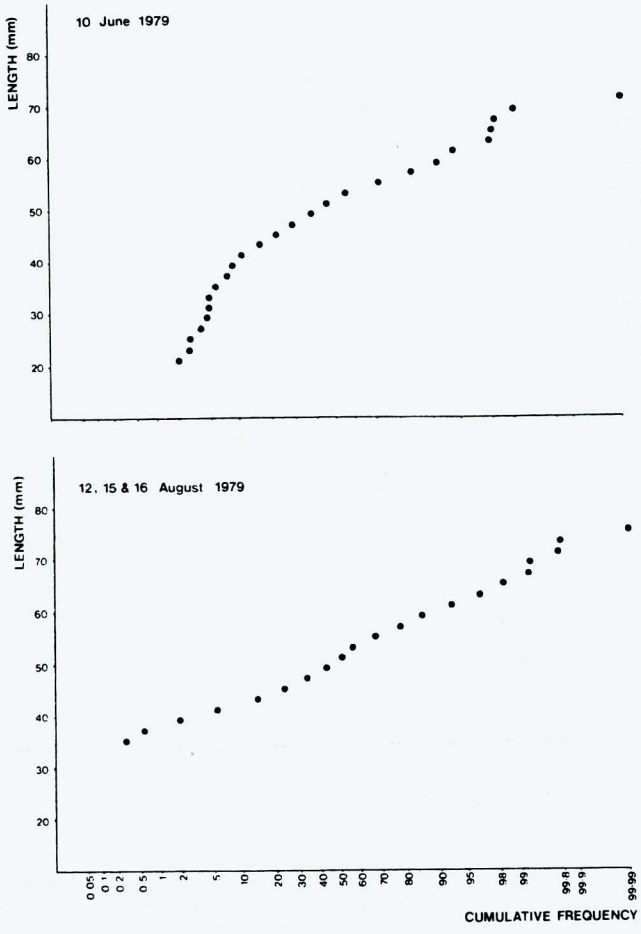


Figure G1.2a. Logarithmic plot of cumulative frequency of 1 mm size classes showing the presence of three age classes in the June catch.

Figure G1.2b. Logarithmic plot of cumulative frequency of 1 mm size classes of the August catch. Note that smaller fish are absent, having attained the size of fish born in the previous year.

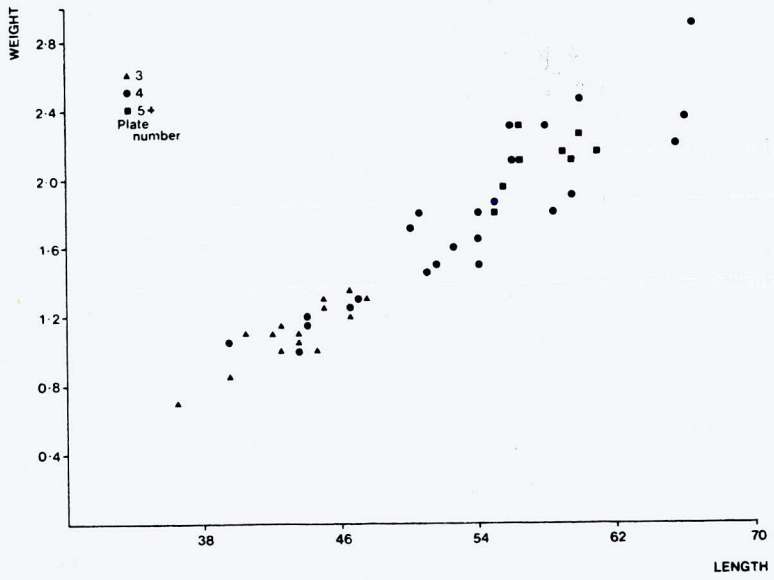


Figure G1.3. Relationship between weight and length of 46 Three-spined Sticklebacks (*Gasterosteus aculeatus*) caught on 16 August, 1979, scored against the number of lateral plates present on each individual.

G 2 DISPERSAL OF STICKLEBACK TO NORTHEAST GREENLAND

D. A. Stroud

Cotton (1971) reported the presence of a Three-spined Stickleback in Lepidurus Loch near Mestersvig, Scoresby Land. There was just one fish collected and the identification was later confirmed by the British Museum (Natural History). As far as can be ascertained, this is the most northerly record of *Gasterosteus aculeatus* in eastern Greenland (72°19'N), their previously recorded range ending near Angmagssalik (c 64°N) (Münzing 1963), thus this is a considerable range extension.

Lepidurus Loch was extensively studied during the summer of 1974 and no fish were found in it (Greenwood *et al.* 1978). The Loch is at most only 0.5 m deep and would almost certainly freeze solid in the winter. It is most unlikely that the fish undertook an anadromic migration from the sea since there is little outflow, and inspection of the area in 1980 showed there to be no direct channel between the lake and the sea. Therefore the remaining and more likely possibility is that the fish was introduced to the loch on the legs or feet of birds (most likely geese), either as an egg or a fry. Both Barnacle and Pink-footed Geese breed near the Nyhavn Hills in which Lepidurus Loch is situated (Ferns and Green 1978) and feed at the pool in early summer. In view of its depth it probably thaws early and thus is one of the first visited by the geese. Barnacle and Pink-footed Geese have previously been implicated in the introduction of certain elements of the east Greenland fauna (Halliday *et al.* 1974) and White-fronts in similar fashion for the west Greenland flora (Iverson 1953). Thus it is quite possible that geese are also important in the introduction of freshwater fauna and flora. It would be interesting to look for specifically British or Icelandic elements in the plankton of pools visited by geese in north-east Greenland.

ACKNOWLEDGEMENTS

Dr J.J.D. Greenwood drew our attention to this record and Drs M.J. Cotton and K.E. Bannister kindly answered correspondence on this topic. W.J. Higgs inspected the site to determine whether migration from the sea was a feasible alternative to the above hypothesis.

We are grateful to Dr R.J. Wootton for reading and criticising both Sections G1 and G2.

G 3 ARCTIC CHAR (*Salvelinus alpinus*)

D. A. Stroud

Arctic Char were seen at Lakesmeet and Aberchar and were caught by the Greenlanders near the mouth of Manx Lake. At Lakesmeet during late May groups of up to 30 were frequently seen, and spent most of the day drifting in the shallows where east Eqalungmiut tasia flowed into the Lakesmeet stream. They seemed to be smaller and less brightly coloured than those seen later on and were no doubt from the lake population that overwinters in freshwater (Freuchen & Salomonsem 1958). At Aberchar, fish congregated close to the ice-edge, where the lake flowed into the river. They could be seen here throughout our stay, although in July and August very big fish were seen to be passing up-stream. About this time numbers were being caught with nets placed across the fjord and Manx Lake and the Greenlanders Johanis, Kaba and David kindly gave us some, allowing us to examine and eat them !

The brilliant colours, especially on the males, and size indicated that they were indeed moving from the sea to the lakes to spawn. Many of them had severe infestations of the parasitic copepod *Salmincola edwardsii* Olsson. These were often attached to large areas of the gills and inside the mouth, One 40 cm long male had over twenty in the mouth alone. Many also had infections of worms in the gut and peritoneum although none was collected for identification. One Char contained several Three-spined Stickleback (*Gasterosteus aculeatus*) in its stomach, although usually the stomach was either empty or contained vast numbers of mosquito larvae.

Char were also seen rising to the surface of Large Lake in early July. This lake belongs to the Eqalungmiut tasê drainage system and possibly is an important spawning area for them.

SECTION H INVERTEBRATE REPORT

H 1 SEASONAL ACTIVITY AND ABUNDANCE OF SOME LAND INVERTEBRATES

J. Madsen

INTRODUCTION

A sampling programme of pitfall trapping, supplemented with sweep-netting was carried out in Eqalungmiut Nunât to survey the activity patterns and relative abundance of arthropods. The object was to study the seasonal abundance of potential prey species of nesting Lapland Buntings and the results of this are discussed elsewhere (Madsen in prep.).

The use of pitfall trapping to estimate availability of potential prey to arctic birds has been discussed by many workers (e.g. Greenwood 1978), although the method is known to have shortcomings (Southwood 1968). However, as Lapland Buntings prey mainly on ground-dwelling arthropods, pitfall trapping was considered the most reliable technique available. Sweep-netting was carried out to give a better overall indication of prey abundance.

Specimens were brought back to Denmark for identification; the beetles and some spiders (Section H2) have been identified to species level, while much of the material has merely been classified to order.

METHODS

Pitfalls

Pitfall trapping was performed at two sites (Base Camp and Aberchar), with traps arranged along transects through most of the representative local vegetation types.

Traps consisted of white plastic jars (12 cm diameter, 13 cm deep) filled to a depth of 2-3 cm with 1-2% formaldehyde solution. Traps were emptied and the contents preserved in 4% formaldehyde.

Base Camp (*c.* 300 m a.s.l.)

Ten traps were set at 30 m intervals and emptied every 3-4 days from 8 May to 17 August. The habitat was gently sloping dwarf heath and steppe with a southerly aspect; two traps were set on the periphery of marshy ground consisting of mosses, *Salix arctophila* and grasses, two were set on dry ground above the marsh amongst *Aulacomnium turgidum* and *Calamagrostis purpurescens*, three on dry moraine hummocks amongst *Betula nana/Salix glauca* scrub, one trap by a stream in *Salix glauca* scrub and two on a sunny ridge under grasses.

Aberchar (*c.* 100 m a.s.l.)

Five traps were set at 30 m intervals and emptied every 7-8 days from 6 June to 13 August. The transect was set on gently sloping dwarf heath with a south-easterly aspect; two traps were set close to a stream in damp ground amongst grasses and mosses, two set on sunny, dry moraine deposits below *Salix glauca* scrub and one on a sandy patch amongst rocks and grasses.

Sweep-netting

Sweeping with a fine-meshed net was carried out on a fixed route along the pitfall transects. A standard 250 strokes, one stroke per step were made along the transects, but were performed only on calm, sunny days.

Butterfly transects

ADF carried out counts of the two butterfly species along transects in the uplands and the results are shown in Figure H1.1.

Statistical Analysis

Results were analysed for seasonal trends in abundance comparing numbers caught during three thirty-four day periods using chi-squared tests. Correlation between the two sites was analysed using Kendall's rank correlation coefficient (Siegel 1956), with the interval between trap collection averaged to coincide with the Aberchar sampling periods.

RESULTS

The total numbers of all arthropods captured in the traps is shown in Table H1.1, and the temporal distribution of abundance for the two sites shown in Tables H1.2 and H1.3.

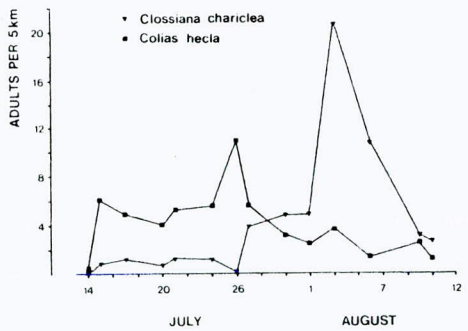


Figure H1.1. Relative abundance of two species of butterfly (*Colias hecla* and *Clossiana chariclea*) along transects in Eqalungmiut Nunât.

Order Araneae (Spiders)

Spiders were the most abundant invertebrates in the pitfalls (Table H1.1); abundant throughout the sampling period, increasing significantly in numbers (days 1-34 compared to 35-68: $p<0.001$; days 35-68 compared to 69-102: $p<0.001$) at the Base Camp site (Figure H1.2), and showing a good relationship between captures at the two sites ($p=0.022$). The large peak in June was caused by the abundance of wolf spiders (Lycosidae) with a later burst of juveniles in July and August.

Order Acarina (mites)

Mites, mainly of the sub-order Prostigmata, were commonly encountered in pitfalls (Figure H1.2), increasing in numbers from the first to the second third of the period ($p<0.001$), with no significant increase and no significant correlation between sites.

TABLE H1.1. Total numbers of arthropods caught in pitfalls.

	Base Camp	Aberchar
Araneae	1899	839
Acarina	365	451
Hemiptera	382	47
Thysanoptera	1	
Neuroptera	6	2
Lepidoptera	11	4
Diptera	1286	139
Hymenoptera	23	5
Coleoptera	104	25
Miscellaneous larvae	100	32

TABLE H1.2. Numbers of arthropods caught per day in 10 pitfalls at Base Camp site.

	Araneae	Acarina	Hemiptera	Thysanoptera	Neuroptera	Lepidoptera	Diptera	Hymenoptera	Coleoptera	Larvae spp.
8/5 - 16/5	6.9	0.3	1.6	-	-	-	-	-	0.9	-
16/5 - 18/5	10.5	0.5	5.0	-	-	-	0.5	-	1.0	-
18/5 - 21/5	9.3	-	7.3	-	-	-	5.3	-	-	0.7
21/5 - 26/5	14.4	1.6	6.0	0.2	-	-	16.4	-	1.0	1.4
26/5 - 29/5	12.3	1.7	6.3	-	-	-	12.3	-	1.7	1.0
29/5 - 4/6	13.6	1.2	4.2	-	-	-	2.2	0.2	1.0	1.4
4/6 - 7/6	9.7	1.0	5.7	-	-	-	6.3	-	1.7	1.3
7/6 - 10/6	3.0	1.3	2.7	-	-	-	4.0	-	0.7	0.7
10/6 - 13/6	25.0	9.0	3.3	-	-	-	10.0	2.7	3.3	1.3
13/6 - 17/6	12.8	2.8	3.5	-	-	-	5.8	-	1.0	1.0
17/6 - 21/6	36.3	4.0	6.0	-	-	-	4.5	-	1.8	2.8
21/6 - 24/6	19.3	2.7	8.0	-	-	0.3	3.3	-	1.0	0.3
24/6 - 27/6	33.7	3.0	3.3	-	-	-	5.0	-	1.3	1.3
27/6 - 1/7	32.3	13.0	3.3	-	-	-	10.3	-	2.0	3.0
1/7 - 4/7	6.3	3.3	2.7	-	-	-	13.7	-	0.3	1.3
4/7 - 8/7	6.5	2.8	1.2	-	-	-	9.3	-	-	3.0
8/7 - 12/7	2.0	4.0	2.3	-	-	-	16.0	0.3	0.3	0.8
12/7 - 17/7	14.6	4.8	4.2	-	-	-	20.2	0.2	1.2	1.2
17/7 - 19/7	19.5	5.5	7.0	-	-	-	229.0	1.5	1.0	0.5
19/7 - 23/7	36.3	12.3	6.8	-	-	0.3	25.5	0.3	2.0	0.3
23/7 - 26/7	16.0	1.3	1.7	-	-	0.3	32.3	1.0	-	-
26/7 - 30/7	15.8	8.8	2.0	-	-	0.5	13.3	0.3	2.3	1.0
30/7 - 2/8	7.3	3.3	3.7	-	-	0.7	5.7	-	-	0.3
2/8 - 6/8	29.4	1.9	3.1	-	0.3	0.5	1.4	0.5	1.1	0.3
6/8 - 9/8	14.3	1.0	3.7	-	-	-	3.0	-	0.3	1.0
9/8 - 13/8	61.3	3.8	4.5	-	1.3	0.5	2.5	0.5	1.2	0.5
13/8 - 17/8	27.5	4.5	0.8	-	-	-	1.8	-	0.2	0.2

TABLE H1.3. Numbers of arthropods caught per day in 5 pitfalls at Aberchar site.

	Araneae	Acarina	Hemiptera	Neuroptera	Lepidoptera	Diptera	Hymenoptera	Coleoptera	Larvae spp.
6/6 - 14/6	6.3	2.3	1.0	-	-	4.1	-	0.4	0.4
14/6 - 19/6	29.2	13.8	2.0	-	-	2.4	-	1.4	1.6
19/6 - 1/7	13.3	5.5	1.0	-	-	0.5	0.2	0.6	0.7
1/7 - 8/7	5.9	4.6	0.4	-	-	1.9	-	-	0.4
8/7 - 17/7	9.0	10.1	0.7	-	-	2.9	0.1	0.3	0.1
17/7 - 23/7	11.2	10.2	0.5	-	0.2	3.7	-	0.2	0.7
23/7 - 30/7	7.6	7.3	-	0.1	0.3	2.9	0.1	-	0.1
30/7 - 6/8	12.6	4.7	0.3	-	-	0.7	0.1	0.4	0.1
6/8 - 13/8	23.6	4.3	0.4	0.1	0.1	0.3	-	0.1	-

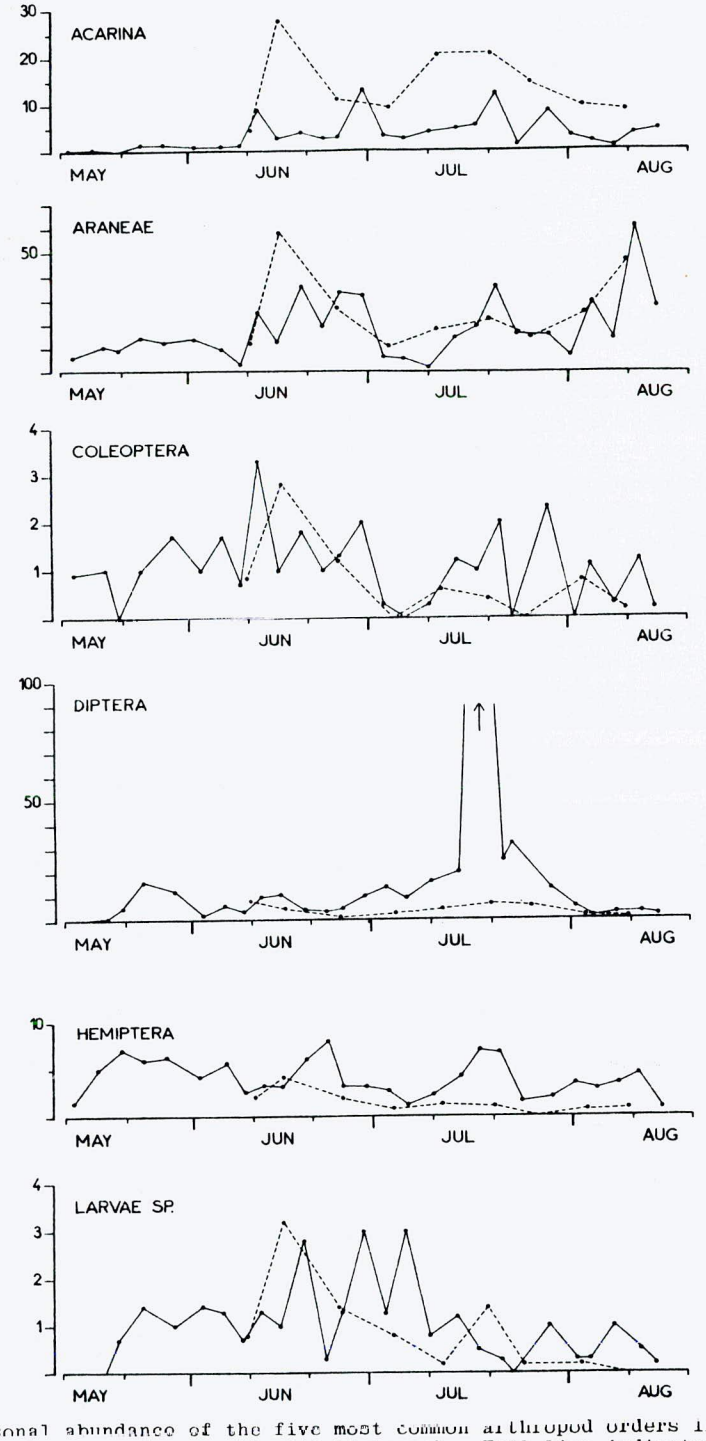


Figure H1.2. Seasonal abundance of the five most common arthropod orders in pitfalls (expressed as numbers per day per 10 pitfall traps). Full line indicates Base Camp site, dotted line indicates Aberchar site.

Order Collembola (springtails)

Springtails were not sampled quantitatively as they were considered too small to be important prey for birds. They appeared in extraordinary numbers during rainy periods.

Order Hemiptera (bugs and aphids)

Bugs and aphids were caught throughout the sampling period in pitfalls and sweep-nets (Figure H1.2, Table H1.4); there are no significant trends in numbers caught and no agreement between sites.

Order Thysanoptera (thrips)

A single thrip was caught in the Base Camp pitfalls.

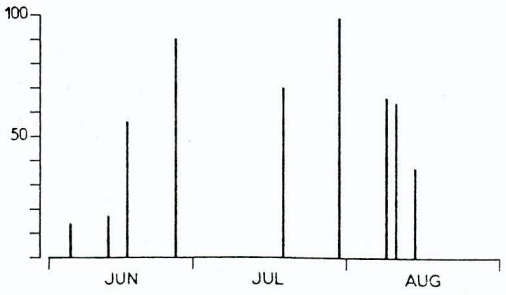


Figure H1.3. Captures of dipterans in sweep net at Base Camp (number per 250 strokes).

TABLE H1.4. Numbers of arthropods caught by sweep-netting.

	Araneae	Hemiptera	Neuroptera	Diptera	Hymenoptera
5/6	-	1	-	14	-
13/6	-	2	-	17	-
17/6	-	4	-	56	-
27/6	2	4	-	90	1
19/7	-	-	-	70	-
30/7	1	3	-	99	3
9/8	1	10	-	66	-
11/8	1	8	1	64	1
15/8	1	5	-	37	2

Order Neuroptera (lacewings)

A few individuals were found in pitfalls from the end of July (see Tables H1.2 and H1.3).

Order Lepidoptera (butterflies and moths)

From mid-July the imagines of moths (and rarely butterflies) were caught regularly in the pitfall traps of both sites (Tables H1.2 and H1.3), although larvae were found throughout the sampling season. The first caterpillars emerged in mid-May, decreasing in numbers at both sites (Base Camp: 1-34 compared to 34-68: NS, 34-68 compared to 69-102: $p<0.001$. Aberchar : 1-34 compared to 34-68: $p<0.001$). Although the overall trend was similar in both sites, the correlation was poor ($p>0.05$).

One species (*Eurois occulta* (L.)) was predominant, comprising more than half the total number of lepidopteran larvae caught, with large numbers of the moth *Apamea exulis* (Lef.). On the DZ slopes, the caterpillars of *Eurois occulta* were superabundant, with 100 larvae removed from a random 9 m^2 plot on 16 June. These had a mean weight of 0.60 g (s.d. 0.20 g) giving a biomass of 6.7 g/m^2 (fresh weight). Weighing was not repeated but a few days later, even more caterpillars were present, feeding on *Salix glauca* leaves.

Only two of the five species of butterflies recorded from Greenland were seen in Eqalungmiut Nunât; these were the Arctic Fritillary (*Clossiana chariclea*) and Northern Clouded Yellow (*Colias hecla*). Both were numerous in the adult stage during July and August, but the egg and larval forms of neither species were located. The larval plant of *Colias* is given as *Astragalus alpinus* by Higgins and Riley (1970), but there are no representatives of the Papilionaceae in Eqalungmiut Nunât. P. Ackery (pers. comm.) gives *Salix arctica* as the food plant of the caterpillars, but the species was probably feeding on *Salix glauca* in the study area. Both species were more numerous on the plateau than regions below 200 m, emerging to coincide with maximum numbers of plant species in flower, although the peak numbers of the two species did not coincide (Figure H1.1).

Order Diptera (two-winged flies)

Dipterans were numerous throughout the sampling period with peak abundance during July at the Base Camp site, resulting from large numbers of small *Cyclorrhapha* flies which were believed to be of minor importance as bird prey. There was no correlation between the two sites and the abundance from sweep-netting shows a different seasonal pattern from that of pitfall data, but peak abundance occurred between late June and the end of July.

Order Hymenoptera (wasps and bees)

Small hymenopterans were regularly found in pitfalls, increasing significantly during the last third of the sampling period at Base Camp ($p<0.001$). Bumble bees, abundant from mid-May, were rarely caught in pitfall traps.

Order Coleoptera (beetles)

Beetles were common in pitfalls (Figure H1.2), showing no seasonal trend in abundance at Base Camp but significantly declining during the second third of the period at Aberchar ($p<0.001$). There was no relationship between numbers at the two sites.

DISCUSSION

Comparision of activity patterns of the arthropod orders shows no clear overall pattern of seasonal abundance. Most invertebrates were abundant from mid-May and showed no decline by mid-August. In May, temperatures regularly fell to -10°C, but with the possible exception of dipterans and mites, this did not seem to affect the activity of many species. Snowfall was infrequent, with the thaw proceeding rapidly after May. This, in combination with high day-time temperatures (see Section J1) presumably led to the early activity. These results contrast with results from arctic Canada and Alaska (Hussell 1972; Maclean & Pitelka 1971; Seastedt & Maclean 1979), where the invertebrate season is short with a discrete peak in activity and an abrupt end to the season. However, in high arctic north-east Greenland, similarly inconclusive results have been found (Greenwood 1978) where the thaw had also commenced before the beginning of the investigation.

Generally, there was a poor correlation between the two sampling sites, although it may prove otherwise when material is considered at the level of species. Greenwood (1978) found a high site-to-site variation in that study and the variation in altitude and habitats will doubtless add to the variance of the sampling.

Sweep-netting as a measure of relative abundance may be useful if applied more frequently than time and weather conditions permitted in 1979. The method undoubtedly caught different species from pitfall trapping and if used regularly at various sites, would give additional information on overall activity patterns.

The early abundance of many invertebrates permits an early start to the birds' breeding season, with Lapland Buntings particularly exhibiting a prolonged nesting season compared to arctic populations in Canada and Alaska (e.g. Custer & Pitelka 1977).

ACKNOWLEDGEMENTS

Boy Overgaard Nielsen gave advice on the sampling programme, while identification of spiders was carried out by Søren Toft, beetles by Viggo Mahler and caterpillars by Ebbe Schmidt Nielsen. Bent Lorentzen and Charlotte Munksgaard helped in sorting the material. All are gratefully thanked.

H 2 AN ANNOTATED LIST OF INVERTEBRATES COLLECTED FROM EQALUNGMIUT NUNÂT

J. E. Bell

Collection of invertebrates in Eqalungmiut Nunât was carried out by JM as part of an investigation of seasonal abundance, but in addition, material was collected on behalf of the British Museum (Natural History). The following list outlines the insects kindly identified by the Department of Entomology, together with preserved arthropod specimens collected by JM and identified in the Institut for Zoologi og Zoofysiologi, Aarhus University.

Order Araneae (spiders) (all det. Søren Toft)

Family Theridiidae (Comb-footed spiders)

Enoplagnatha intrepida (Sor.)

Family Linyphiidae (Sheet-web spiders)

Cochlembolus alpinus (Banks)
Cornicularia clavicornis (Em.)
Erigone whymperi (Cambr.)
Islandiana princeps (Braend.)
Latithorax obtusus (Em.)
Metopobactrus prominolus (Cambr.)
Praestigia groenlandica (Holm)
Typhocrestus pygmaeus (Sor.)
Meioneta levinseni (Sor.)

Family Araneidae (Orb-web spiders)

Singa groenlandica (Sim.) Male individuals have not been previously found in Greenland (Holm 1967). Several males were collected.

Family Tetragnathidae

Tetragnatha extensa (Linn.)

Family Lycosidae (Wolf spiders)

Arctosa insignita (Thor.)
Pardosa furcifera (Thor.)
Pardosa glacialis (Thor.)
Pardosa groenlandica (Thor.)

Family Gnaphosidae

Haplodrassus signifer (C.L.K.)

Family Philodromidae

Thanatus arcticus (Thor.)

Family Thomisidae

Xysticus durus (Sor.)

CLASS INSECTA

Order Hemiptera (bugs and aphids)

Superfamily Coccoidea

*_Arctorthezia cataphracta_ (Olaf.) det. D.J. Williams. Found 15 cm deep under small stones in loose earth beneath _Calamagrostis purpurescens_, _Polytrichum spp._ under _Salix glauca_ scrub, 28/05/79.

Order Lepidoptera (butterflies and moths)

Family Noctuidae

*_Anarta richardsoni_ Curtis det. M.R. Honey
*_Apamea exulis_ Leferbre det. M.R. Honey
Eurois occulta (L.) det. E.S. Nielson

Family Geometridae

*_Eupithecia gelidata_ Moschler det. M.R. Honey

Family Nymphalidae

*_Clossiana chariclea_ Schm. det. P. Ackey

Family Pieridae

*_Colias hecla_ Lef. det. P.Ackey

Order Diptera

Family Tipulidae

*_Tipula arctica_ Curtis det. A.E. Stubbs

Family Culicidae

*_Aedes (Ochlerotatus) impiger_ Walker det. J.A. Reid. Collected from fish carcass, 05/06/79.

Family Ceratopogonidae

*_Culicoides grisescens_ (Edwards) det. S.A. Nielson. Blood-sucking midges were collected in mid-August from exposed human skin and from tents etc. All individuals were identified as _C. grisescens_, although the only described _Culicoides_ species from Greenland is _C. sordidellus_ (Zetterstedt). However, measurements used in the identification of female insects do not deviate from those of _C. grisescens_. Similarly, measurements of male genitalia from the collected material do not deviate from measurements of _C. grisescens_, a species widely distributed in northern Europe.

Family Simuliidae

*_Simulium groenlandicum_ Enderlein det. R.W. Crosskey. This is the rarer of two possible species - more specimens are required to undertake chromosome studies to sort out taxonomy.

Family Empididae

*_Rhamphomyia sp._ det. K.G.V. Smith. New to Greenland.

Family Dolichopodidae

*_Dolichopus sp._ det. A.E. Stubbs.

Family Syphidae

*_Platycheirus sp._ det. A.E. Stubbs. Collected from fish carcass, 05/06/79.
*_Sphaerophoria sp._ det. A.E. Stubbs.
*_Metasyrphus sp._ det. A.E. Stubbs.
*_Heliophilus ?groenlandicus_ det. A.E. Stubbs.

Family Anthomyzidae

*_Hydrophoria vertecina_ Zett. det. D.M. Ackland. Collected from fish carcass, 05/06/79.
*_Lasiomma octoguttatum_ Zett. det. D.M. Ackland. Collected from fish carcass, 05/06/79.
*_Pegomya albimargo_ Pandelé det. D.M. Ackland. Collected from fish carcass, 05/06/79.

Family Calliphoridae

*_Boreëllus atriceps_ Zett. det. J.P. Dean. Collected from fish carcass, 05/06/79, only 2 previous specimens in BM(NH).

Family Muscidae

Fannia sp. two females hatched from Lapland Buntings nests; tentatively identified as _?F. armata_ Mg. by Lektor B. Overgaard Nielsen, a species previously recorded from Greenland by Hennig (1964). _Fannia_ larvae are saprophagous and the larvae of many species are commonly found in birds nests.

Order Siphonaptera

Family Ceratophyllidae

Ceratophyllus garei Rothchild. det. Overgaard Nielsen. Hundreds of specimens were hatched from Lapland Bunting nests. _C. garei_ is a circumpolar species extending southwards to central Europe and through Alaska and Canada to the western United States (Rothchild 1952); the species is previously recorded from Greenland (Henriksen & Lundbeck 1917; Smit 1954). This species prefers groundnesting host species, favouring damp sites and open nests (Rothchild 1952).

Order Hymenoptera

Sub-order Parasitica

*_Syrphoctomus sp._ det. I. Gould.

Order Coleoptera

Family Carabidae

*_Bembidion yukonum_ Fallen det. N.D. Stork, Around roots of _Salix glauca_ in loamy soil with much decaying leaf litter, 28/05/79. New to BM(NH).

Bembidion grapii (Gyllenhal) det. Viggo Mahler.

Family Staphylinidae

Atheta islandica (Johansen) det. Viggo Mahler.

Family Byrrhidae

Byrrhus fasciatus (Forster) det. Viggo Mahler.
Simplocaria metallica (Strum) det. Viggo Mahler.

Family Coccinellidae

*_Coccinella transversoguttata_ (Falderman) det. R.D. Pope. Widespread and common, feeds on _Cinara spp._, etc.

* indicates specimen now in BM(NH) collections

The insect fauna of Greenland is quite well documented, but there have been many collections made in the last ten years and it would be very useful if this information could be gathered together at some stage. Tony Hutson informs us that there were several specimens of particular interest and it would certainly be very worthwhile following some of these up, since the collection appeared to contain more unusual species than might be expected.

ACKNOWLEDGEMENTS

The material was identified at the British Museum (Natural History) by the following, to whom we are most grateful: R.D. Pope, N.D. Stork, J.P. Dean, D.M. Ackland, R.W. Crosskey, M.R. Honey, P. Ackey, I. Gould, J.A. Reid, A.E. Stubbs, K.G.V. Smith, D.J. Williams. We are also very grateful for the help and advice of Tony Hutson, both on collection techniques before the expedition and for co-ordinating the identification process at the British Museum (Natural History).

The material identified in Denmark was identified by S.A. Nielsen, Lektor B.O. Nielsen, S.Toft, Viggo Mahler and E.S. Nielsen, whose help is also greatly appreciated.

SECTION I PLANT REPORT

I 1

THE FLORA OF EQALUNGMIUT NUNÂT

A. D. Fox

INTRODUCTION

Although the original aim of the Greenland expedition was to carry out a botanical exploration of an area of mid-west Greenland (see Section C1), in practice there was little opportunity for detailed studies of the vegetation of Eqalungmiut Nunât. The botanical notes are here divided into several sections dealing with the most distinct vegetation types, each having a brief description of the varieties of communities present. These vegetation types are based loosely on those recognised by previous authors (see below), but generally are discussed in terms of their relationship to aspect, exposure and other factors in the absence of a deeper knowledge of related vegetation in west Greenland. Due to the limited time available for botanical work, the descriptions are necessarily brief, and the amount of detail given reflects the attention devoted to the various communities. In particular, the feeding marshes of the Greenland White-fronted Geese were studied in some detail and a short investigation of the dune vegetation was undertaken towards the end of the project.

The vegetation appeared similar to areas studied in other parts of continental west Greenland (see Trapnell 1933; Bocher 1949, 1952, 1954 and 1959; Bocher & Laegaard 1962), although there are differences compared to the Søndre Strømfjord Air Base area some 60 km to the south (see especially Bocher 1952), which may suggest that the area experiences slightly less continental conditions than are known to exist at Søndre Strømfjord Air Base. The typical vegetation consists of steppe-like communities interrupted by willow scrub and with dry barren type communities on the exposed areas of the upper plateau. The area falls within the middle Continental West Greenland floral province of Bocher *et al.* (1968) and is part of the low arctic belt which extends as far north as about 72°N.

The books of Bocher *et al.* (1968) and Polunin (1959) were used for identification of angiosperms, the former being an excellent key to all species present. Without prior knowledge of many of the species, there was some difficulty in the identification of, for example, the yellow *Potentilla* species, but generally few problems were encountered in determination of flowering material. The major problem was identifying Cyperacean species and many grasses in the absence of flowers, and in this respect we recommend future expeditions to study herbarium material before starting field work. Smith (1978) proved adequate for identification of most species of mosses, although in some cases plants could only be keyed down to genera. Dahl and Krog (1973) was extremely useful for lichen identification, but again some specimens could only be determined to generic level.

Soils and Climate

The soils and climate of Eqalungmiut Nunât are dealt with elsewhere (see Sections B2 and J1), but the interaction of these two factors has a considerable influence on the vegetation present, and hence is briefly discussed here.

The most striking feature of the climate was the extreme aridity resulting from the relatively high temperature, low humidity and low summer precipitation (see Section J1). The combination of these features distinguishes the continental elements of the west Greenland flora from those of the coastal region with its greater precipitation and lower summer temperatures. Eqalungmiut Nunât falls within the continental zone of west Greenland, lying close to the interior ice-cap, thus ensuring an abundant source of rock-flour from the glacial melt sandar which border the area to the north and south.

The bedrock underlying most of Eqalungmiut Nunât is mainly of a gneissic nature (see Section B2) giving rise to a rather acidic, base-poor soil which is consequently rich in humus and often highly podsolised in areas of greatest humidity. Thus on the north-facing slopes, characterised by lower temperatures, later snow lie and higher moisture content, there were considerable accumulations of organic material. These sites were characterised by plant communities with a large bryophyte component, such as *Empetrum* moss-mat where the dominant *Aulacomnium turgidum* is the main 'peat'-producing species. Similarly, on late snow-fields, mosses tend to predominate, resulting in soils of high organic content. In areas of impeded drainage, the development of small mire complexes leads to additional local accumulations of peat-material. This particularly happens in the presence of *Sphagnum*-lawns, which result in a reduced pH that further inhibits microbial breakdown of organic material.

By contrast, on many of the sunny, south-facing slopes, the low precipitation during the growing season results in minimal loss of nutrients during the period of microbial breakdown of the previous years' litter accumulation which might otherwise be leached out of the soil. The dry atmosphere might well contribute to the concentration of mineral salts at the soil surface by rapid evaporation. The aridity of the region close to the ice-cap means that material in and around the glacial melt rivers dries and is then blown on to the land. As the thaw and subsequent drought sets in, a range of different sized sediments, from fine glacial muds to coarser sands, is released to form loose deposits. With the frequent prevailing winds from the ice-cap, the finer material becomes wind borne and is distributed over much of Eqalungmiut Nunât. The contribution to the soil made in this way is clearly demonstrated by clouds of rock-flour disturbed whilst walking in areas often considerable distances from the sandur valleys and at altitudes up to 500 m. This continuous deposition of wind-blown loess doubtless further contributes to the improved nutrient status of the lowland in particular.

The deposits, trapped by the vegetation, are retained and washed down into the substrate by the low summer rainfall, rather than being flushed away down the slopes as would occur during more severe precipitation. This is clearly shown by examination of *Aulacomnium turgidum* moss-mat from a variety of more acidic situations where particles of loess were found amongst the underlying humus accumulations. This perhaps explains why many of the heath and moor soils of continental west Greenland are less acid than might be expected.

An extreme situation was the soil of Kûk Marshes which appeared to be of an alkaline nature in places, presumably resulting from the maritime influence as well as from the factors listed above. In the lowland zones, the onset of the thaw commences considerably earlier than at higher altitudes and hence this alkalinity would be accentuated.

In conclusion, aspect radically affects the nutrient status of sites as well as the more obvious differences in temperature and humidity, with drainage and depth of soil imposing additional patterns on the vegetation.

VEGETATION TYPES OF EQALUNGMIUT NUNÂT

The vegetation types here follow Bocher *et al.* (1968: pp12-14).

1. SCRUB

It seems likely that there are at least two ecotypes of *Salix glauca* present in Eqalungmiut Nunât which may correspond to *Salix glauca glauca* and *Salix glauca callicarpaea*. Both types formed scrub communities, and were growing together around Whiskey. In many areas, the *Salix glauca* becomes co-dominant, with *Betula nana* invariably forming the understorey of the willow scrub, but with *Salix* becoming dominant in some areas (e.g. the slopes of Observation Hill above the Goose nest BC1). There appear to be many different forms of *Salix* scrub however, and the separation of these falls into the following groups:-

(a) Loose scrub - A feature of the *Carex supina* and *Kobresia myosuroides* steppe vegetation of the sunny, generally south-facing slopes, were the frequent stands of *Salix glauca* scrub present in many areas. This scrub was generally indicative of deeper accumulations of soil or of damper substrates. Hence on many of the slopes below the Crusties, the *Carex supina* steppe was punctuated with patches of scrub, and on the dry *Calamagrostis purpurescens* slopes above Upper Marsh there was a heath-herb type of species assemblage with very low *Salix glauca* scrub, co-dominant *Calamagrostis* and a variety of herb species, such as *Cerastium alpinum, Campanula gieseckiana, Draba glabella, Pedicularis labradorica, Pyrola grandiflora* and *Stellaria longipes.* Also, along the fringe of west Eqalungmiut tasia near to Aberchar there was a similar area but with rather higher scrub, with fewer, but larger (up to 2 m) *Salix glauca* bushes.

(b) DZ-type - The typical scrub appeared on the slopes below DZ on the dry sunny slopes dropping down to west Eqalungmiut tasia and on the thick scrubby slopes below False Eyrie Crags to George Eliot. Here, cover of *Salix* is dense, but with an equally well developed herb layer of *Campanula gieseckiana, Cerastium alpinum, Draba glabella, D. aurea, Pedicularis labradorica, P. lapponica, Stellaria longipes* and species more typical of the steppe-like communities such as *Arnica alpina* and *Luzula spp.*

(c) Yankee-type - On the slopes below the ridge immediately north of Yankee-Doodle, there were considerable talus-scree slopes in sunny warm situations. This gave rise to drier soils with a dense *Salix glauca* growth and a herb layer essentially similar to the DZ-type, but with greater amounts of *Draba aurea* and carpets of the more typically steppe-like *Euphrasia frigida.*

(d) Plateau scrub - The *Salix* scrub of the uplands was generally much shorter than at lower altitudes with sparser understoreys (e.g. around Lake 67). In more open, level situations, as along much of Lake Line, there was a very distinct scrub-type, resembling a heath-steppe community with *Calamagrostis purpurescens, Taraxacum spp., Arnica alpina, Pyrola grandiflora, Potentilla crantzii* and *Armeria scabra.*

(e) Willow runnel - *Salix glauca* also followed water courses down the slopes of Needle Cairn Heights to Upper Marsh. In many areas this was further developed, with the scrub often standing in constantly running water, forming a very distinct community. Examples of this type were evident at the outflows of east Eqalungmiut tasia at Lakesmeet, as well as at Doodle, Top Tarn, Zulu and Boulder Lake, all having dense *Salix glauca* growth associated with *Calamagrostis langsdorfii* and *Angelica archangelica*, the latter being absent from sites which dried up during the summer.

2. SNOW PATCHES

Conditions of topography, aspect, temperature and altitude often result in deep snow fields persisting long after the melt of snow cover elsewhere. Typically, snow patches persisting into July were situated in deep shadow below north facing slopes. The vegetation of the snow banks varied according to the lateness of the snow-lie as follows:-

(a) The most severe conditions result in snow remaining well into July, resulting in a very short potential growing season. These sites were generally devoid of vegetation, the melt often leaving large accumulations of litter and wind blown plant material which had accumulated on the snow surface. Only a very few species were able to survive these conditions: a few plants of *Ranunculus pygmaeus* on the snow lie of the slopes above Welsh, and a few late emerging *Saxifraga hyperborea* (e.g. at Lake 24 and below 627 m).

(b) *Oxyria digyna* snow patches were frequently encountered with such species as *Poa pratensis, Saxifraga cernua, S. foliolosa* and *Polygonum viviparum* in many sites. This was invariably edged with *Salix herbacea* (see below) merging into *Cassiope tetragona* heath about the edges and above the snow fields.

(c) The *Salix herbacea* types of late snow patches were frequently associated with banks of snow near lake margins. The nature of the bedrock meant that many of the lakes lying in depressions of eroded bands of weak rock were often steeply banked on the southern fringe. The communities here contained a large cryptogam element, with often considerable patches of bare soil or plant fragments. In some areas *Carex bigelowii* hummocks formed with *Poa arctica*; other typical species include *Polygonum viviparum, Veronica alpinum, Poa pratensis* and *Arenaria humifusa.*

3. GRASSLAND SLOPES

This community is rather difficult to distinguish from the steppe and scrub communities, but the huge preponderance of graminoid species in the group makes it distinct from the other similar lowland habitats. This is the 'tall-grass prairie' habitat of Bocher (1954: p191) and was of considerable importance as habitat of nesting Lapland Buntings. The vegetation merges into loose *Salix glauca* scrub and mixed heath-herb communities dominated by *Calamagrostis purpurescens* and willow scrub, although the typical form consisted of an almost pure stand of *Calamagrostis purpurescens.* From quadrat analysis, the only interruption of this grass carpet (with pure *Aulacomnium turgidum* ground layer) was the occurrence of single *Stellaria longipes* plants once every 3 m^2.

4. SUBARCTIC STEPPE

The steppe-like communities of the inner areas of west Greenland are an extremely important part of the overall vegetation. Unfortunately, very little attention was given to these habitats, and the problem of identification of the vegetative parts of Cyperaceans meant steppe vegetation was somewhat neglected. It would appear that there were a range of steppe communities present within the region.

On the sunny south-facing slopes and on some of the thin soils of the lowlands, the predominant vegetation was steppe-like, growing on fine loess soils on level or gently-sloping rock faces. These areas were frequently punctuated by patches of willow and dwarf heath vegetation resulting from deeper accumulations of soil or from streams and rivulets giving rise to *Salix glauca* scrub. This pattern suggests that water stress is the limiting factor determining species presence; correspondingly there were few bryophytes, although *Tortula ruralis* and *Polytrichum alpinum* were present where topography or drainage permitted. Three major steppe types were recognised, but it should be stressed that the divisions are gross simplifications.

(a) The most easily recognised and widespread type was dominated by *Carex supina* , frequently encountered with the ubiquitous *Calamagrostis purpurescens* as well as many other Cyperaceans such as *Carex glacialis* and *C. scirpoidea* and such herb species as *Potentilla nivea, Artemisia borealis, Melandrium triflorum* and *Saxifraga tricuspidata*.

(b) The *Kobresia myosuroides* associations so typical of the upper reaches of Kangerdlugssuaq (Bocher 1954) seemed restricted in Eqalungmiut Nunât in comparison. However this type of vegetation was present between *Salix glauca* scrub on south facing slopes and on level areas between 300 - 400 m. This association is rich in lichens with a distinctive assemblage of flowering plants such as *Antennaria ekmaniana, Minuartia rubella, Artemisia borealis* and *Draba nivalis*. This community type was common around Delta and amongst the *Salix-Calamagrostis* heath-herb slopes of the Crusties.

(c) The *Saxifraga tricuspidata* type was frequently present in lowland and upland sites alike, the assemblage being typical of talus slopes, rock-falls and other rocky vegetation types. In lowland areas, species present included *Potentilla tridentata, P. nivea, Dryopteris fragrans, Calamagrostis purpurescens, Campanula gieseckiana, Draba aurea* and *Viscaria alpina*, with *Artemisia borealis* in some areas. This assemblage was common on the Aberchar whaleback, on the more disturbed faces of the Crusties and on the south-facing slopes of Ímajuitsoq. In the plateau regions, *Saxifraga paniculata* became more numerous, apparently replacing *S. tricuspidata* at high altitudes, with other species appearing such as *Sedum villosum* and *Erigeron compositus*.

5. DWARF SCRUB HEATH

Large areas of the uplands and considerable parts of the lowland area of Eqalungmiut Nunât were covered by dwarf scrub vegetation as distinct from the scrub communities of *Salix glauca*. The separation of distinct types of dwarf scrub based on dominant species can be summarised as follows:

(a) *Vaccinium uliginosum* type - Heaths of the small-leaved form of *Vaccinium uliginosum* are perhaps one of the most important dwarf heath habitats of the plateau. They tended to prevail in level upland areas above 350 m, containing a rich diversity of lichens and much *Aulacomnium turgidum, Polytrichum alpinum* and *Hylocomium splendens*. In the areas above Base Camp, the community grades into the lower *Salix glauca* slopes and the *Calamagrostis purpurescens* grasslands, while merging into the *Dryas integrifolia/ Carex nardina* fell field or *Diapensia* and *Rhododendron* heaths at higher altitude. Lower down, the *Vaccinium* becomes co-dominant with *Betula nana* with encroaching *Calamagrostis purpurescens*, but retains large amounts of lichen cover such as *Alectoria* and *Cetraria*, with elements of the barren community present (e.g. *Hierochloe alpinum* and *Kobresia myosuroides*). This community would seem equivalent to the steppe communities at lower altitudes, but with the later snow lie over large areas and the delayed thaw of the higher regions resulting in the dwarf heath vegetation.

(b) *Betula nana* type - In some areas, particularly in the lowlands, *Betula nana* became dominant often on the soils of greatest organic content, as on the gentle north-facing slopes above Upper Marsh on Observation Hill. Here, the *Betula nana* heath occurs in the absence of *Salix glauca* scrub, generally on *Aulacomnium turgidum* moss mat with some *Ledum palustre*. This was the typical habitat of *Pedicularis labradorica*.

(c) *Empetrum* moss-mat - This community is one of the most frequent and easily recognised, typical of north-facing slopes at altitudes of up to 400 m. The species assemblage consisted of *Empetrum nigrum, Ledum palustre, Betula nana, Vaccinium vitis-idaea* with a dense understorey of *Aulacomnium turgidum, Peltigera apthosa* and in some areas, *Hylocomium splendens*. In some areas, as below Angmat ridge, there was also considerable *Vaccinium uliginosum* in this community. This vegetation type gives rise to a highly organic substrate subject to active layer slippages on the invariably steep north-facing slopes. Recent slippages were seen on the north face of Ímajuitsoq and south of the west end of Mirrormere.

(d) *Cassiope tetragona* type - *Cassiope tetragona* was common on the plateau above 350 m on steep north-facing slopes, generally forming moss-rich heaths with particularly late winter snow-lie. It seems typical of the upper edges of the *Empetrum* moss-mat and late snow fields and hence was common along the northern edges of Needle Cairn Heights, e.g. above Alpha, where it mixed with *Ledum palustre, Empetrum , Dryas* and some *Vaccinium vitis-idaea*; the community was otherwise herb-poor, and dominated by mosses and lichens.

(e) *Dryas integrifolia* type - This closely resembles the *Dryas* barren, but with considerably increased higher plant cover. It was frequently characterised by the appearance of *Carex rupestris* (perhaps a sign of reduced exposure) and merged with *Rhododendron* heath with increasing moisture and with *Diapensia* heath with an increase in available gravel substrate.

(f) *Diapensia* heath - This closely resembles the *Dryas* heath, but with predominant *Diapensia lapponica*, and generally occurs in areas of deeper gravel accumulation resulting in a generally greater flowering-plant diversity. The heath type was largely confined to the very highest altitudes and was common only above 450 m.

(g) *Rhododendron* type - The *Rhododendron lapponicum* -dominated heaths were rarely extensive, and closely resembled the *Dryas* heath type, fading directly into *Salix glauca* scrub along the Crusties to the Cornerstone.

(h) *Phyllodoce* Dwarf Heaths - *Phyllodoce coerula* is essentially oceanic in habit, more characteristic of the coastal mountain ranges of west Greenland. However, *Phyllodoce* heath was located in a few sites of relatively late snow-lie in the interior of the plateau region. These sites were cryptogam -rich, with some *Empetrum nigrum*.

(i) *Loiseleuria* type - Like *Phyllodoce coerula, Loiseleuria procumbens* belongs to the oceanic element of the west Greenland flora. The species was present on the slopes above the Zulu-Doodle valley where it grew on patches between bare rock surfaces and on solifluction slopes in the vicinity. Very few associated species were present, with the exception of *Salix herbacea*, a typical solifluction species.

6. FELL-FIELD

The fell-field vegetation type is applied to the community of highly scattered plants present on the wind-exposed localities which typify much of the plateau tops and mountain peaks above 400 m. These areas are generally very species-poor, with crustose lichens on the bare rock surfaces and stones, and small assemblages of flowering plants in cracks between boulders or in local accumulations of gravel. There appear to be three major subdivisions of this community:

(a) Open Cyperacean type - Many barren areas were characterised by *Carex nardina* and *Hierochloe alpinum* growing in localised pockets of soil on otherwise bare rock faces. This was found around Llyn Anne/Needle Cairn Heights ridge to False Eyrie Crags and around Qilertinguit where *Poa glauca* and *Luzula arctica* were also present. This community is rich in lichens with *Alectoria ochroleuca* particularly abundant, but with *Cetraria*, *Cladonia* and *Stereocaulon* species also. In a few places, *Carex glacialis* and *C. rupestris* extend into this vegetation type, generally with increasing shelter, and *Salix glauca*, *Polygonum viviparum* and *Vaccinium uliginosum* also appear at lower altitudes. This community changes into *Carex supina/Kobresia myosuroides* steppe communities in less exposed situations, and to *Dryas* fell-field on the tops of the hills. The apparently local *Tofieldia coccinea* was found in this type of situation. In the slightly more sheltered areas, such as clefts and runnels in rock faces, *Saxifraga oppositifolia* and *Silene acaulis* appear, with *Chamaenerion latifolium* and *Artemisia borealis* on the lower barrens as evident on the gravelly fell-field above the Gullery.

(b) *Dryas* barren - The *Dryas integrifolia* -dominated fell field is extremely similar to the preceeding type, but tends to appear in areas with a better developed substrate. There are still large amounts of lichen present with species of *Cetraria*, *Alectoria*, *Physcia*, *Candellaria* and *Cornicularia* all present, with the same flowering plants as the more open fell field, and with *Papaver radicatum* in some situations (e.g. the Delta/Charlie area).

(c) *Racomitrium lanuginosum* - This variant was very similar to the open type, but with a large moss component, resembling the more typical oceanic barrens of the coasts. This type was particularly evident in the vicinity of Wallbanger and Vee.

7. KÛK DUNES

Kûk dunes lie in the lee of Angmat Ridge, and their formation presumably results from the sharp turn in the glacial melt river at this point. The sandur flows generally west from Inugpait qûat glacier towards the sea, but is deflected south-west by the Îmajuitsoq-Angmat upland complex and then turns abruptly north-west, widening in the process; the frequent dust storms of the region have deposited wind-blown material in the wind-shadow of Angmat ridge. The deposition of fine glacial material has formed a sand spit stretching from 'The Temple' below Angmat and laid down directly on the sandur floor. It seems likely that the resulting impedance of drainage from the area has resulted in the formation of Kûk Marshes to the north, although the present Afon Char drains into the glacial melt river at the westernmost end of the sandbar below Eqalungmiut nûat.

The southernmost edge of the dune system was relatively straight, whilst the northern fringe was convex, forming a lozenge-shaped area over 3 km long and as much as 1 km wide at its widest point.

The most striking feature of the formation was the total lack of decompositional gradients so evident in coastal dune systems in Europe (see Ranwell 1972). Equally remarkable was the fact that the mosaic of vegetation present showed no seral development, and comparision of aerial photographs taken in 1948 (Geodaetisk Institut GRE-9-204) with photographs taken from the helicopter in August, shows extremely similar patterns of vegetation, with little or no evidence of increasing stability and virtually no change in over 32 years.

There seemed to be little suggestion of environmental gradients exerting an influence on vegetational development, although in some parts of the dunes, the water table depth clearly influenced the species composition. This, particularly at the extreme east end, clearly had a corresponding effect on patterns of decomposition. Here, the water table favoured the development of a low (5-20 cm) *Salix glauca* scrub which seemed to have an increasingly stabilising effect on the sand. However, in other areas adjacent to the low willow cover, there were high *Salix glauca* hummocks (up to 2 m) very similar to the structures at, for example, Newborough Warren as described by Ranwell (1960), where the species is the similar *S. repens*.

After an initial visit on 7 May, there was little human activity near Kûk Dunes until August, when a short investigation of some of the vegetation types present was undertaken.

Methods

The two transects across the dunes were approximately perpendicular to the major axis of the bar, as shown in Figure I1.1. Data were collected from 1 m^2 quadrats sampled at 20 m intervals along the transect lines, and cover values for the different species were assessed on the basis of a modified Domin scale as follows:

1 Present
2 Less than 10% cover
3 10 - 25% cover
4 25 - 50% cover
5 more than 50% cover

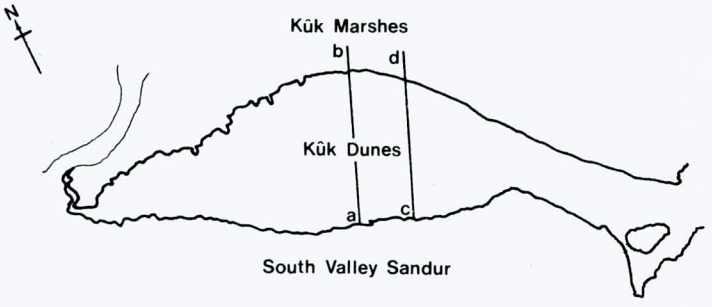


Figure I1.1. Location of transects on Kûk Dunes, the vegetation sampled by 1 m^2 quadrats at 20 m intervals along either transect.

The data collected in this way were analysised using the computer programmes at the University College of Wales, Aberystwyth, using both Normal and Inverse Association Analysis based on Chi-squared and Information Statistic methods (see Lambert & Williams 1966 for details). Both the Normal Association Analysis and the Normal Information Statistic methods produced similar aggregations of species, and hence in the discussion below only the former is referred to. The results of the computer programme are shown in Figure I1.2, in the form of an association diagram, while the associations as distributed along the length of the transect are illustrated in Figure I1.3. The distributions of species within and between associations are shown in Tables I1.1 & I1.2.

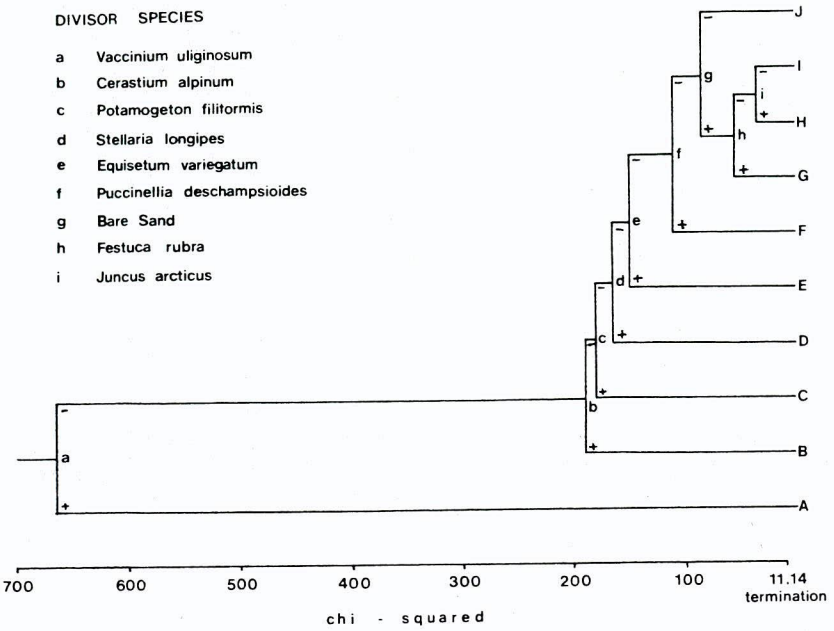


Figure I1.2. Association diagram showing divisor species from Kûk dunes vegetation analysis

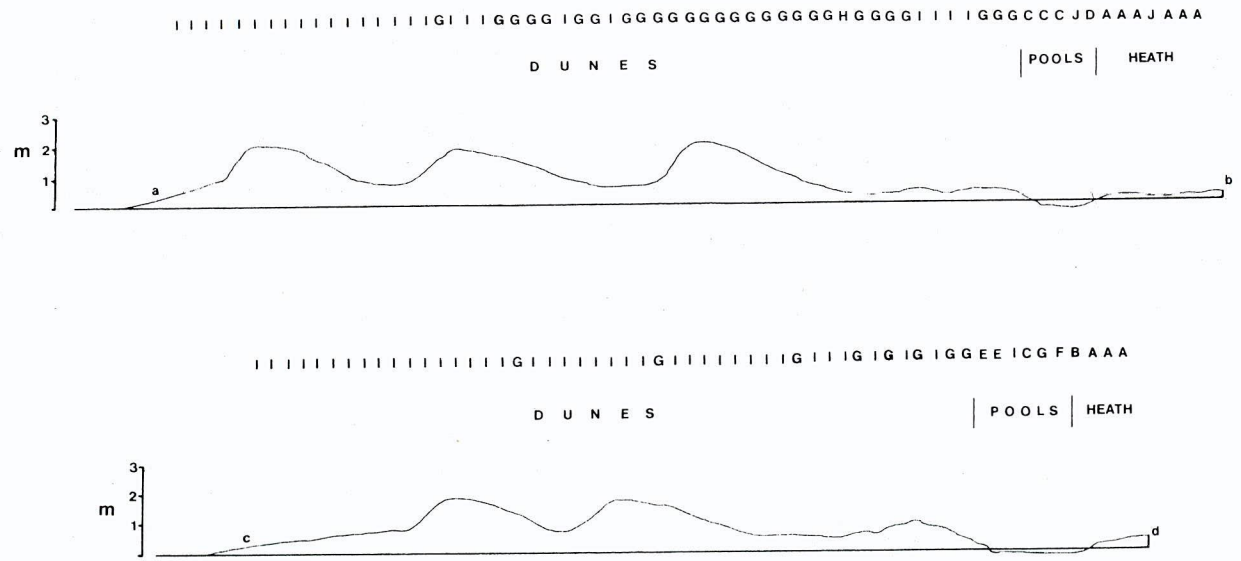


Figure I1.3. Diagram of association distribution along the two transects across the dunes, north-south. Letters indicate associations defined in Figure I1.2.

Results and Discussion

(i) Initial colonisation

The entire southern fringe of Kûk Dunes was edged by a single line of *Honkenya peploides* hummocks which presumably grow on a strand line where the highest tides within the fjord deposit organic matter, facilitating plant colonisation of the unstable sand. This feature is common to most dune systems, and results from the combination of localised nutrient availability and the topographic discontinuity giving rise to a measure of stability. This feature is perhaps a little surprising in view of the lack of sub-littoral fauna and flora which gave the sandur a rather sterile appearance with a notable absence of litter and floating matter. It seems likely that this area of dunes is subject to some active erosion by the fjord waters which have shaped this southern edge of the sand bar.

TABLE II.1. Species Frequencies within Associations, Normal Association Analysis of Kûk Dunes vegetation, August 1979.

ASSOCIATION LETTER	A	B	C	D	E	F	G	H	I	J
Number of Quadrats:	9	1	4	1	2	1	37	1	66	2
Artemisia borealis	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.02	0.00
Bare sand	0.56	0.00	0.25	0.00	0.50	1.00	0.03	0.00	0.02	0.00
Betula nana	0.33	0.00	0.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00
Calamagrostis neglecta	0.00	0.00	0.50	1.00	1.00	0.00	0.16	0.00	0.02	1.00
Carex maritima	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00
Cerastium alpinum	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elymus arenarius	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.18	0.00
Eriophorum angustifolium	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Eriophorum scheuchzeri	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.02	0.00
Festuca rubra	0.33	1.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00
Honkenya peploides	0.00	0.00	0.00	0.00	0.00	0.00	0.41	1.00	0.51	0.00
Juncus arcticus	0.00	0.00	0.00	1.00	0.00	0.00	0.19	1.00	0.00	0.50
Lomatogonium rotatum	0.00	0.00	0.00	1.00	0.00	0.00	0.03	0.00	0.00	0.00
Open Water	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poa pratensis	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polygonum viviparum	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
Potamogeton filiformis	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Puccinellia deschampsioides	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Salix glauca	0.33	0.00	0.00	0.00	1.00	0.00	0.14	1.00	0.50	0.00
Stellaria longipes	0.11	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Triglochin palustre	0.00	0.00	0.25	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Vaccinium uliginosum	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Equisetum variegatum	0.00	0.00	0.00	0.00	1.00	0.00	0.03	0.00	0.00	0.00
Aulacomnium turgidum	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Drepanocladus uncialis	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fontinalis antipyretica	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polytrichum alpestre	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortula ruralis	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peltigera aphthosa	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NUMBER OF SPECIES:	12	4	6	5	6	3	12	3	7	3

(ii) Unstable Dunes

As much as 50% of the total dune area consisted of unstable and mobile sand banks, with relatively little vegetational cover. This is defined as Association I in the Normal Association Analysis and was largely bare sand, with some colonising *Honkenya peploides* and *Elymus arenarius*. Both are perennial species with creeping stolons which show considerable lateral and vertical growth to keep up with sand accretion rates (Bond 1952; Ranwell 1972), and it is thus significant that these are the only species present in the less stable zones

(iii) Stable Dunes

Within the unstable dune areas was a patchwork of vegetated islands. It was notable that these areas were generally at the tops of sand banks separated by unstable slopes between, and these patches of more mature community development seem identical to the patterns shown in aerial photographs taken 32 years ago. It seems likely that such apparently stochastic plant colonisation and community development is stable over a considerable time period. The aggregation of plants emerged as Association G in the analysis, and is presumably relict development from the initial *Honkenya peploides* pioneer colonisation. *Honkenya* is still present in the community but at a relatively low abundance, appearing amongst the more typical species such as *Elymus arenarius*, *Carex maritima*, *Festuca rubra*, *Artemisia borealis* with *Armeria scabra* and *Plantago maritima* in some of the small depressions. The presence of these plants undoubtedly has a stabilising effect on the substrate, increasing the total plant cover from the usual less than 5% of the unstable dune zone to 25-50%. However in the absence of depositional gradients and clines in environmental parameters, the explanation of the distribution of these species remains obscure.

TABLE I1.2. Species Frequencies between Associations, Normal Association Analyis of Kûk Dunes vegetation, August 1979.

ASSOCIATION LETTER	A	B	C	D	E	F	G	H	I	J
Number of Quadrats:	9	1	4	1	2	1	37	1	66	2
Artemisia borealis	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.17	0.00
Bare Sand	0.50	0.00	0.10	0.00	0.10	0.10	0.10	0.00	0.10	0.00
Betula nana	0.60	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.00	0.00
Calamagrostis neglecta	0.00	0.00	0.14	0.07	0.14	0.00	0.43	0.00	0.07	0.14
Carex maritima	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
Cerastium alpinum	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elymus arenarius	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.40	0.00
Eriophorum angustifolium	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Eriophorum scheuchzeri	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.33	0.00
Festuca rubra	0.08	0.02	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00
Honkenya peploides	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.02	0.68	0.00
Juncus arcticus	0.00	0.00	0.00	0.10	0.00	0.00	0.70	0.10	0.00	0.10
Lomatogonium rotatum	0.00	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.00
Open Water	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poa pratensis	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polygonum viviparum	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Potamogeton filiformis	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Puccinellia deschampsioides	0.00	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00
Salix glauca	0.25	0.00	0.00	0.00	0.17	0.00	0.42	0.08	0.08	0.00
Stellaria longipes	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Triglochin palustre	0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00
Vaccinium uliginosum	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Equisetum variegatum	0.00	0.00	0.00	0.00	0.67	0.00	0.33	0.00	0.00	0.00
Aulacomnium turgidum	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Drepanocladus uncialis	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fontinalis antipyretica	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polytrichum alpestre	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00.	0.00
Tortula ruralis	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peltigera aphthosa	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NUMBER OF SPECIES:	12	4	6	5	6	3	12	3	7	3

(iv) Dune Pools

Set within the dune system were a number of ponds, perched high above the general water table, up to 2 m above the level of the glacial melt river and the marsh pools of Kûk Marshes. These pools were associated with surrounding high water tables which were indicated by the presence of *Juncus arcticus*, *Eriophorum angustifolium* and *E. scheuchzeri* and low (5-20 cm) *Salix glauca* scrub. These areas of open water were rarely more than 10 m in diameter, and were subject to large fluctuations, as was shown by the concentric terracing about their perimeters in August. It seemed that some had fallen in depth by up to 60 cm between May and August, and presumably the effect of these fluctuations occurring in the course of a single season, together with the poor nutrient status, precludes large scale plant production at such pools. Botanically, the pools were scantily vegetated, with bare edges and only limited emergent *Eriophorum angustifolium* and *E. scheuchzeri* about the shallows. Some contained considerable growth of *Potamogeton filiformis* which was often associated with large populations of the snail *Lymnaea vahli*.

(v) Beach Pools

Immediately north-east of the sand bar lay a series of pool and marshy areas. The edges of the dune system were very well defined and the sharp disjunction between the dune associations (G, H,I) and the wetland communities in the transect emphasises the relatively recent development of the dunes on the sandur valley floor. The boundary between dune and marsh was a dynamic one, clear-cut in May, but by August dune encroachment on the pools and heath communities was clearly visible. Many of the marsh pools had contained brackish water at the beginning of May, and at this time when phytoproduction had still to get under way, these pools had been important feeding areas for the White-fronts and Mallard. By mid-August many of the pools had dried out substantially, leaving bare areas of mud and large stands of *Triglochin palustre* with up to 100% cover of the moss *Fontinalis antipyretica*. In areas retaining standing water to the end of the summer, *Potamogeton filiformis*

was again abundant, with dense stands of *Calamagrostis neglecta* in the wetter areas associated with conspicuous increases in the organic content of the soil. This community type emerges from the analysis as Association type C. The *Calamagrostis neglecta* tended to exclude all other flowering plants by its remarkably crowded habit, but about the periphery of such stands it merged with *Eriophorum angustifolium*, *E. scheuchzeri* and *Equisetum variegatum* with some localised patches of *Juncus arcticus* on some of the ponds (Association E). In the more extreme pools with little humic fraction to the substrate, the vegetation was sparse and poor with small amounts of *Triglochin palustre* and isolated plants of *Puccinellia deschampsioides* on the wetter areas of otherwise bare glacial deposits (Association F). In a few corners of the very driest of these deposits, stands of *Puccinellia deschampsioides* colonised the bare grey mud, a finer deposit than that of the dunes which retained the yellow colour. The pools of Kûk Marshes when dry had a characteristic grey substrate identical to the sandur terrace to the south. These sparse *Puccinellia* stands were important during August as a food source for Lapland Buntings, the seed-set period corresponding to the dispersal of large numbers of immature birds from the nesting areas.

(vi) Ecotonal Zone

In many places the margins of the beach pools merged from typical wetland species gradually through the grass species to a heath-grassland community which dominated the drier part of the area, In some places however, there was a sharp disjunction between the two vegetation types, and this area was best defined by the presence of *Lomatogonium rotatum*. Only one quadrat fell within this zone of change, showing a rather atypical assemblage of *Juncus arcticus*, *Calamagrostis neglecta*, *Betula nana*, *Lomatogonium*, *Stellaria longipes* and various mosses.

(vii) *Vaccinium uliginosum/Salix glauca* heath

The major component of the vegetation of Kûk Marshes was a heath-type community dominated by *Vaccinium uliginosum*, not dissimilar to heath types found on the plateau. The *Vaccinium* was co-dominant with *Salix glauca* with the usual understorey of *Aulacomnium turgidum* and *Peltigera aphthosa*. In addition, there was much *Calamagrostis lapponica* and *C. purpurescens* amongst the scrub, as well as herb species typical of this community such as *Pedicularis labradorica* *Cerastium alpinum* and *Stellaris longipes*. The main difference in this community compared to the vegetation types at higher altitudes was the presence of *Festuca rubra*, a species rarely encountered away from these lowland sites yet common amongst the heath matrix on Kûk Marshes. In addition, another heath-herb assemblage emerged from the analysis which was again not representative of the vegetation present; this was Association B, one quadrat comprising *Festuca rubra* sward but including *Cerastium alpinum*, *Poa pratensis* and *Puccinellia deschampsioides* reflecting the boundaries of the dune heath vegetation types.

Discussion

The Kûk dune system is undoubtedly a recent phenomenon, with a history stretching back perhaps a few hundred years. The vegetation has done little to stabilise the sand, and its effect in purely vegetative terms is more marked on the Kûk Marshes section of the sandur floor to the north. Here, there is some development of the glacial deposits towards a full tundra heath typical of higher altitudes. The dunes themselves bear a characteristic plant community, with several species showing adaptations towards survival in unstable habitats. It is interesting to note that no part of the dunes exhibited more than 50% vegetation cover, with no evidence of long-term stabilisation of the substrate excepting the distinctive *Salix glauca* hummocks. This forms a contrast with the dune system further east at the foot of Pass of Jennings, which considerably pre-dates Kûk and represents a similar formation based on an ancient sandur floor at higher elevation. The build-up of humic material in the soil there indicates a much longer period of development and indeed, the full heath community showed identical constituents with the higher tundra heath (including *Ledum palustre*, *Empetrum nigrum*, *Salix glauca* and many cryptogams; mosses and lichens were conspicuously absent on Kûk). This rather suggests the Kûk system may in the future develop to full tundra heath.

In the absence of identification of the depositional patterns and their influence on plant distribution, it is difficult to draw conclusions about the nature of the processes occurring on Kûk dunes. In the absence of clear environmental gradients that are such a feature of coastal dune succession, there is considerable scope for further research on such a system.

There were many such 'yellow dune' systems on the north side of North Valley, most associated with the confluence of drainage systems of the uplands into the North Valley sandur. The habitat type is thus apparently very common in this area of west Greenland, representing potential breeding habitat for Ringed Plover, so further exploration would be of importance.

8. LAKES

(a) Upland Lakes

The aquatic vegetation of the upland lakes was characteristically poor, the peripheral shallow shelves of the plateau lakes being typically devoid of plant cover. In some lakes up to 300 m, *Hippuris vulgaris* and emergent *Menyanthes trifoliata* were present, presumably reflecting an earlier thaw at these waters. At a few sites, *Sparganium hyperboreum* was present, as at one small shallow water in the Spidermere complex.

(b) Lowland Lakes

The vegetation of the shallow shelves of Eqalungmiut tasê was often dominated by *Fontinalis antipyretica* with some *Potomogeton alpinus*, the latter extending down along the ponded sections of Afon Char. *P. pusillus* was present at a few sites in the lowlands, as was *P. filiformis* which was most numerous in the salt lakes of Kûk Marshes. *Hippuris vulgaris* and *Menyanthes trifoliata* were both very common throughout, although absent from the large Eqalungmiut tasê.

9. SALTMARSH

There was little evidence of saltmarsh development in Eqalungmiut Nunât, the only traces being of sparse *Juncus arcticus/Plantago maritima/Potentilla egedii* plants on the sandur deposits below the Gullery. This was the only site of colonisation of these deposits noted on South Valley.

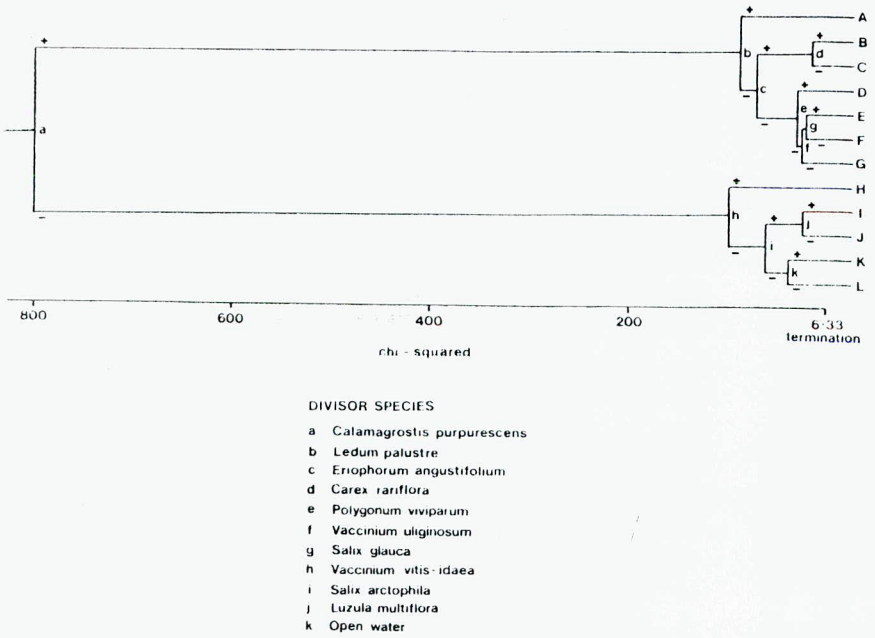
10. FRESHWATER MARSHES

Three broad categories of freshwater marsh could be defined amongst wetland habitats in Eqalungmiut Nunât: mature sandur flats (see Kûk Marshes material included in 7. KÛK DUNES), lowland marshes and marsh communities associated with the edges of upland lakes.

For analysis of wetland communities, the reader is referred to the Association Analysis of 115 1 x 1 m quadrats in section D8, from upland lakes and lowland marshes. These quadrats are included in a more extensive analysis based on the same method, but also taking in quadrats from the peripheral *Calamagrostis purpurescens/Salix glauca/Betula nana* slopes about the edges of Rimwater and Upper Marshes. The results of the Association Analysis on the 214 quadrats is shown in Figures I1.4 and I1.5 and Tables I1.3 and I1.4. The first divisor species is *Calamagrostis purpurescens* which effectively divides the quadrats into heath (presence) and marsh (absence), giving ultimately seven heath assemblages and five marsh groupings, demonstrating the uniformity of the marshland communities. The wetland sites are all *Sphagnum*-dominated (*Sphagnum plumulosum* on plateau lake margins, *S. squarrosum* on lowland marshes - the loss of moss specimens resulted in the exclusion of cryptogams from the analysis) with *Carex rariflora, Eriophorum angustifolium, E. scheuchzeri* and *Salix arctophila*. Some of the upland communities were characterised by *Luzula multiflora* and *Vaccinium vitis-ideae* which were absent from the lowland marshes, but apart from increased cover of *Salix arctophila* and *E. scheuchzeri* at higher altitudes, the two types are very similar. Pattern is imposed within these mires by drainage, faster flowing stretches of water being largely devoid of moss cover with dense stands of *Eriophorum spp.* and in peripheral areas, *Carex bigelowii* and *Calamagrostis lapponica*. The wetlands merged into the marginal drier slopes via wet areas with much bare mud, *Drepanocladus spp.* and *Calliergon stramineum*, the the characteristic vegetation of seepage patches amongst the *Salix* scrub.

TABLE I1.3. Species Frequencies within Associations, Normal Association Analysis for Upper Marsh Vegetation Survey.

ASSOCIATION LETTER	A	B	C	D	E	F	G	H	I	J	K	L
Number of Quadrats:	19	5	4	13	6	25	35	9	8	54	11	25
Betula nana	0.84	0.20	1.00	0.69	1.00	1.00	0.86	0.78	0.00	0.11	0.00	0.24
Calamagrostis purpurescens	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00
Calamagrostis langsdorfii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.04
Campanula gieseckiana	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Carex bigelowii	0.00	0.20	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.36	0.40
Carex canescens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Carex rariflora	0.00	1.00	0.00	0.00	0.17	0.00	0.00	0.56	1.00	0.85	0.45	0.60
Carex sp.	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cerastium alpinum	0.00	0.00	0.00	0.15	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00
Draba glabella	0.00	0.00	0.00	0.23	0.17	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Empetrum nigrum	0.53	0.20	0.00	0.08	0.00	0.04	0.00	0.56	0.00	0.04	0.00	0.16
Equisetum variegatum	0.26	0.20	0.75	0.38	0.67	0.16	0.23	0.00	0.12	0.17	0.00	0.40
Eriophorum angustifolium	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.33	1.00	0.91	0.64	0.76
Eriophorum scheuchzeri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.11	0.55	0.08
Hippuris vulgaris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.04	0.45	0.04
Ledum palustre	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
Luzula confusa	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.11	0.00	0.00	0.00	0.00
Luzula groenlandica	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.11	0.00	0.00	0.00	0.04
Pedicularis labradorica	0.26	0.00	0.00	0.31	0.50	0.24	0.06	0.11	0.00	0.00	0.00	0.00
Pedicularis lapponica	0.11	0.00	0.00	0.08	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Poa arctica	0.58	0.20	0.50	0.77	0.33	0.44	0.40	0.11	0.00	0.04	0.00	0.04
Poa glauca	0.00	0.00	0.00	0.08	0.00	0.00	0.06	0.11	0.00	0.00	0.00	0.00
Poa spp.	0.00	0.20	0.00	0.00	0.00	0.04	0.09	0.00	0.12	0.04	0.00	0.08
Polygonum viviparum	0.05	0.60	1.00	1.00	0.00	0.00	0.00	0.22	0.75	0.33	0.09	0.08
Pyrola grandiflora	0.00	0.00	0.25	0.08	0.33	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Ranunculus hyperboreus	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.09	0.04
Ranunculus lapponicus	0.05	0.40	0.00	0.23	0.00	0.04	0.09	0.56	0.12	0.04	0.00	0.04
Salix arctophila	0.05	0.60	0.50	0.08	0.00	0.00	0.06	0.11	1.00	1.00	0.00	0.00
Salix glauca	0.05	0.00	0.50	0.62	1.00	0.00	0.23	0.00	0.00	0.07	0.09	0.20
Stellaria longipes	0.95	0.20	0.75	0.77	0.33	0.88	0.89	0.44	0.12	0.04	0.00	0.16
Vaccinium uliginosum	0.79	0.20	1.00	0.54	1.00	1.00	0.00	0.78	0.00	0.46	0.09	0.40
Vaccinium vitis-idaea	0.79	0.20	0.00	0.15	0.00	0.52	0.09	1.00	0.00	0.00	0.00	0.00
Bare ground	0.05	0.40	0.00	0.46	0.33	0.24	0.26	0.11	0.12	0.31	0.09	0.24
Open water	0.05	0.20	0.00	0.00	0.00	0.00	0.00	0.11	0.25	0.13	1.00	0.00
Luzula multiflora	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	1.00	0.00	0.09	0.08
Saxifraga stellaris	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salix herbacea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.04	0.09	0.00
NUMBER OF SPECIES	17	18	13	20	12	14	18	20	14	21	13	20



DIVISOR SPECIES

a Calamagrostis purpurescens
b Ledum palustre
c Eriophorum angustifolium
d Carex rariflora
e Polygonum viviparum
f Vaccinium uliginosum
g Salix glauca
h Vaccinium vitis-idaea
i Salix arctophila
j Luzula multiflora
k Open water

Figure 11.4. Association diagram showing divisor species from 214 1 m^2 quadrats from Upper Marsh and Rimwater Marsh vegetation analysis.

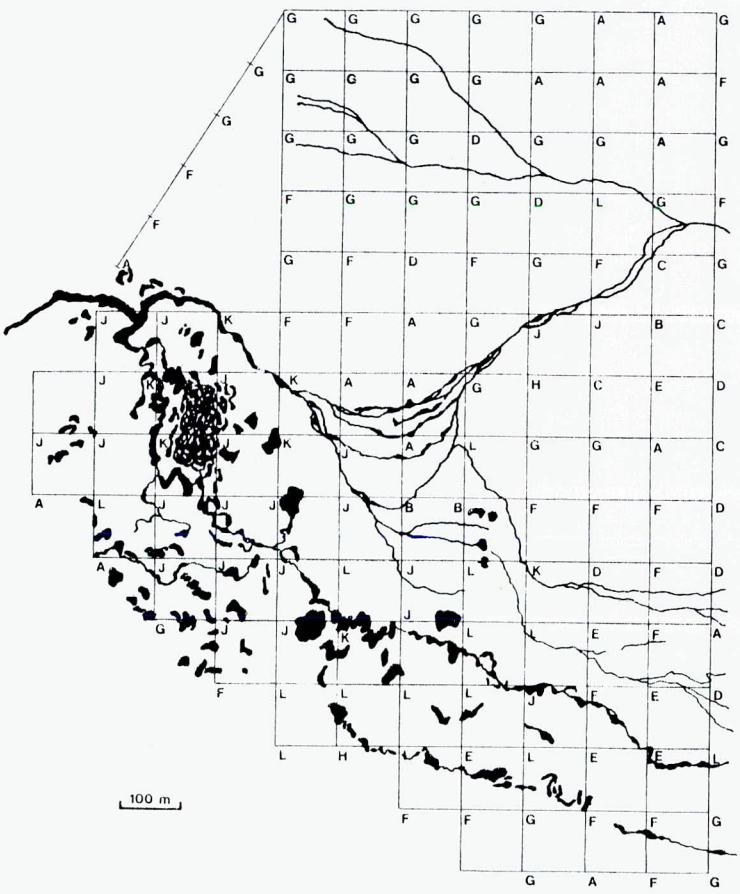


Figure 11.5. Diagram of association distributions over Upper Marsh and Rimwater Marsh. Letters indicate associations defined in Figure 11.4.

TABLE I1.4. Species Frequencies between Associations, Normal Association Analysis for Upper Marsh Vegetation Survey.

ASSOCIATION LETTER	A	B	C	D	E	F	G	H	I	J	K	L
Number of Quadrats:	19	5	4	13	6	25	35	9	8	54	11	25
Betula nana	0.15	0.01	0.04	0.08	0.05	0.23	0.27	0.06	0.00	0.05	0.00	0.05
Calamagrostis purpurescens	0.18	0.05	0.04	0.12	0.06	0.23	0.33	0.00	0.00	0.00	0.00	0.00
Calamagrostis langsdorfii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.50
Campanula gieseckiana	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Carex bigelowii	0.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.18	0.45
Carex canescens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Carex rariflora	0.00	0.06	0.00	0.00	0.01	0.00	0.00	0.06	0.09	0.54	0.06	0.18
Carex sp.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cerastium alpinum	0.00	0.00	0.00	0.40	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00
Draba glabella	0.00	0.00	0.00	0.50	0.17	0.00	0.33	0.00	0.00	0.00	0.00	0.00
Empetrum nigrum	0.42	0.04	0.00	0.04	0.00	0.04	0.00	0.21	0.00	0.08	0.00	0.17
Equisetum variegatum	0.10	0.02	0.06	0.10	0.08	0.08	0.16	0.00	0.02	0.18	0.00	0.20
Eriophorum angustifolium	0.00	0.05	0.04	0.00	0.00	0.00	0.00	0.03	0.08	0.52	0.07	0.20
Eriophorum scheuchzeri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.37	0.37	0.12
Hippuris vulgaris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.22	0.56	0.11
Ledum palustre	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Luzula confusa	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.00	0.00	0.00
Luzula groenlandica	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.20	0.00	0.00	0.00	0.20
Pedicularis labradorica	0.24	0.00	0.00	0.19	0.14	0.29	0.10	0.05	0.00	0.00	0.00	0.00
Pedicularis lapponica	0.50	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
Poa arctica	0.20	0.02	0.04	0.18	0.04	0.20	0.25	0.02	0.00	0.04	0.00	0.02
Poa glauca	0.00	0.00	0.00	0.25	0.00	0.00	0.50	0.25	0.00	0.00	0.00	0.00
Poa spp.	0.00	0.10	0.00	0.00	0.00	0.10	0.30	0.00	0.10	0.20	0.00	0.20
Polygonum viviparum	0.02	0.06	0.08	0.26	0.00	0.00	0.00	0.04	0.12	0.36	0.02	0.04
Pyrola grandiflora	0.00	0.00	0.20	0.20	0.40	0.00	0.20	0.00	0.00	0.00	0.00	0.00
Ranunculus hyperboreus	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25
Ranunculus lapponicus	0.05	0.11	0.00	0.16	0.00	0.05	0.16	0.26	0.05	0.11	0.00	0.05
Salix arctophila	0.01	0.04	0.03	0.01	0.00	0.00	0.03	0.01	0.11	0.75	0.00	0.00
Salix glauca	0.03	0.00	0.06	0.23	0.17	0.00	0.23	0.00	0.00	0.11	0.03	0.14
Stellaria longipes	0.18	0.01	0.03	0.10	0.02	0.22	0.32	0.04	0.01	0.02	0.00	0.04
Vaccinium uliginosum	0.15	0.01	0.04	0.07	0.06	0.25	0.00	0.07	0.00	0.25	0.01	0.10
Vaccinium vitis-idaea	0.35	0.02	0.00	0.05	0.00	0.30	0.07	0.21	0.00	0.00	0.00	0.00
Bare ground	0.02	0.04	0.00	0.12	0.04	0.12	0.17	0.02	0.02	0.33	0.02	0.12
Open water	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.04	0.09	0.30	0.48	0.00
Luzula multiflora	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.62	0.00	0.08	0.15
Saxifraga stellaris	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salix herbacea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.50	0.25	0.00
NUMBER OF SPECIES	17	18	13	20	12	14	18	20	14	21	13	20



SILENE ACAULIS

AN ANNOTATED LIST OF THE PLANTS OF EQALUNGMIUT NUNÂT

A. D. Fox & A. M. V. Higgs

An extensive herbarium of plant material was collected by AMVH, and lists of plant species present were prepared from notes taken in the field. Few of the species present represent unusual records, the species list corresponding well with previously documented plant distribution patterns. The list below follows the order of Bocher *et al.* (1968); while this is not necessarily the best authority, it has been used in the absence of more recent comprehensive works.

In the following list each species is coded for abundance, presence in the different community types (see Section I1), and altitude, using the following abbreviations:-

ABUNDANCE	COMMUNITY TYPES	ALTITUDE
1 - rare	S - scrub	L - only below 200 m
2 - occasional	SP - snow patch	(L) - mostly below 200 m
3 - local	G - grassland	U - only above 200 m
4 - locally common	ST - steppe	(U) - mostly above 200 m
5 - common	H - dwarf scrub heath	UL - throughout
6 - very common	FF - fell-field	
7 - abundant	SF - solifluction soils	Absence of a symbol indicates the species was found too infrequently to assign to catagories.
	D - dunes	
	SM - saltmarsh	
	B - bogs	
	M - marshes	
	L - lakes or lake margins	

Huperzia selago - 4, FF/H, U; few sites on north-facing slopes, associated with *Hylocomium splendens* and *Peltigera aphthosa*.

Lycopodium dubium - 4, H/SP, U; e.g. snow banks above Hotel.

Equisetum arvense - 5, M/L, L; common on the clay terraces about George Eliot and on runnels below *Salix glauca*, typically associated with *Eriophorum angustifolium* and *Salix arctophila*.

Equisetum variegatum - 7, B/M/I, UL; frequently associated with *Drepanocladus* and *Calliergon* moss-mat.

Cystopteris fragilis - 5, ST; rock-falls and talus slopes.

Dryopteris fragrans - 5, ST; as above, but rarely growing together.

Juniperus communis - 3, ST/H, (L); forming low scrub over dry rocks.

Ranunculus confervoides - 2, L, L;

Ranunculus hyperboreus - 6, L/M, UL;

Ranunculus lapponicus - 5, B/M/L, UL; common on *Aulacomnium turgidum* in wetlands never in open water.

Thalictrum alpinum - 2, S/G; probably overlooked, but common above Welsh and near Foxtrot.

Dryas integrifolia - 7, FF/H, U;

Comarum palustre - 5, B/M, L; common along Afon Char meadows.

Potentilla tridentata - 5, ST, UL; on rocks, dry gravel and crevices throughout.

Potentilla eyedii - 4, SM, L;

Potentilla hookeriana - 1, ST; present at a few sites on dry shallow soils in sunny situations.

Potentilla nivea - The *Potentilla* identified in the field as *P. hyparctica* proved to be *P. nivea* on return to Britain, although *P. hyparctica* should in theory occur in Eqalungmiut Nunât, so the status of the common and freely flowering yellow *Potentilla spp.* must remain obscure.

Pontentilla crantzii - 5, S/C, U; surprisingly common on rock-crevices and fell-field (e.g. above Ptarmigan Gorge) and on sunny heath-herb areas (as around November-December).

Sedum rosea - 1, ST; present at a few sites along the fringe of the south fjord near Niaqorssua.

Sedum villosum - 5, FF/ST, (U); e.g. above the Gullery, above Lake 18, etc..

Saxifraga nivalis - 5, FF/SP, U; wet ground on dry barrens, crevices and snow patches throughout.

Saxifraga tenuis - 1, SP;

Saxifraga foliolosa - 3, SP, U; also north-facing slopes on moss mats.

Saxifraga stellaris - 3, H/FF, U; wet runnels on heath-herb slopes and fell-field, e.g. near Lake 20.

Saxifraga cernua - 7, SP/B/M/L/SF, U; moist ground from a variety of situations.

Saxifraga rivularis - 1, SP; found only below 627 m on bare mud and subject to considerable Caribou trampling.

Saxifraga hyperborea - 4, M/SP, U;

Saxifraga caespitosa - 3, FF/ST, U;

Saxifraga tricuspidata - 7, ST, UL; most abundant saxifrage present throughout the area in dry sunny sites. Large stands below the Gullery.

Saxifraga paniculata - 4, ST, U; similar situations to above, but higher altitudes and less common, numerous around Lake 38.

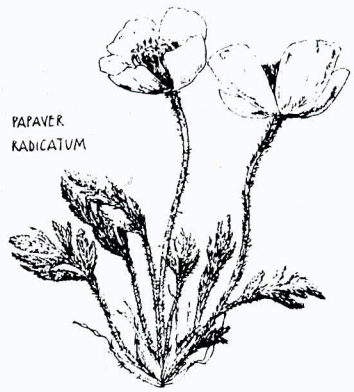
Saxifraga oppositifolia - 4, FF/SP, U;

Chamaenerion latifolium - 5, ST/FF, UL; on stony river beds (e.g. Goose River) and in rock crevices and dry shallow soils on barrens (e.g. Niaqorssua).

Epilobium palustre - One small group of plants from the previous season was found on Kûk Marshes during May, but was not subsequently rediscovered.

Hippuris vulgaris - 6, L, L; also in slow-flowing rivers as Afon Char.

Papaver radicatum - 3, ST/FF, U;



Draba nivalis - 6, ST/FF, U;

Draba cinerea - 1, ST; located three times on Crusties slopes.

Draba glabella - 6, ST/S, UL;

Draba aurea - 5, ST/S, UL;

Cardamine bellidifolia - 3, SP, U;

Cardamine pratensis - 4, M/L, L;

Halimolobus mollis - 3, ST, L; rocky crevices above Aberchar and below Gullery and Niaqorssua.

Angelica archangelica - 5, M/L; found only in fast flowing streams which did not dry out in summer, usually under *Salix glauca* with *Calamagrostis langsdorfii*.

Salix herbacea - 5, FF/SF/SP, U;

Salix arctophila - 5, M/B, UL; typically on *Sphagnum* moss-mat.

Salix glauca - 7, S/G/ST/H/FF/M/L, UL;

Betula nana - 5, S/G/ST/H/M, UL;

Oxyris digyna - 5, SP/H/ST, U; often in dense carpets, as in the base of the deep gorge above Hookwater.

Polygonum viviparum - 6, SP/ST/M, UL; widespread along river courses, but absent from dry areas.

Rumex acetosella - 3, ST, L; on dry slopes and amongst grassy heath.

Montia fontana - 1, SP/M; probably much overlooked.

Cerastium alpinum - 6, S/ST, UL; associated with *Stellaria longipes* and *Viscaria alpina* in heath-herb situations.

Stellaria longipes - 6, S/ST/G, UL;

Stellaria humifusa - 2, SM/M; found on Kûk Marshes.

Arenaria humifusa - 2, SP, U;

Minuartia rubella - 4, ST/S, U; on damp parts of sandy, gravelly or sunny slopes - e.g. gravel pans of Boulder Lake and on Crusties slopes.

Honkenya peploides - 5, SM, L; initial coloniser of sandur deposits.

Melandrium triflorum - 5, ST, UL; dry sunny sites on moraines, dry slopes etc..

Melandrium affine - 5, ST, UL; generally wetter, richer situations than above.

Viscaria alpina - 5, ST/S/H, U;

Silene acaulis - 4, FF, U;

Primula stricta - 1, SM/M, L; found once on Kûk Marshes.

Armeria scabra - 2, D/FF/ST/S; all plants apparently keyed out to *Armeria maritima* according to Bocher *et al.* (1968).

Pyrola grandiflora - 6, H/S/ST, UL; forms dense cover in many areas.



Cassiope tetragona - 5, H/FF/SP, U;

Ledum palustre - 6, H/M/B, UL;

Loiseleuria procumbens - 2, SF, U;

Phyllodoce coerulea - 3, H/SP, U;

Rhododendron lapponicum - 5, FF/H/S, U;

Oxycoccus palustris - 1, B/M; found in several parts of Upper Marsh.

Vaccinium vitis-idaea - 5, H/S/M, U; surprisingly common and widespread.

Vaccinium uliginosum - 7, H/S/M/B/FF, UL;

Empetrum nigrum - 5, H/M, UL;

Diapensia lapponica - 5, H/FF, U;

Gentiana nivalis - 2, ST; sunny south-facing slopes.

Gentiana detonsa - 1, ST; on south-facing thin soil slopes at the Gullery and north-facing slope at the Torrents below Doodle.

Gentiana tenella - 1, M; on Ridgeway Marshes on the top of grass hummock in wet marsh community.

Gentiana aurea - 1, ST; sunny south-facing *Calamagrostis purpurescens* slopes.

Lomatogonium rotatum - 4, G/S/D, L; on low level unstable clay soils around Kûk Marshes, Afon Char etc..

Menyanthes trifoliata - 5, L, L;

Veronica alpina - 2, SP, H; as at Axewater.

Pedicularis lapponica - 5, H/G/S;

Pedicularis labradorica - 5, H/G/S;

Pedicularis flammea - 3, SP/M, U; wet flushes and late snow lie.

Pedicularis hirsuta - 5, H/S, U;

Bartsia alpina - 3, H/S, U;

Euphrasia frigida - 6, ST/S, U;

Plantago maritima - 3, D/SM, L;

Galium brandegei - 1, M; found once on *Sphagnum* lawn, Lakesmeet, but common at this locality.

Campanula gieseckiana - 6, FF/ST/S/H/G, UL;



Campanula uniflora - 3, FF/ST, U;

Erigeron compositus - 2, ST, U;

Antennaria ekmaniana - 5, ST/FF, U;

Artemesia borealis - 6, ST/D, UL; extremely large specimens beneath the Gullery.

Arnica alpina - 5, ST/S/G, UL; later flowering plants much larger than earlier forms.

Taraxacum spp. (i) - 4, S, U; as along Lake Line, on dry steppe/scrub
(ii) - 2, S, U; as in *Salix glauca* runnels on north-facing slopes (e.g. above Zulu).

Tofieldia pusilla - 4, H/M/L, U;

Tofieldia coccinea - 1, FF, U;

Juncus arcticus - 3, SM/L/D, L;

Juncus biglumis - 1, L; present at Top Tarn overflow.

Luzula spicata - 4, S/M/H/G, UL; wet patches in a variety of situations.

Luzula confusa - 3, FF/H, (U);

Luzula arctica - 5, FF/SP, U;

Luzula multiflora - 4, H/S/G;

Luzula groenlandica - 3, H/M;

Eriophorum scheuchzeri - 5, M/L, UL;

Eriophorum angustifolium - 6, M/B/L, UL; (includes *E. triste*).

Kobresia myosuroides - 6, ST/G, UL;

Carex nardina - 5, FF/H, U;

Carex maritima - 4, D, L;

Carex lachenalii - 1, H; found once on north-facing slope, probably overlooked.

Carex canescens - 1, B/M, found on Upper Marsh.

Carex rupestris - ?, ST/G; probably common.

Carex scirpoidea - 5, ST/S/M, UL;

Carex supina - 6, ST, UL;

Carex glacialis - ?, FF/H; probably common.

Carex bigelowii - 6, G/M/B/SP, UL;

Carex norvegica - 5, H/M/ST, UL;

Carex rariflora - 7, B/M/L, UL;

Carex saxatilis - 5, B/M/L, UL; common along Afon Char and around Lake 58.

Festuca brachyphylla - 4, FF/H, UL;

Festuca rubra - 4, SM/D/H, L; common on Kûk Marshes.

Poa glauca - 6, FF/H/ST, UL;

Poa arctica - 4, FF/H, UL;

Poa pratensis - 5, G/H/S/SP, UL;

Poa alpina - 4, G/ST/SP, UL;

Puccinellia deschampsioides - 4, L/M, L; on Kûk Marshes.

Puccinellia groenlandica - 1, M, L; on Kûk Marshes.

Puccinellia phyganodes - non-flowering plants were ascribed to this species from many pools around Kûk Marshes, spreading by stolons.

Trisetum spicatum - 5, SP/FF/ST, (U);

Trisetum triflorum - 4, ST;

Calamagrostis purpurescens - 7, G/ST/S/FF, UL;

Calamagrostis langsdorfii - 4, G/S/M/B, UL;

Calamagrostis lapponica - 4, H/G/S, UL; generally moist situations compared to *C. purpurescens*.

Calamagrostis neglecta - 4, D/M, (L);

Alopecurus aequalis - 2, L; found along lake-side, Aberchar.

Hierochloe alpina - 6, FF/ST/H, U;

Elymus arenarius - 4, D/M, L;

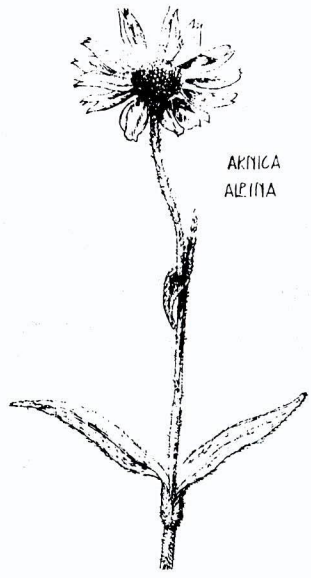
Potamogeton filiformis - 3, L, (L);

Potamogeton alpinus - 2, L, (L); Eqalungmiut tasê and Afon Char.

Potamogeton pusillus - 1, L, (L);

Triglochin palustre - 5, M/L, (L); common on clay terraces of sandur and Kûk Marshes.

Sparganium hyperboreum - 2, L;



I 3 OBSERVATIONS ON *Dryas integrifolia*

D. A. Stroud

Large numbers of *Dryas integrifolia* grew on a dry barren area on top of Observation Hill. The first of these was seen in flower in the early hours of 14 June. On this day and for a week thereafter, the fortunes of all the plants in a 400 m^2 plot were followed with the intention of investigating the relationship between flower and bud number, phenology of flowering, plant size and other factors. However the project was discontinued for various reasons, not least of which was the time needed to count accurately often hundreds of buds on each plant. The following observations are made with the intention of suggestions for future study.

There is a wide range of vigour in *Dryas* plants. Small individuals (<100 cm^2) had few flowers whilst larger plants (100 - 900 cm^2) had high flower densities (up to 300 m^{-2}). Senile plants often covered large areas but had few live leaves except around the edges and no flowers. Thus *Dryas* seems to undergo maturation as it grows, affecting fecundity. If growth rate is constant, then the age structure of a population (these tend to be discrete) could be calculated from the areas of the plants present. Further, changes in fecundity over the life of the plant could also be assessed in a similar manner.

Since they are very flat, no more than 2 cm high, competition between plants is essentially two-dimensional, and many of the factors important in competition between plants in temperate regions, such as shading, are absent. There is little or no interspecific competition as the barrens on which they grow support few other higher plants. For these reasons *Dryas integrifolia* would seem to be an ideal plant on which to undertake an arctic population study.

I 4 LIST OF BRYOPHYTES FROM EQALUNGMIUT NUNÂT

A. D. Fox

An extensive bryophyte collection composed of specimens obtained throughout Eqalungmiut Nunat was unfortunately lost in transit. The following list represents the few species identified in the field.

Tortula ruralis
Racomitrium lanuginosum
Pohlia nutans
Mnium spp.
Aulacomnium palustre
Aulocomnium turgidum
Fontinalis antipyretica
Climacium dendroides
Calliergon stramineum
Drepanocladus uncinatus
Drepanocladus revolvens
Scorpidium scorpioides
Pleurozium schreberi
Hylocomium splendens
Polytrichum alpinum
Polytrichum commune
Polytrichum juniperinum
Sphagnum squarrosum
Sphagnum plumulosum
Sphagnum rubellum
Sphagnum warnsdorfii
Sphagnum fuscum
Sphagnum lindbergii

I5 LIST OF LICHENS FROM EQALUNGMIUT NUNÂT

A.D. Fox

No detailed lichen investigations were undertaken and no attempt made to draw up an extensive list of species present. The following lists species collected during the vegetation survey of Upper and Rimwater Marshes with additional species identified elsewhere.

Alectoria ochroleuca
Cetraria islandica
Cetraria nivalis
Cladonia chlorophaea
Cladonia coccifera
Cladonia crispata
Cladonia gracilis
Cladonia lepidota
Cladonia milis
Cladonia pyxidata
Cladonia uncialis
Peltigera aphthosa
Peltigera polydactyla
var. crassoides
Peltigera rufescens
Peltigera scabrosa
Peltigera spuria
Psoroma hypnorum
Renodina turfescens
Stereocaulon alpinum

My grateful thanks go to Svenhildur Svane of the Botanical Institute at Risskov for identification assistance.

I 6 LIST OF FUNGI FROM EQALUNGMIUT NUNÂT

A. D. Fox

No specific investigations were undertaken during the expedition concerning the fungi of the area, and regrettably no specimens were collected for examination in Great Britain. However, most of the common species were at least recorded on transparencies and most kindly identified by Dr. Roy Watling at the Royal Botanic Garden, Edinburgh. As identification from photographs is so difficult, the following account is only a tentative attempt to describe some of the macrofungi encountered.

BASIDIOMYCETES

Agaricales

Agaricaceae

Agaricus campestris group - One specimen tentatively identified as *A. porphyrocephalus*, others assigned to the group as a whole, locally found on dry, free-draining soils, as well as on heath-herb slopes with *Salix glauca* and *Calamagrostis spp.*, June.

Amanitaceae

Amanita nivalis Grev. - Found amongst lichen mat in Sisimiut, August.

Boletaceae

Leccinium spp. - The most abundant macrofungi encountered in Eqalungmiut Nunât, probably consisting of several different species, with at least *L. tundrae* (Kallio) Smith, Thiers & Watling and *L. salicola* Watling present, associated with *Salix* scrub, and perhaps *L. rotundifoliae* (Singer) Smith, Theirs & Watling associated with the *Betula nana* scrub.

Cortinariaceae

Cortinarius hinnuleus group - Very common species noted from *Salix*- scrub throughout the area in July.
Hebeloma sp. - One location only, growing on the marsh adjacent to Hotel, amongst *Polytrichum spp.* and *Ranunculus lapponicus*, July.
?Galerina sp. - Common on bare peat surfaces, June-July.

Russulaceae

Russula alpina Blytt - Very common, present in a large number of situations, frequently associated with *Polytrichum spp.* on heath-herb slopes. This species typically fades with age, some of the specimens approaching *R. norvegica* Reid in colouration, and further work might well show this species to be present.

Tricholomataceae

Collybia dryophila (Bull. ex Fr.) Kummer - Very common in a variety of situations, notably amongst dry *Carex*-dominated communities on slopes, but also under *Salix*-scrub canopies in July.
Laccaria ?ohiensis Singer - Frequently found on dead wood below thick *Salix glauca* thickets, but rather local, the first mushroom located, appearing during early June.
Leptoglossum rickenii (Hora) Singer - One specimen located, habitat notes mislaid.
Mycena ?avenacea (Fr.) Quelet - Found occasionally on sunny, dry slopes with various *Carex* species, June; resembled a *Tephrocybe* in overall colours.
Mycena ?vitilis (Fr.) Quelet - Common on degrading moss-hummocks, especially amongst *Polytrichum spp.*, July.
Omphalina ericetorum (Fr. ex Fr.) M Lange - The most abundant Basidiomycete in marshy areas, present on *Aulacomnium turgidum*-mats in many situations. Very common, June-July.
Omphalina obsurata Reid - Common species associated with *Polytrichum* hummocks, July.

Gasteromycetales

Lycoperdales

Large numbers of 'puff-balls' appeared during July and August throughout the study area, generally on the plateau regions, often amongst *Salix*-scrub, but also on dry barrens and even on late snow-lie areas, as amongst *Salix herbacea* on the south side of Axewater.

ASCOMYCETES

Pezizales

Morchellaceae

Morchella sp. - Several specimens were found on dry moraine deposits around Base Camp, above Atanârssuk and near West Eqalungmiut tasia during late June.

Pezizaceae

Peziza sp. - A small *Peziza* similar to members of the genus seen in Great Britain was discovered in the Kûk dune system during mid-August, and was tentatively identified as *P. ammophila*.

MYXOMYCETES

A slime mould was noted from several stations on moss-mat and heath-herb slopes around Atanârssuk during mid-July.

This species list contains the major elements of the macrofungal flora, but a caveat must be applied to the identifications in view of the method utilised. The photographs used in the identification of these specimens are lodged with the author and some in the collection of the Royal Botanical Garden, Edinburgh. For further information, the reader is referred to Watling (1977) and to Lange (1948, 1955 and 1957).

The considerable help given by Dr. Roy Watling in the identification of specimens and the preparation of this section is gratefully acknowledged, and thanks are also due to Dr. John Hedger for help and advice.

SECTION J METEOROLOGICAL REPORT

J1 METEOROLOGY

J. E. Bell & D. A. Stroud

The climate of west Greenland shows a strong west-east, maritime-continental gradient running across the unglaciated "coastal" regions. Eqalungmiut Nunât, being near the ice-cap, experiences a continental climate typified by high summer temperatures, low rainfall and low relative humidity often with slight cloud cover, particularly near the ice-cap.

The nearest meteorological station to Eqalungmiut Nunât is at Søndre Strømfjord Air Base, and a summary of the weather experienced there during May to August 1979 is given in Figures J1.1, J1.6 and J1.8. Meteorological observations were taken daily at or near Base Camp at 11.00, 17.00 and 24.00 hours GMT and hourly during the period 1-22 June. The following features were noted: type of precipitation, if any, in the previous hour, cloud cover, wind speed, rainfall (at 17.00 hours GMT), wind direction, visibility and temperature; the data are presented in Figures J1.2, J1.3, J1.4, J1.5, J1.7 and J1.9. It should be noted that the camp was sheltered by hills to the east and north whilst at an altitude (300 m) that made it appreciably colder than at sea level, especially in May. Wind speeds in particular were probably lower than on the plateau.

Visibility was excellent throughout the summer and the exceptional clarity of the air enabled the coastal mountains (130 km west) to be clearly seen on many days. The weather in May was settled with large diurnal temperature fluctuations, but often clear and hot. In late May and early June, the weather changed bringing long periods of snow, rain and high winds. This change may have been due to the break-up of the coastal pack-ice affecting the stability of the weather systems. The beginning of July was clear, dry and hot with little wind and August continued very dry, although there was a large number of hazy days with poor visibility. Night-time temperatures fell below freezing for the first time again in the first week of August, giving a frost-free period of about six weeks.

GENERAL WEATHER PATTERNS

May 5	Clear and hot, cold at night.
May 6	Continuous rain and drizzle throughout the day - this is unusual for this time of year (S. Malmquist pers. comm.).
May 7-12	Clear and warm during the day, dry with cold nights.
May 13-15	Cloudy with intermittent snow, small daily temperature range.
May 16-17	Warm, clear and windy.
May 18-19	Cold with snow.
May 20-23	Sunny with little cloud.
May 24	Cloudy with very strong winds from the NW, some light rain.
May 25-28	Cloudy but warm; night temperatures rarely below freezing.
May 29-June 2	Snow and sleet often in blizzards, freezing at night with much wind.
June 3-15	Unsettled often with rain, snow and high winds. Temperatures above freezing. Very high winds from SE on evening of June 12 followed the next day by heavy snow and low visibility. All snow thawed by noon June 14, with more falling 14/15, heavy rain at times and little wind.
June 25-July 1	Much snow and rain for long periods, overcast with little wind and temperatures rarely falling below freezing. Often cloud remaining in valleys after clearing from the tops and higher ground.
July 2-5	Overcast at times, little rain. Very sunny on 4 July.
July 6-10	As June 25-July 1.
July 14-August 6	Generally cool and cold if wind blowing. Often hazy during the day. Winds from S to SE very strong on higher ground and exposed peaks, particularly July 16-17.
August 7-8	Much rain from the evening of August 7 until the morning of August 8; by noon, weather began to clear again and afternoon sky was clear.
August 8-20	Often clear, hot, sunny days although cold at night; sub-zero temperatures again being recorded. Short periods of dull persistent drizzle between 12 and 14 August. Occasional large numbers of cumulus clouds towards the end of the period.

Day length

Located less than a degree above the Arctic Circle, Base Camp experienced a short period when the sun was above the horizon for 24 hours per day. However, because of considerable twilight, there was sufficient light throughout the night in May, June and July for work to continue around the clock. From 300 m a.s.l. the sun was seen touching the horizon for the first time on 14 July, solar midnight being about 03.30 hours GMT. By the first week in August it was dark enough to see the first stars and by 20 August the period of darkness lasted five hours.

Wind

Figure J1.3 shows the direction of all wind records over the period in Eqalungmiut Nunât. There was no significant difference in wind direction between different months, the wind coming predominantly from the north or south-east. The south-easterly winds were probably due to air ascending from the southerly of the two ice-cap high points by gravity flow. Relative humidity was not recorded because of equipment failure, but low precipitation correlated well with wind direction since the north and south-east winds would not have passed over major bodies of open water. Evaporation loss was very high; one pool of 10 m diameter and about 0.5 m depth was seen to dry up completely in just over a month.

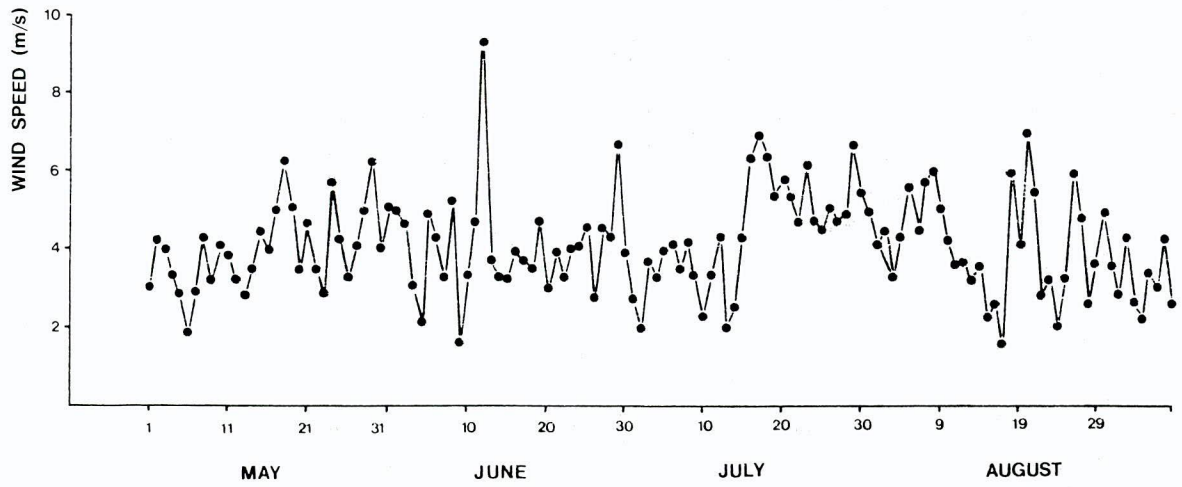


Figure J1.1. Mean daily wind speed measurements from Søndre Strømfjord Air Base, May-August 1979.

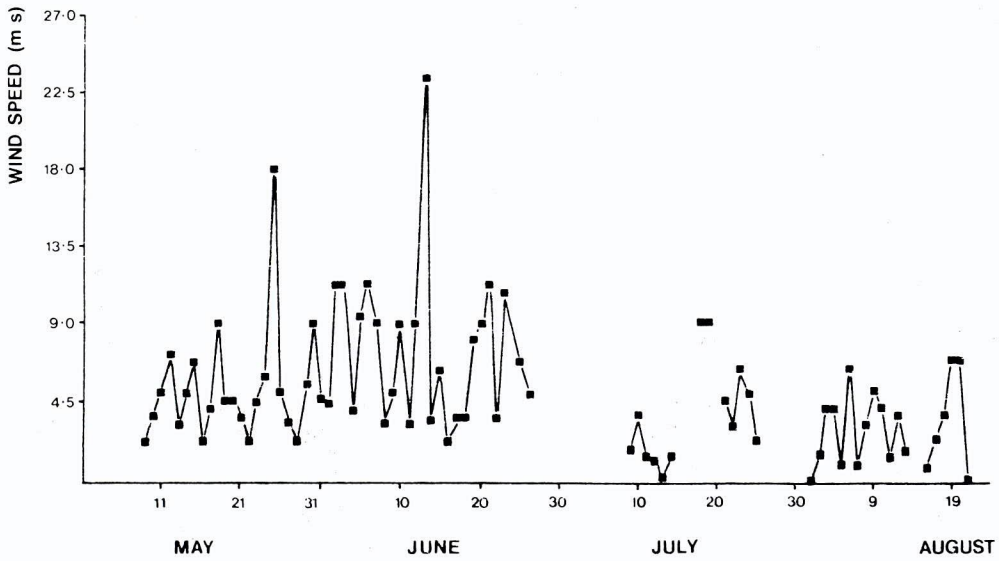


Figure J1.2. Maximum daily wind speed measurements from Eqalungmiut Nunât, May-August 1979.

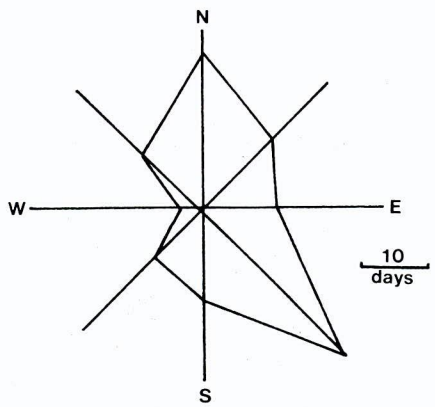


Figure J1.3. Daily wind direction by cardinal points from Eqalungmiut Nunât, May-August 1979.

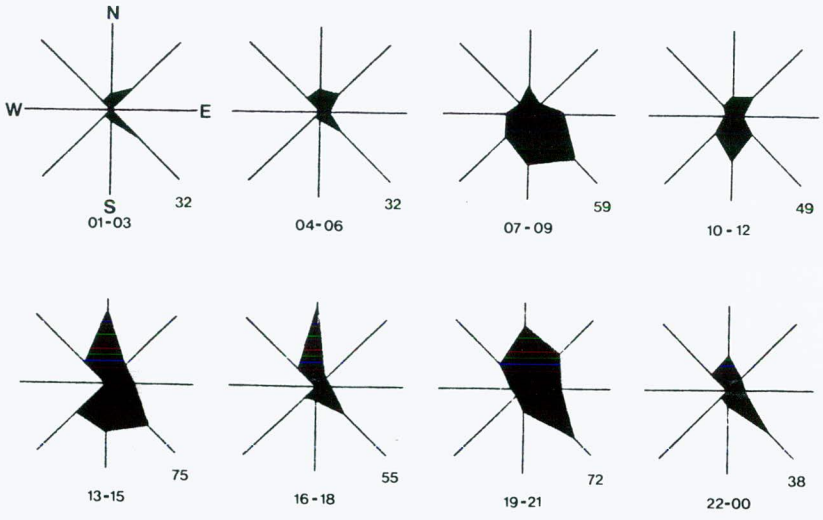


Figure J1.4. Diurnal patterns in wind direction by 3-hour period from Eqalungmiut Nunât May-August 1979. Sample sizes given for each plot.

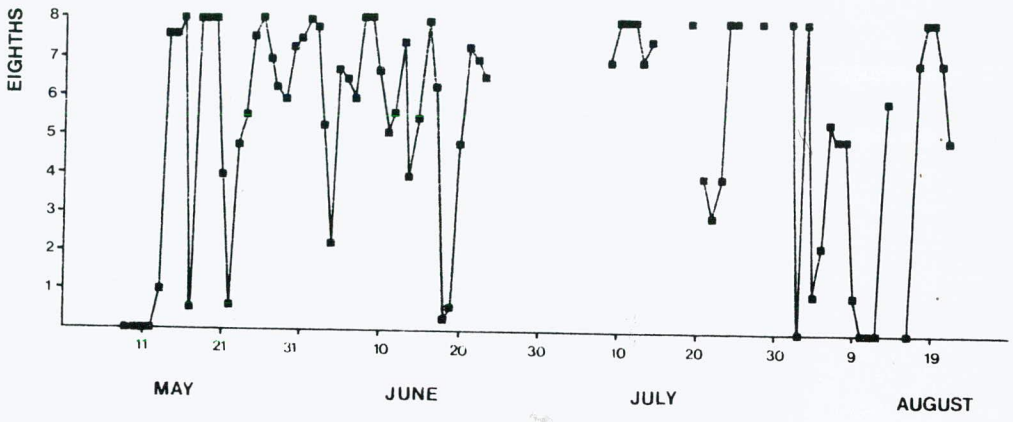


Figure J1.5. Cloud cover in oktas, Eqalungmiut Nunât, May-August 1979.

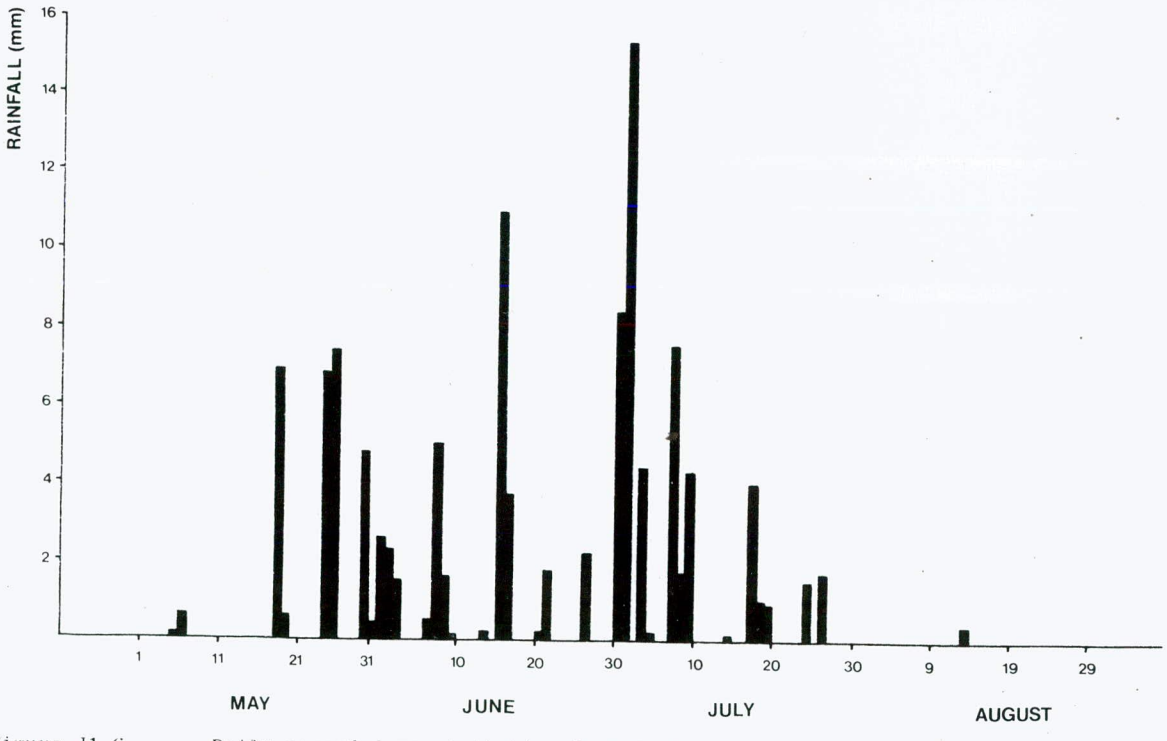


Figure J1.6. Daily recorded precipitation from Søndre Strømfjord Air Base, May-August 1979.

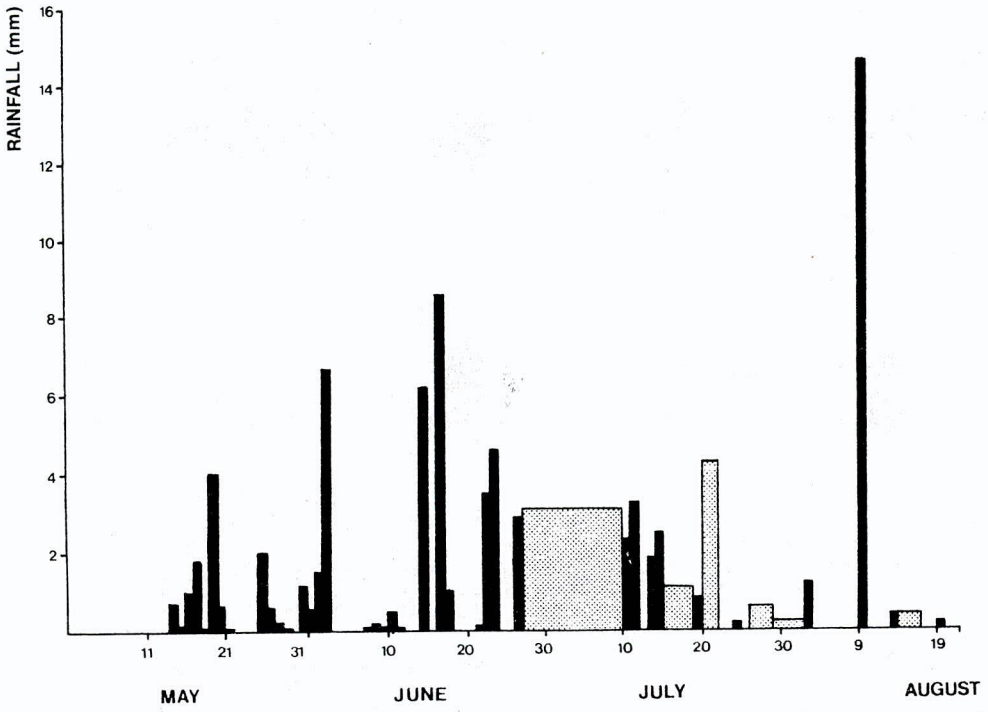


Figure J1.7. Daily recorded precipitation from Eqalungmiut Nunât, May-August 1979. Shaded areas indicate combined daily measurements.

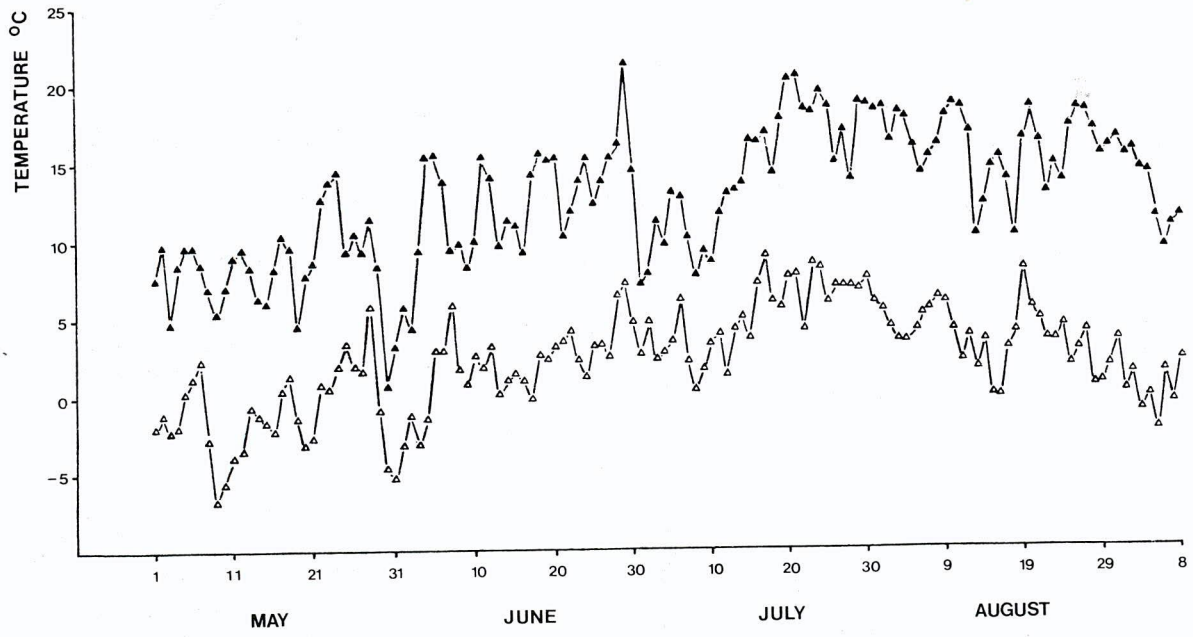


Figure J1.8. Maximum and minimum daily temperatures recorded at Søndre Strømfjord Air Base, May-August 1979.

Diurnal frequencies of wind direction are shown in Figure J1.4; no trends emerge, except perhaps a greater frequency of northerly winds after midday. Thus, Base Camp at least did not experience any diurnal catabatic winds from the plateau.

Föhn-type winds were experienced on several occasions. There are two types which are difficult to distinguish; air passing with sufficient velocity over a high barrier such as the ice-cap develops standing waves on the lee side, resulting in either lenticular or wave clouds, and it becomes warmer and drier as it descends. A similar effect is found when a large temperature inversion over the ice drains off by gravity flow with originally cold air already very dry. We experienced strong, warm and dry winds on at least two occasions, 11-12 June and 16-17 July, although on the latter date, it seems to have been very sheltered in Base Camp, where winds exceeded 80 km h^{-1}, compared with the plateau. Lenticular clouds associated with less intense winds were visible on other dates in the latter half of July.

The maximum recorded wind speed on a daily basis is shown in Figure J1.2, a calm August contrasts with a much windier May and June.

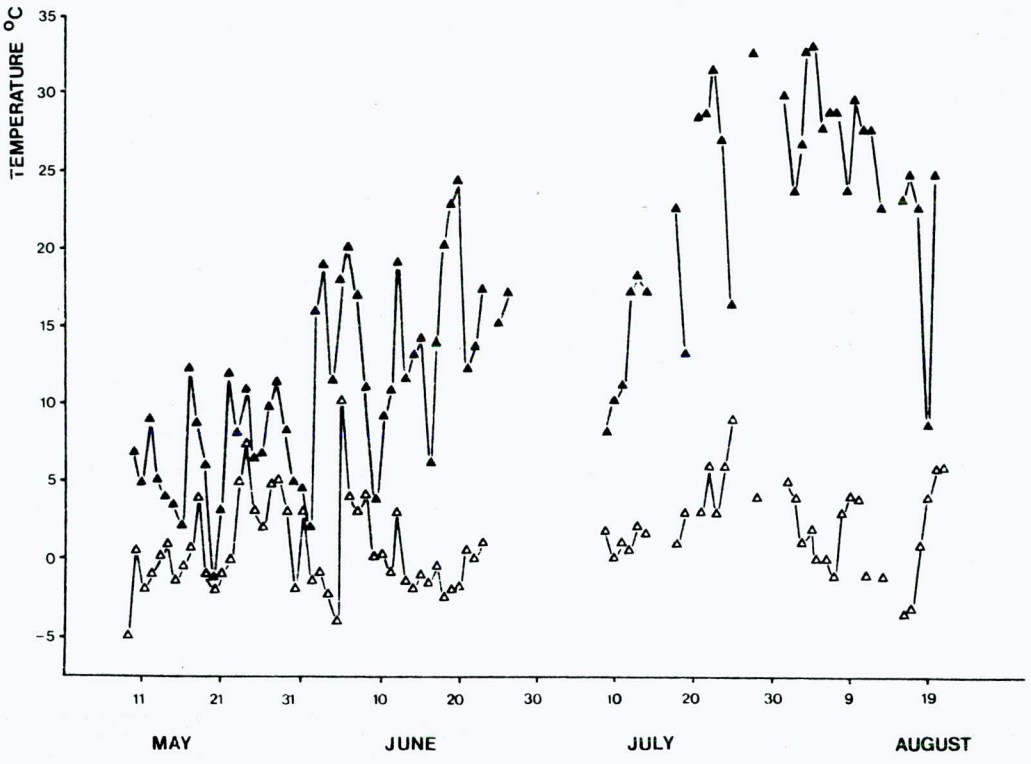


Figure J1.9. Maximum and minimum daily temperatures recorded from Eqalungmiut Nunât, May-August 1979.

Cloud Cover

Patterns in cloud cover shown in Figure J1.5 suggest a high input of solar radiation throughout the summer period which accentuated the water stress imposed on the vegetation system by the already dry air and low precipitation.

Precipitation

Eqalungmiut Nunât experiences low precipitaion, distributed throughout the period May to September (Figure J1.7).

Temperature

Minimum temperatures were usually recorded at 24.00 hours and since it seemed to get colder later in the night, these do not represent absolute minima. Similarly, the maximum recorded temperatures may be slightly inflated in the absence of a Stephenson's Screen.

DISCUSSION

The climate of this region of west Greenland is important since it is here that there is a major disjunction in botanical communities (Bocher & Laegaard 1962). Unfortunately our observations were not sufficiently precise to allow comparison with other areas, but gross comparisons with Søndre Strømfjord Air Base (Figures J1.1, J1.6 and J1.8) indicate that the latter site has a more severely continental climate. This was apparent by comparison of vegetation in August; Eqalungmiut Nunât remained quite lush whilst Søndre Strømfjord Air Base appeared severely drought-stricken. Although Eqalungmiut Nunât Base Camp and Søndre Strømfjord Air Base are similar distances from both ice-cap and open coast, the former is closer to large expanses of open water in Nagssugtôq and the Arfersiofik fjord complex and this fact may explain the more mildly continental climate of Eqalungmiut Nunât.

In future, it would be interesting to see how different areas of Eqalungmiut Nunât differ with respect to meteorological variables recorded in this study, since the climatic pattern is known to have an important effect in determining not only differences between regions (Bocher & Laegaard 1962), but also the spatial variation of plant communities over relatively small areas (Trapnell 1933).

J2 THAW OF SEASONAL ICE

D. A. Stroud

In planning our projects it was not appreciated how important the thaw was to be in determining movements of the local fauna, so unfortunately we did not set up soil temperature recording stations or make regular observations of the thaw of the ice on the lakes. However, with regard to the latter, there are sufficient photographs and observations to construct a fairly accurate account of the thaw as reflected in the surface ice melt. As intimated earlier in this Report, the thaw on the plateau was considerably later than on the lowlands. Most of the small pools of Kûk Marshes had thawed completely by 7 May whereas there was still considerable ice on Atanârssuk in the first week of July.

LAKES

Lowlands

On 5 May the ice of Eqalungmiut tasê was thick enough to land a plane on (*c.* 30 cm), although it was beginning to turn slushy around the edges, particularly on the northern side. By 21 May there was about 3 m of open water around the edge of the lakes, increasing in width to 5 m the following week. By the end of the month the water level of the lakes had risen noticeably. On 5 June the ice suddenly appeared very dark and patchy and large cracks appeared; shortly afterwards the single ice sheet fragmented into several large pieces. By about 7 June it was noticed that the ice of the east lake was thawing considerably more slowly than that of the west lake, which apart from a few cracks around the edges was more or less in one piece. This was probably due to shading from Ímajuitsoq. By 10 June the west lake was only half covered by a thin ice sheet in the middle. On the following day it was driven against the north shore by strong föhn winds and, after riding up over the bank in places, completely broke up. On 12 June the winter ice had entirely gone but on still nights for the next week the surface could be seen to freeze.

The other lowland lakes followed a similar pattern of thaw and breakup, although the smaller, lower and more exposed to the sun they were, the quicker they became ice-free.

Plateau

On 5 May Top Tarn (300 m altitude) had thawed for 2 m around the edge but all the lakes higher than this were more or less completely covered with ice thick enough to support Caribou herds and walkers. Axewater took a particularly long time to melt, largely due to its being shaded from most angles. On 17 June it still had 95% cover of thick ice though there was a 6 m clear strip about the edge. On 23 June Alpha, Bravo and Charlie each had between 90 - 95% cover. A week later this had been reduced to about 45% cover of slushy ice that was melting fast. On 2 July, Zulu and Welsh were seen to be clear of ice, but upstream at Boulder Lake there was *c.* 10% and Atanârssuk was still half covered, as was Lake 45. Another week saw the rest of the plateau lakes lose their winter ice.

An important factor determining the date of thaw for the plateau lakes was whether or not they were situated in valleys in the shade of steep north-facing slopes on one side. Those that were, e.g. Axewater, Juliet and Boulder Lake thawed more slowly. The rate of thaw was also affected by the depth and area of water, the largest lakes clearing more slowly, e.g. Atanârssuk and Lake 45.

GROUND ICE

The thaw of ground ice was difficult to follow but was probably related to the flow of runoff. On arrival all ground was frozen, but by about 16 May the ground at Base Camp had become very wet and slushy. The following week was wet underfoot everywhere in the lowlands as the active layer began to form. The rivers rose from a very low level in early May to a distinct peak of flow in mid-June, with a rapid increase about 10 June. There was then a slow decline in surface flow until August when once more streams were at a very low level.

RIVER ICE

Along most rivers the winter ice cleared by mid-May but some accumulations of aufeis persisted longer, until early July on the Atanârssuk outflow, the South Valley sandur was ice-free by the end of May.

SNOW

When we arrived snow-cover was very variable. In the lowlands generally there was little snow on south-facing slopes and probably less than 10% snow cover overall. On north-facing, shaded, lowland slopes and on the plateau, snow-banks could still be found with complete snow-cover. Snow banks shrank steadily throughout the summer and very few pockets of snow remained in August. There do not seem to be any perennial drifts and we found no evidence that any local glaciation has occurred recently.

The Eqalungmiut tasê valley has a reputation in Søndre Strømfjord Air Base for having very little snow even in bad winters and so the region may not be typical, in this respect, of the surrounding area.

SECTION K OBSERVATIONS FROM SISIMIUT

K1 BRIEF OBSERVATIONS ON THE BIRDS OF THE WEST GREENLAND COAST BETWEEN SØNDRE STRØMFJORD AND SISIMIUT

A. D. Fox

INTRODUCTION

Members of the group travelled from Søndre Strømfjord Air Base to Sisimiut on 20 August, to return on 26 August. The passage coincided with substantial movements of seabirds in inshore waters. In an attempt to quantify these, counts were carried out aboard the M.S. *Disko* on both journeys and sea watches were also made from the coast at Sisimit.

In spite of the relative accessibility of this area of coastline, it appears that few previous observations from the region have been published. Brown (1968) collected data from Newfoundland and Greenland waters to the south and brought together information from several surveys in Brown *et al.* (1975), whilst birds seen on sea watches on a route similar to ours are recorded by Wille (1975) and Nordquist and Wille (1976). Evans (1981) carried out extensive census work to the north and south of Sisimiut and in offshore waters to the west.

METHODS

The ship left Søndre Strømfjord Air Base at 16.00 hours on 20 August travelling swiftly down Kangerdlugssuaq to meet the open sea at 23.00 hours, subsequently slowing and turning north to arrive in Sisimiut at 07.00 hours on 21 August. Observations on the passage commenced at first light (around 03.00 hours) and continued to just outside Sisimiut Harbour. Returning along the same route on 26 August, departure was at 16.00 hours, the census started a little later and continued until poor visibility and large numbers of birds brought an early end to the watch at 20.00 hours. The precise course taken by the *Disko* is shown in Figure K1.1. Uninterrupted views over an arc of 180° astern were possible from a position 8-10 m above sea level. Birds were counted as they passed the observation point during five minute intervals. Abundance was plotted graphically (Figures K1.2 and K1.3) along the transect, but general observations were made throughout the duration of the daylight passage. In addition, notes are given on the sea and land birds of the Sisimiut area during the six-day period.

SPECIES NOTES AND DESCRIPTIONS

Red-throated Diver

A common breeding species in this area of west Greenland (S. Malmquist, pers. comm.), two groups of three birds were noted just out of Søndre Strømfjord Air Base, both apparently consisting of two summer plumage birds with an accompanying juvenile as described by Sjolander (1973). Others were seen further down the fjord towards dusk.

Great Northern Diver

Two birds were seen shortly after departure from Søndre Strømfjord Air Base apparently in an advanced state of moult, with a further group of three birds halfway down Kangerdlugssuaq.

Fulmar

Considerably more Fulmar, with a mean of 16.7 birds/five minutes (total 401), were noted on the return passage compared to 4.56 birds/five minutes (total 164) on the outward voyage. The majority of birds were of the double light morph (Fisher 1952), but there was a number of buff-coloured lighter forms on both passages: 6.1% of all birds on 21 August, 7.7% of all birds on 26 August. The precise definition of morph-type of these birds is difficult; in general they were buff-coloured and showed little contrast between mantle and general body colouration and it seems likely that they are best ascribed to the dark (D) form. Brown (1968) found between zero and 5% (mean 2.4%) of dark (D) morphs in small sample counts in April and May, whilst Salomonsen (1965a) found 5-10% in transects off Kap Farvel in May. Evans (1981) saw a total of 2.5% dark morphs (up to 6.1% on individual transects) in late August to early September off west Greenland. The presence of at least some high arctic darker morphs suggests that birds off this section of coast at this time come from the more northerly of the Greenland colonies, migrating to the cold waters inshore off Newfoundland where they are thought to winter (Brown 1970; Tuck 1971). No birds were encountered within the coastal archipelago fringing the coastline.

Great Shearwater

On the outward journey, a total of 73 Great Shearwaters passed the *Disko* moving south in 2¼ hours, but the ship passed considerably more birds (192 in 40 minutes) on the return journey on 26 August; on both occasions, birds were encountered immediately before passing into a fog bank. After 18.40 hours on 26 August, attempts to count the birds were abandoned with up to 500 Shearwaters around the vessel at this time. Birds were moving both north and south, and this, together with a large number associated with the *Disko*, made accurate assessment of numbers impossible. It was generally agreed by the members of the group that we had seen several thousand birds.

The entire breeding population of at least 5 000 000 Great Shearwaters undertakes a transequatorial migration to spend the northern summer in the North Atlantic. The majority seem to summer off the Newfoundland Banks, but may penetrate north into Greenland waters (Brown 1968; Brown *et al.* 1981; Voous and Wattel 1963). Salomonsen (1950a) describes the Great Shearwater as a common species in the southern Davis Straits northwards to *c.* 66°N, arriving in early June, increasing until August and leaving Greenland waters in the latter part of September. He also states that foggy weather often results in large numbers approaching close inshore.

Eider

A few Eider were seen, mostly in the entrance to the Sisimiut Harbour.

Red-breasted Merganser

A female with five small ducklings was seen on the town reservoir, Sisimiut.

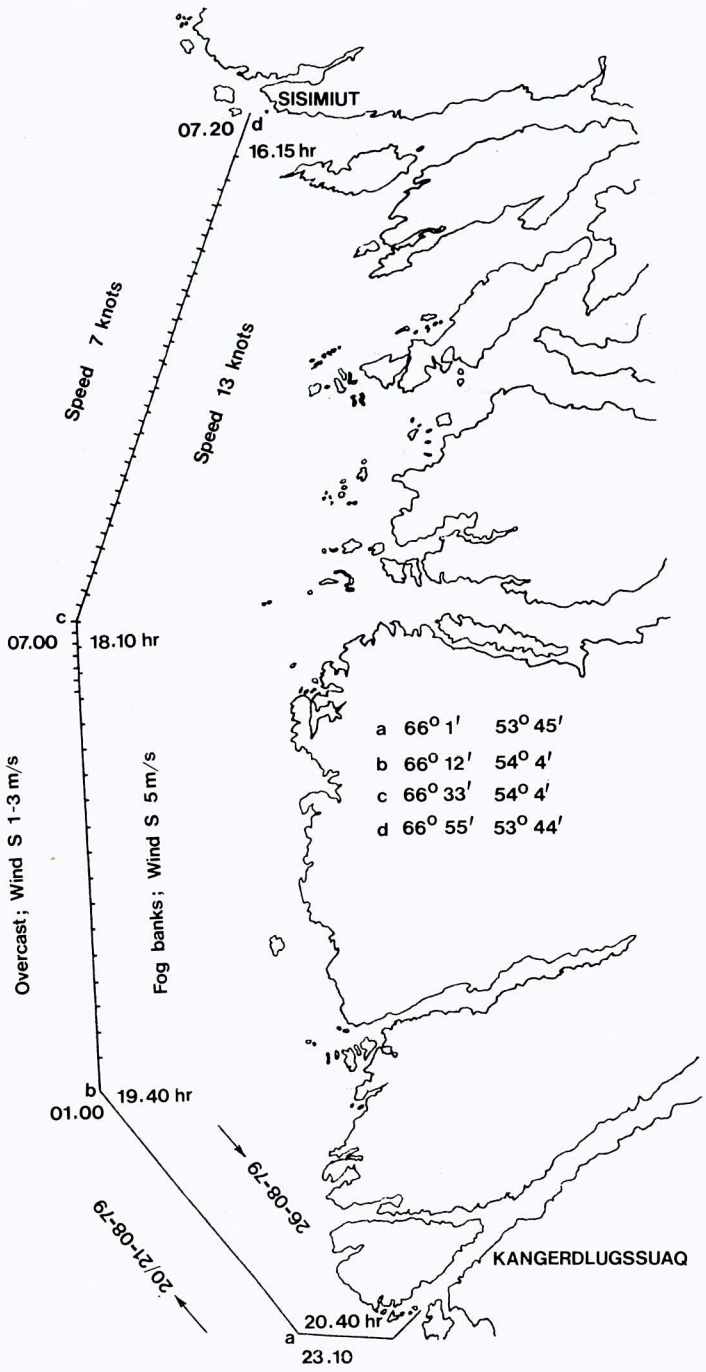


Figure K1.1. Course of the M.S. *Disko* on 21 and 26 August 1979, showing five-minute census intervals and other details from both passages (from details supplied by J. Jensen).

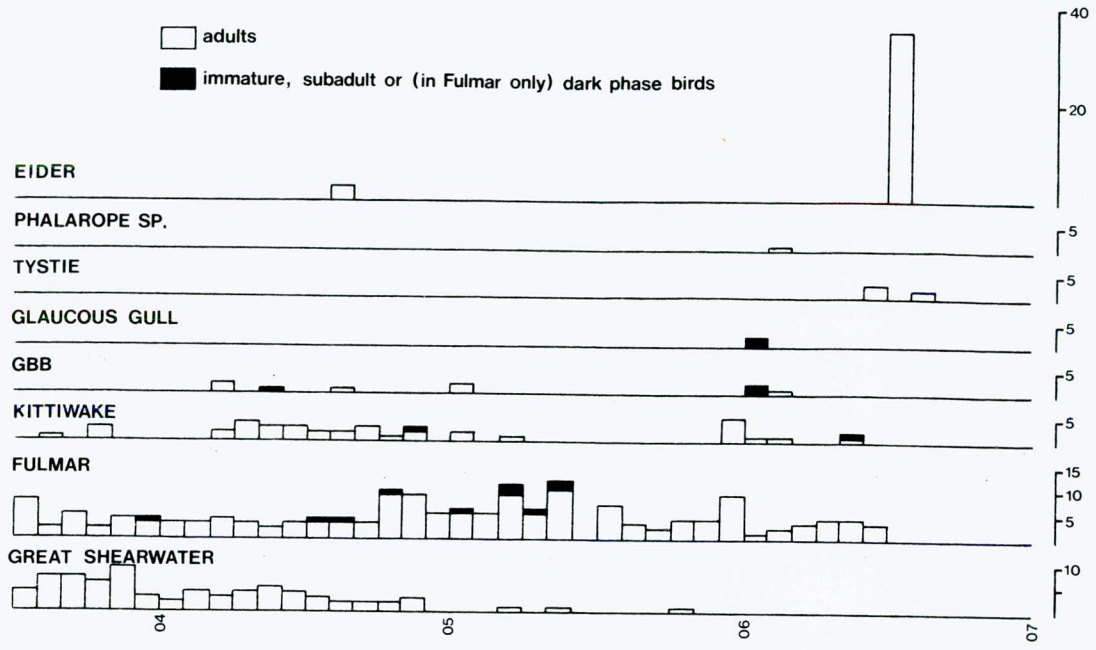


Figure K1.2. Numerical abundance of sea-birds during the passage to Sisimiut, 21 August 1979.

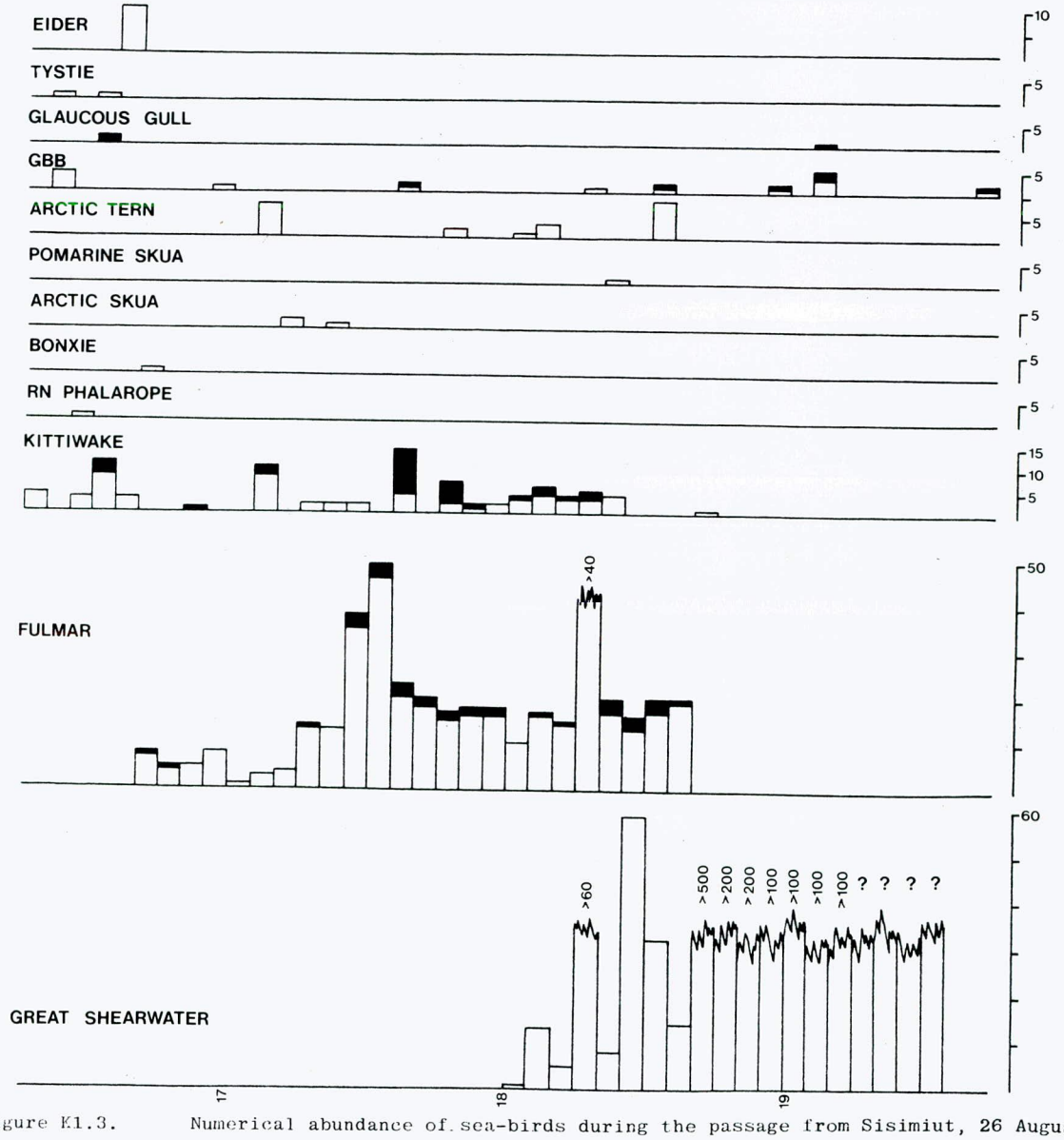


Figure K1.3. Numerical abundance of sea-birds during the passage from Sisimiut, 26 August 1979.

Peregrine

Birds were heard calling from Kaellingehaetten, Sisimiut, on 23 and 24 August, although no birds were seen.

Ptarmigan

No birds were seen, but droppings were found amongst the *Salix glauca* scrub along the coast south of Sisimiut.

Ringed Plover

Four or five birds flew over the camp site south of Sisimiut calling on 23 August after dark.

Purple Sandpiper

Single birds were noted from the shoreline south of the town on a number of occasions.

Phalaropes

Two single Phalaropes were noted on each passage in inshore waters close to Sisimiut. On 21 August, the species was not determined but the concensus of opinion was that it was a Grey Phalarope. A winter plumaged Red-necked Phalarope passed close to the *Disko* on the return voyage.

Great Skua

One bird was watched south of Sisimiut on 26 August. Salomonsen (1941b) recorded only 16 occurrences of this species in Greenland, but increased activity in the area has brought more records. Brown *et al.* (1975) record 26 sightings in the Davis Strait from August to October, whilst numbers were regularly recorded from off the Labrador coast and other parts of eastern Canada from all times of the year. Similarly Boertmann (1979) recorded the following numbers during Danish Ornithological Expeditions, 1972 - 77:

1972	0	1973	2	1974	3
1975	7	1976	6		

During extensive census work in late August and early September 1974, a total of twelve birds was seen off the coast of west Greenland (Evans pers. comm.). Ringed returns have shown that these are non-breeding second and third year birds from the eastern Atlantic colonies (Landsborough-Thomson 1966; Tuck 1971; Furness 1978).

Pomarine Skua

A single light phase bird was observed pursuing an adult Kittiwake on 26 August.

Arctic Skua

One pair and later a single dark phase bird were noted on 26 August. This species is common along the entire west coast of Greenland during August and September (Godfrey 1966; Brown *et al.* 1975). It is generally assumed that they are less numerous than Pomarine Skuas and it is likely that the major part of the movement south of both species occurs later than the dates of the voyages.

Iceland Gull

Up to 40 birds associated with Glaucous Gulls fed about the *Disko* at rest in Kangerdlugssuaq with birds following the vessel down the fjord for some hours. No Iceland Gulls were seen during the transect census, but up to 60 were present in and around Sisimiut, although it is interesting to note that no second year birds were encountered.

Glaucous Gull

A few juvenile birds were seen during the passage, with adults and birds of the year in large numbers close inshore at Sisimiut and along the eastern stretches of Kangerdlugssuaq. A maximum of *c.* 150 hyperboreal gulls, mostly this species, were present in the harbour at Sisimiut on the arrival of the *Disko* on 21 August, seemingly the result of the roosting flock being held on site late into the morning by a sea mist. Birds regularly flew into the harbour to roost from the north and south, dispersing during the morning to leave 15 - 80 birds throughout the day.

Great Black-backed Gull

Up to *c.* 40 birds gathered in the harbour at Sisimiut on most days, and were observed off the coast south of the town. Ratios of adult: sub-adult: juveniles were 7:3:1 from five hours of sea-watching, and 22:4:9 from two counts in the harbour. Occasional birds were encountered at sea along the transect from inshore and outer waters alike, small groups frequently emrging from the sea mist. The species breeds no further north than Disko Bay with most of the population moving south, although Brown *et al.* (1975) state that Great Black-backed Gulls remain in the Atlantic Boreal and low Arctic waters throughout the winter.

Kittiwake

Considerably more birds were noted on the journey south from Sisimiut compared with the earlier passage, and on the second journey, the proportions of juveniles had risen from 5.9% (n=36) to 33.0% (n=88). Birds were present inshore and several kilometres out from the coast, but large numbers were noted off Sisimiut on 26 August when as many as 300 were present in three large rafts just south of the town.

Arctic Tern

No birds were seen on the outward journey to Sisimiut, but 22 flew south past the ship on 26 August. It would seem that these were amongst the later birds in the vicinity as Brown *et al.*(1975) state that most Arctic Terns have left Greenlandic waters by early September.

Black Guillemot

Characteristically solitary, the Black Guillemot was rarely seen far from the shore, being numerous in the coves of the coast south of Sisimiut.

Water Pipit

Birds were heard on 23 and 24 August, and finally two birds were seen around the camp south of Sisimiut on 26 August.

Wheatear

Juvenile birds were present on most days around the Sisimiut reservoirs.

Lapland Bunting

Relatively few Lapland Buntings were seen during the stay on the coast, with only a maximum of ten seen in any one day around the town, the majority being juvenile birds.

Snow Bunting

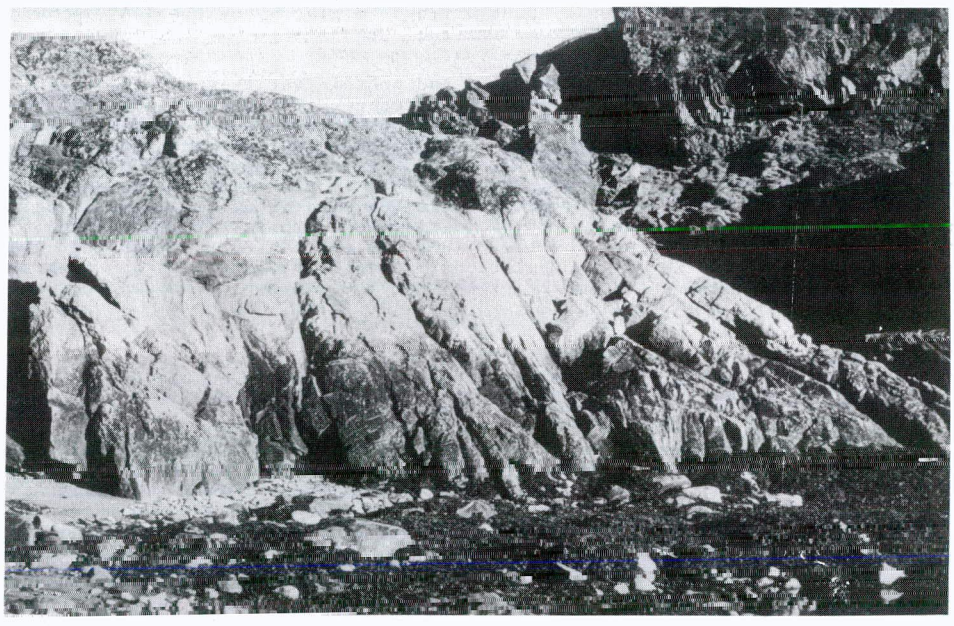
Large aggregations of young birds were moving through and around Sisimiut during the stay. Birds were particularly numerous behind the Sømandshjemmet feeding on a bank covered with *Stellaria media*, and in the surrounding areas out of town the birds fed on the plentiful bulbils of *Polygonum viviparum*.

Redpoll

This is the most numerous bird in Sisimiut, with large numbers about the houses feeding on the seed heads of *Taraxacum spp.*, *Eriophorum angustifolium* and *Polygonum viviparum*. This abundance is remarkable in view of the rarity of the Redpoll as a breeding species in the cool, damp coastal areas of west Greenland. Many of the birds were juveniles, presumably on post-breeding passage from the interior. Redpoll made up 76% of the birds ringed in Sisimiut.

ACKNOWLEDGEMENTS

I am extremely grateful to Dr Peter Evans for permitting me to use data taken from his extensive sea transect work of 1974 and for comments on the status of sea birds in the Davis Strait. My sincere gratitude also goes to Captain Jorgen Jensen, master of the M.S. *Disko* who kindly and cheerfully supplied considerable detailed information on the course and speed of the vessel and to Peter Hope-Jones for his advice on colour morphs of the Fulmar.



Shore-line *Littorina rudis* collection site, Sisimiut, September 1979. Note clear ice-scoured region in Littoral zone.

K2 THE DEMOGRAPHY AND REPRODUCTION OF *LITTORINA RUDIS* Maton 1797 FROM GREENLAND

D. A. Stroud & J. Knudsen

INTRODUCTION

The ecology of *Littorina rudis* from temperate shores has been well documented, however compared with the volume of publications concerning these southerly populations there have been very few investigations of the basic ecology of this species in the arctic. In many respects this is surprising since there is much to be learnt from populations at the edge of a species' range. The material presented here derives from two sources. Whilst in Sisimiut, DAS made collections of *Littorina* for subsequent investigation of population structure at different levels on the shore. An investigation of the reproduction of *Littorina* in Greenland was undertaken by JK using material mainly collected by Dr F Salomonsen on his 1936 expedition to north-west Greenland (Salomonsen 1943: p.7). Studies of material collected at the same sampling sites had previously been published by Madsen (1940) and Vibe (1940). The collections of the present expedition and those of the Zoologisk Museum, Copenhagen allow a comparision of many Greenlandic populations. As this work has not previously been published and is largely complementary to the Sisimiut investigation it is presented here. A brief review of the literature concerning *Littorina rudis* in Greenland has also been undertaken, together with a short summary of the taxonomic history of this species.

The Sisimiut demographic study is presented first, followed by the 1936 study of reproduction and fecundity.

Taxonomy

The taxonomic history of the *Littorina saxatilis* species-complex is involved. *Littorina groenlandica* was first described by Mencke in 1830 as a full species, but Posselt and Jensen (1898) considered it to be a variety of *L.rudis* distinguished by its more slender shell shape and strongly developed sculpture. James (1968) examined over 55 000 *Littorina* from British shores, describing a large number of varieties and sub-species from the *Littorina saxatilis* group, giving *L. s. groenlandica* full sub-species status. He considered that it could be found outside Iceland and Greenland citing records from Shetlands and Dublin. Heller (1975), in a study of the rough winkle from Wales, found that such 'splitting' was unjustified and that the variation within the group could adequately be described within a framework of four species *L. rudis*, *L. nigrolineata*, *L. patula* and *L. neglecta*. Both Heller (1975), and Raffaelli (1979) have shown that on morphological grounds, *L. s. groenlandica* is only an extreme variant of *L. rudis*. More recently Heller's classification of the group has been changed when it was shown that *L. patula* was in fact synonymous with *L. rudis* (Rafaelli 1979, Hannaford Ellis 1979). Although *patula* is now regarded as a synonym of *rudis*, this species has recently been divided to give a new species, *Littorina arcana* (Hannaford Ellis 1978, 1979). Thus at the time of writing the *Littorina 'saxatilis'* species complex is thought to consist of four valid biological species: *Littorina rudis*, *L. nigrolineata*, *L. neglecta* and *L. arcana*.

Wium-Andersen (1970) investigated the haemoglobin and protein variation of the rough winkle from Denmark and Greenland. She found considerable genetic differences between *L. rudis* from the two areas, which, together with ecological differences (Petersen 1962, Muus 1967), she considered enough to indicate that *L. rudis groenlandica* was a distinct species. Given that there are genetic but little or no morphological differences between the *Littorina* of Greenland and those of more southerly populations, this would suggest that they are sibling species (Mayr 1963). Such a situation is common in the arctic (Dunbar 1968) and might explain the taxonomic confusion concerning this population, for despite a general structural similarity, there are ecological differences shown by rough winkle in Greenland and the geographic separation of the population has naturally led to a supposition that there should be racial differences compared with European populations. Genetic differences, as shown by electrophoretic studies, should be given more taxonomic weight than the absence of any major morphological difference.

No specific investigation of this complex problem has been undertaken in this study. However, both the samples from Sisimiut and elsewhere are broadly similar to *Littorina rudis* from the North Sea, and will be referred to as such hereafter, given the reservations expressed above.

Distribution

The distribution of *Littorina rudis* in Greenland has been described by Posselt and Jensen (1898) and Thorson (1944). On the west coast, the rough winkle is found as far north as the Upernavik District (Figure K2.1). Madsen (1940) mentions that Salomonsen found *Littorina* at Tasiussak (73°22'N), although a number of localities north of this were searched in vain (Vibe 1950). In east Greenland its limit seems to be Tasiusaq (Angmagssalik) (Thorson 1944), although it may extend slightly further north in benthic populations.

Together with *Balanus balanoides* and *Mytilus edulis*, *L. rudis* is a subarctic indicator species (Stephenson and Stephenson 1972). On the west coast of Greenland the subarctic littoral extends above the Svartenhuk Peninsula (72°N). The marine subarctic extends further north on the west side of Baffin Bay to Melville Bay (Dunbar 1968). In east Greenland the littoral subarctic extends to just north of Tasiusaq (65°30'N).

DEMOGRAPHY

SITE DESCRIPTION AT SISIMIUT AND METHODS

Our visit to Sisimiut (66°57'N) coincided with a period of spring tides, thus collection could be made in the sublittoral zone. The tidal range at Sisimiut is 4.8 m and on 24 and 25 August 1979, the level dropped to within 0.9 m of the extreme annual low water spring tide. Steven (1938) collected from the shores of Amerdloq Fjord to the south of Sisimiut, but unfortunately there was little opportunity to visit the same sites and all collections were made from one very sheltered bay 1 km south of town. This bay (Figure K2.2) is at the head of a narrow 1 km long inlet facing due west and sheltered from the north and south. Its mouth is protected from westerly seas by the islands lying immediately offshore and the lack of exposure is reflected in both flora and fauna present. On Ballentine's (1961) exposure scale, derived from a study of Welsh shores, the exposure was estimated to be "very sheltered" or Scale 7.



Figure K2.1. The range of *Littorina rudis* in Greenland. Sampling sites are shown in bold type, other localities are referred to in the text. The range in north-east Greenland may extend further north in the sublittoral.

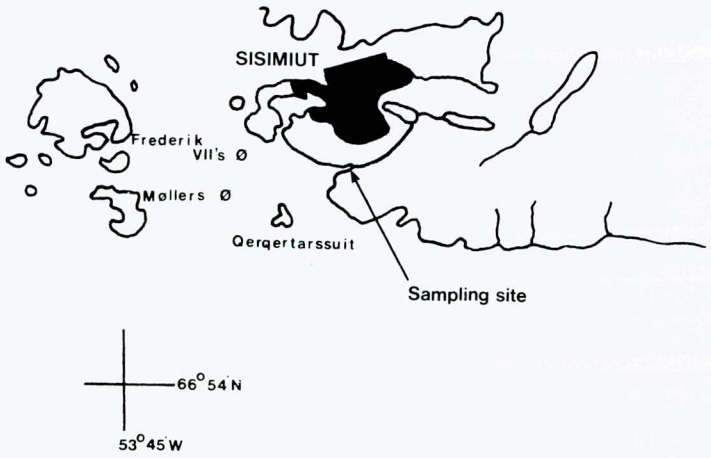


Figure K2.2. Sketch map showing the location of the Sisimiut sampling site in relation to the town. The shaded area marks the extent of the town, whilst the arrow indicates the collection site.

On the north side of the inlet, about 0.5 km from the beach, a sewage outlet and drainage from the town rubbish dump results in dystrophication and the rocks nearby are covered with green algae. However, the visible effects of this pollution do not extend for more than 100 m on either side of the outfall and it is unlikely that the sewage has much effect on the beach. The inlet is cliff bound (10 m height) for its entire length, but at the inland end there is an area of silver sand and algal covered rocks (Figure K2.3). The sand extends out into the sea from the base of the cliffs. A stream enters the bay across areas of mud exposed at low tide, and between this and the sand is a flat expanse of rocks with large boulders.

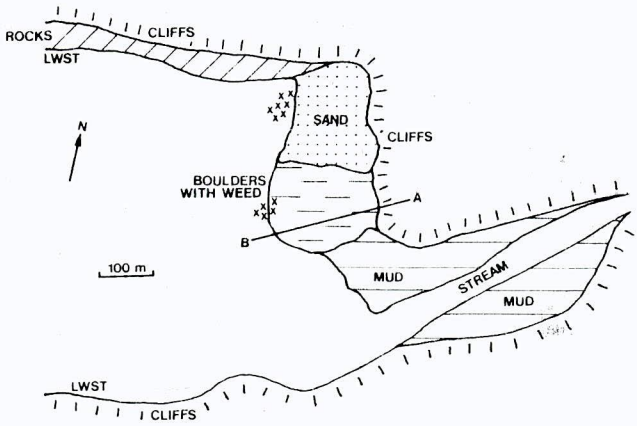


Figure K2.3. Head of inlet south of Sisimiut, the collection site of both *Littorina* and Ostracoda. Ostracod collection sites (section K3) are marked with small crosses, whilst the *Littorina* were collected along the transect A - B (see Figure K2.4).

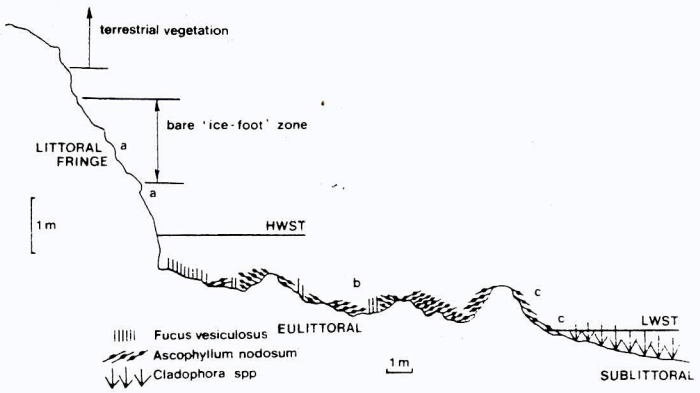


Figure K2.4. Transect across the shore A - B, showing the collection sites of *Littorina rudis*: a = high shore sites, b = mid-shore site, c = low shore sites.

A section across the rocky foreshore is shown in Figure K2.4. One of the most immediately obvious features of the cliffs is a 3 m strip of barren rock near the high tide level more or less coinciding with the littoral fringe zone. The strip is devoid of any lichen cover and the rosy pink of the underlying gneiss is conspicuous. The terrestrial vegetation of stunted *Salix glauca*, *Vaccinium uliginosum*, *Polygonum viviparum*, *Sedum rosaea* and grasses, mosses and lichens extends down to the barren strip in places, although more usually there is a region of crustose lichens between the top of the bare zone and the cliff-top turf.

The barren region is caused by the action of the winter "ice-foot" disrupting normal settlement patterns (Petersen 1977) and is important in the annual cycle of arctic *Littorina* (see below). At the base of the cliffs the dominant algal cover is of *Fucus* and *Ascophyllum nodosum* with increasing abundance of *Cladophora* and Rhodophyceans on the lower shore.

Samples of *Littorina* were taken from three shore levels: from the barren littoral fringe region, from the fucoid-covered eulittoral, and from the cladophoran-covered sublittoral (Figure K2.4). Collections were made by taking every individual in a delimited area, although no records were made of density. Animals were preserved in borax-buffered 4% formalin shortly after collection. Two samples of 835 and 487 animals were collected from the upper shore, but as the age and shell height frequencies of these samples were not significantly different from each other they have been combined. One sample of 357 was collected on the mid-shore, and two samples of 550 and 208 from the low shore which have similarly been combined.

It was found possible to age shells on the basis of the prominent annual growth rings indicating where shell growth has stopped for the winter. On arctic molluscs these lines are distinct and in the same relative positions on all shells. They have previously been used with great success in other arctic molluscan studies (e.g. Petersen 1978). It was not possible to directly age two categories of shell: those in which the shell had been chipped and where regrowth had subsequently obscured the rings, and those on the low shore where algal growth and other encrustations grew on the shell surface. It was not possible to remove these encrustations for fear of damaging the shell, thus shell height frequency was used as an approximation of age class frequency in low shore samples. Shell height and width were measured to 0.05 mm with vernier calipers using the parameters of Raffaelli and Hughes (1978), but shells less than 3.5 mm high were measured to the nearest 0.5 mm.

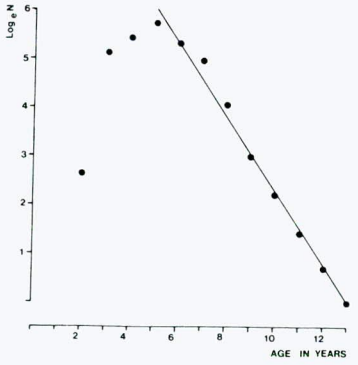


Figure K2.5. Survivorship curve for amalgamated high shore samples of *Littorina rudis* at Sisimiut. Total sample = 1028 individuals. There are reasons to believe that immigration into this population occurs in the first five years (see text); adult instantaneous mortality, μ, is estimated by the regression coefficient between years 5 and 13, and equals -0.765. Adult suvivorship (proportion surviving per time t) is equal to $e^{-\mu t}$, and for this population is 0.465.

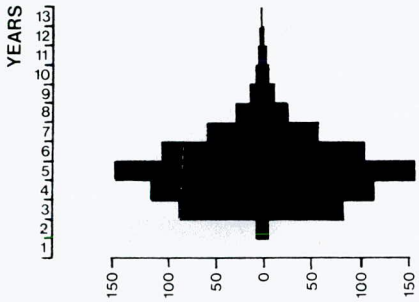


Figure K2.6. Age structure for amalgamated high shore samples (n = 1028).

RESULTS

Age Structure of Samples

It was only possible to age directly the high shore sample and Figures K2.5 and K2.6 show the frequency of the age classes. The trend is clear; no young of the first year, but thereafter they occur in increasing numbers with a maximum density in the 5+ year class. Then there is an annual logarithmic decline in the numbers of each cohort to a maximum age of 13 years (0.092% of the population). The frequency of shell heights in each cohort is shown in Figure K2.7.

Size Frequency

Nearly all the low and mid-shore animals were covered in encrustations, thus no direct measure of age structure was possible and the frequency of different shell heights was used instead (Figure K2.8). The results show that the size frequency of animals varies markedly at different heights on the shore. The high shore sample is characterised by animals more than four years old, and this is shown by a predominance of shells greater than 7 mm high; however the low shore sample contains very few of these older animals and a high proportion of the younger age classes. Low-shore *Littorina* grow to about the same maximum height as those on the upper shore, although it is not possible to say if the growth rate is the same. The mid-shore sample shows characteristics of the populations above and below it. Young animals (although fewer than on the low-shore) are present, as are older animals. The modal peak of 7.0 - 7.5 mm approximates to the fifth age class as is found on the upper-shore.

Growth Rates

It is possible to estimate growth rates for the upper shore samples by plotting the mean size of cohorts against their age (Figure K2.9). This is not as satisfactory as using size changes from marked animals over periods of time (e.g. Hughes 1980, Hughes and Roberts 1980, 1981), since it is assumed that all animals of the same age grow at the same rate, a premise that may not be strictly true. The growth rate is given by the equation:

$$y = 1.16 + 3.99 \ln x$$

where y is shell height in mm, and x is age in years.

Greenland *Littorina* have a very slow growth rate compared with more southerly populations. At Sisimiut *L. rudis* take ten years to grow to a height of 10 mm whilst in North Wales this height is achieved by animals less than two years old (Hughes and Roberts 1981). The maximum size to which arctic winkles grow is possibly slightly less than temperate animals: at Sisimiut the maximum recorded height was 13.8 mm compared with 15.2 mm in North Wales.

Shell Shape

The relationship between shell height and width is linear and can be expressed by the equation:

$$y = 0.2 + 0.7 x$$

where y is shell width and x is shell height in mm. The very linear relationship suggests a functional significance, however comparision with samples from shores of differing exposure is needed to elucidate this.

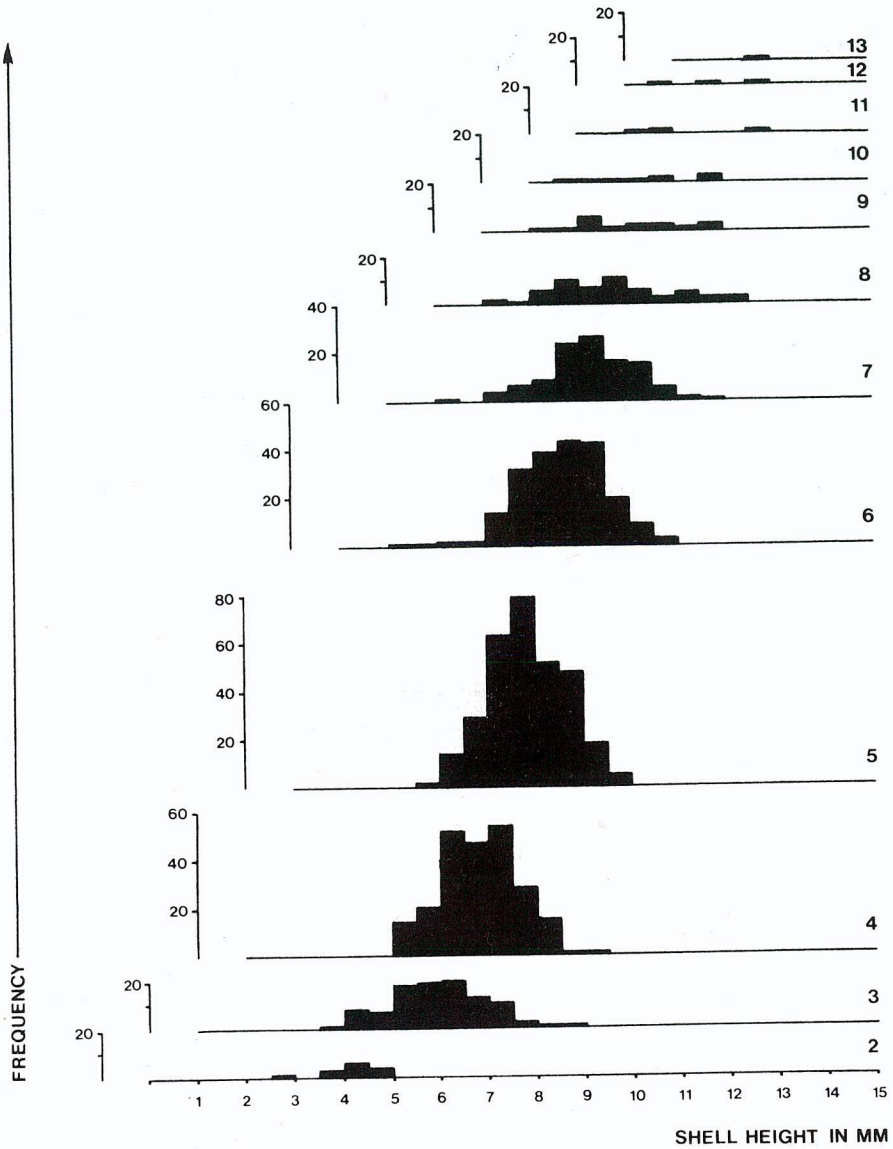


Figure K2.7. Age-height frequencies for each of the year classes present in the high-shore samples.

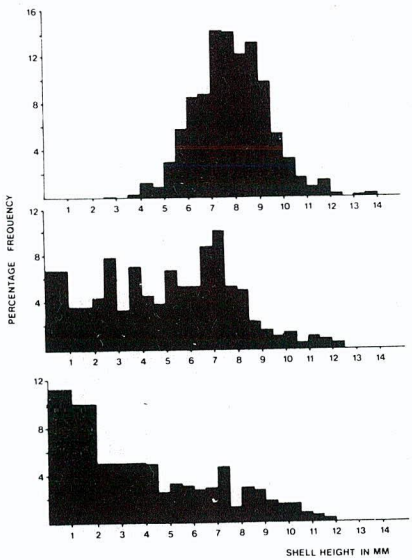


Figure K2.8. Size frequencies at different levels on the shore. Sample sizes: high shore = 1148, mid-shore = 357, low shore = 758.

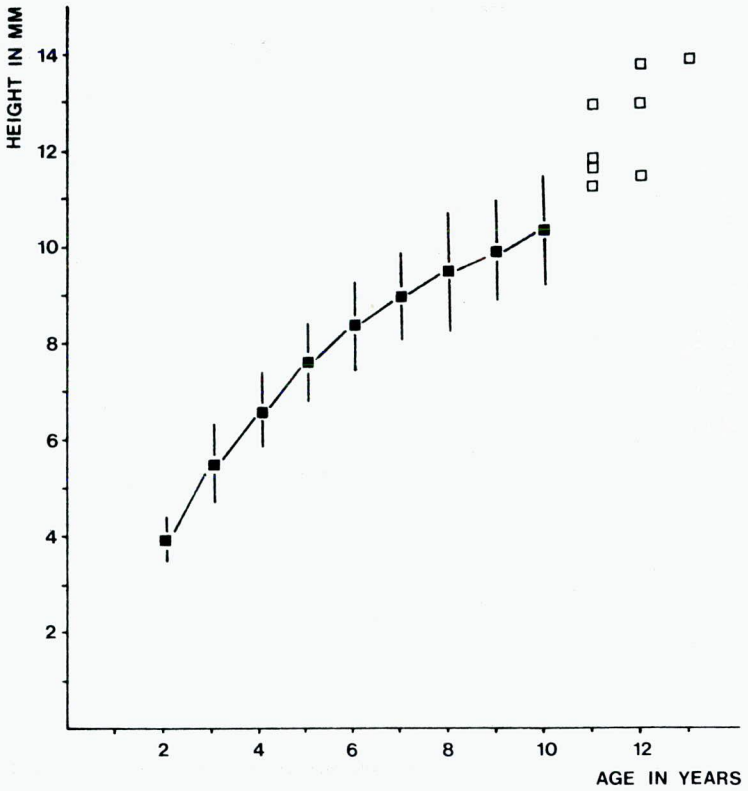


Figure K2.9. Growth curve of high shore samples. Mean Height (± standard deviation) of each year class. Points are single shell values. Line plotted by eye but described by the equation $y = 1.16 + 3.99 \ln x$.

Smith (1981) investigated the shape and size of the shell aperture in *L. rudis* from Cornwall and found with increasing shelter the relative breadth of shells decreased whilst the height of the spire increased. Of his study sites the regression coefficient between shell height and width varied between 1.90 (most exposed) and 1.59 (most sheltered). That found in this study, 0.7, is lower than any found by Smith and possibly indicates the extreme shelter. The significance of this is less than clear, however, without measurements from exposed populations, since it may be that the regression coefficients of all arctic *Littorina rudis* are lower than those of temperate animals.

Littorina rudis is apparently not found in brackish waters in Greenland. In North Atlantic waters it can be found in a wide range of salinities (down to 7-8‰; Fretter and Graham 1981), and Thorson (1940) records *L. rudis* from a number of brackish localities in Iceland; however there are no records from Greenland either in the literature or from collections in the Zoologisk Museum, Copenhagen. Until extensive searches have been made not much stress can be laid on the absence of reports. If a real phenomenon, it may be due to waters of a lower salinity freezing earlier and thawing later than normal sea water. This will reduce the growing season in the summer, and in effect create conditions similar to those at higher latitudes. It also seems that *Littorina* is absent from the brackish waters of other arctic areas such as Spitzbergen and north Norway.

REPRODUCTION AND FECUNDITY

MATERIAL AND METHODS

Specimens were collected from a range of localities shown in Figure K2.1 for a study of reproduction in Greenlandic *Littorina rudis* (not all of which is reported here). Some of these samples contained several thousand animals, and where these were too big to analyse in their entirety, sub-samples were taken. The length and breadth were measured and the sex determined. In the sample from Upernavik the development of the penis and the presence or absence of embryos was noted in order to determine the size at onset of maturity. In a large number of the specimens from various localities the number of embryos was counted and the stage of development ascertained. Most oocytes, eggs and hatching embryos were measured.

Unfortunately only preserved material could be examined and thus there is some uncertainty about the degree of shrinkage of eggs and embryos. These difficulties are referred to below and further observations of living animals from Greenland are highly desirable. Figures K2.10 - K2.14 inclusive and Table K2.1 all use 1936 data.

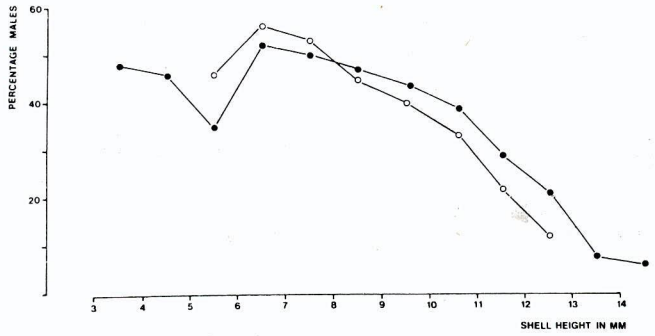


Figure K2.10. Sex ratio found in samples from Nûk Fjord (solid circles) and Upernavik (open circles). Percentage of males plotted against shell height.

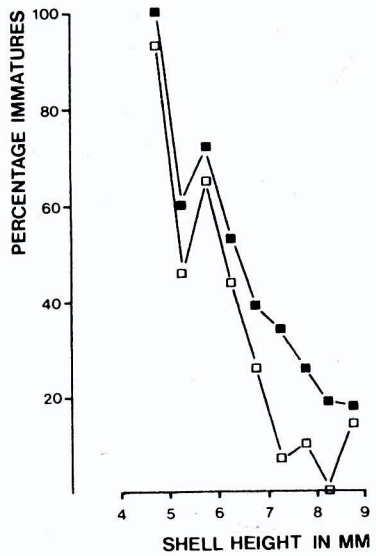


Figure K2.11. Size of *Littorina* at onset of sexual maturity as determined by either size of penis or presence of embryos in brood pouch. Percentage of immature animals against shell height; dashed line for males, continuous line for females. Sample from Nûk Fjord.

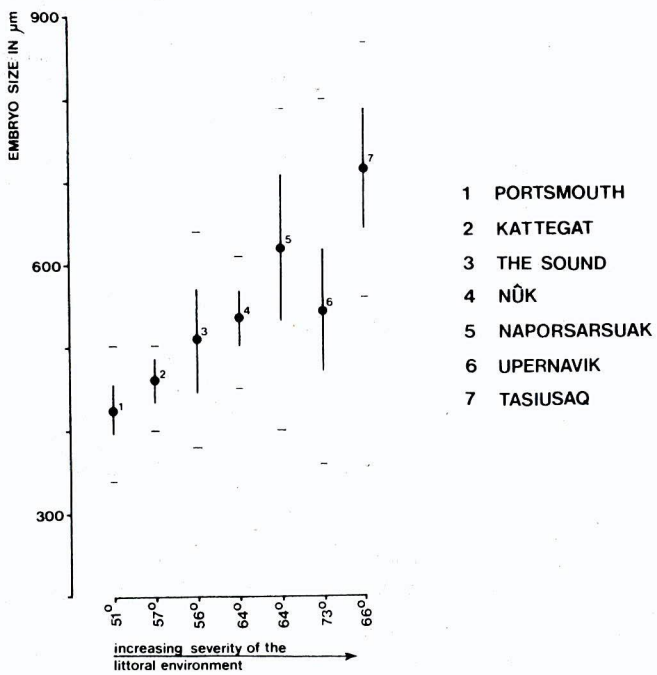


Figure K2.12. Relationship between size of hatching embryo and climatic conditions. Mean, standard deviation and range are indicated. The sites are arranged in order of increasing severity of conditions. (Although at a low latitude Tasiusaq is at the northern range of *L. rudis* due to the presence of the cold east Greenland current draining the Arctic Ocean).

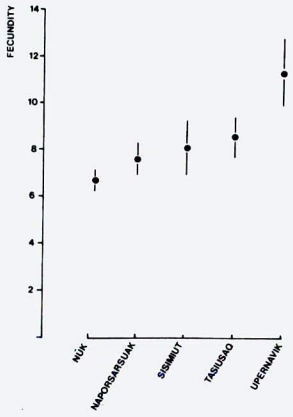


Figure K2.13. Differences in fecundity between collection sites showing a general increase in fecundity with increasing latitude (or more accurately with increasing severity of conditions as the northern limit to the range is approached). Fecundity index is taken as the mean number of young per 1 mm female size. This removes the effect of increasing fecundity with female size (Figure K2.14). Thus a fecundity index of 10 indicates that a 10 mm female would have a reproductive output of 100 embryos at any time. Mean and standard error of mean indicated.

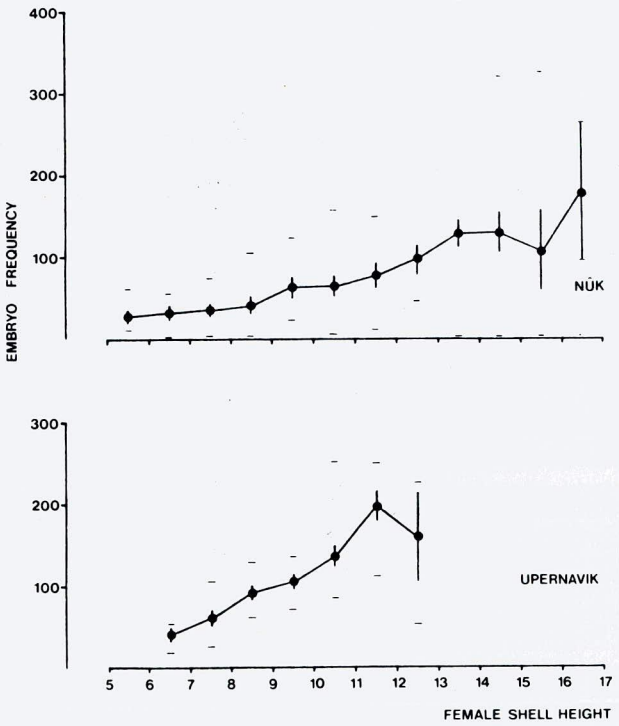


Figure K2.14. Size specific fecundity at Nûk and Upernavik, showing increase of fecundity with size of animal, and also greater reproductive output at Upernavik. Means, standard error of mean and range are all indicated.

TABLE K2.1. Number of 'generations' of eggs and embryos found in the brood pouch.

	NO. OF GENERATIONS					
COLLECTION SITES	1	2	3	4	5	mean ± s.d.
Tasiusaq	2	18	10	3	1	2.50 ± 0.86
Upernavik	1	5	11	3	0	2.80 ± 0.76
Nûk Fjord	1	11	12	8	0	2.84 ± 0.84
TOTAL	4	34	33	14	1	2.69 ± 0.84

RESULTS AND DISCUSSION

Sex Ratio

The sample sizes at Nûk and Upernavik were large enough to permit the assessment of sex ratio. Because of differences in growth and longevity of the sexes the proportions vary in different size classes. The females grow to a larger size and older age than the males, a feature known from other prosobranchs (Fischer 1950). The decreasing proportion of males with increasing size is shown in Figure K2.10. The data from Upernavik and Nûk Fjord are basically similar, and both show that the proportion of males about the 7 mm size class exceeds 50% due to the slower growth rate. The cause of the low proportion of males in the 5 mm size class is unknown. Although only a small number of very small *Littorina* have been examined, it would appear, at Nûk Fjord at least, that young of both sexes are born in equal proportions.

Onset of Sexual Maturity

Two samples from Nûk Fjord were examined to determine the onset of maturity. The size of the penis was used as a reliable indicator of maturity in males since immature animals have a penis only 1 mm long while in adults it is at least 4 mm long. The presence of eggs or embryos in the brood pouch was used as the criterion in females. The proportion of immature animals in different size classes is shown in Figure K2.11. The onset of maturity does not seem to take place at a fixed age or size, but rather over a range of sizes. It can be seen that males become sexually mature at a somewhat smaller size than females. The unusually high proportion of mature animals in the 5.0-5.5 mm size class is possibly related to the low proportion of males found in the same class, but since this unusual size class is only found in one sample it may be due to sampling error.

In one sample a large number of copulating pairs of *Littorina rudis* was collected and kept separately. Fifty of these couples were examined and the sex of each of the pair determined. Thirty male-female copulations were found of which in 17 the female was smaller than the male and 13 in which the female was larger than the male. Twenty of the matings were between males. Sexual recognition seems thus to be poorly developed, and there are previous records of attempted copulation with other species (Linke 1934).

The smallest male copulating with a female was 6.5 mm long, whilst the smallest female was 4.9 mm long and did not contain any embryos.

Eggs

The eggs of several animals were measured where these had obviously been not too badly distorted by preservation in alcohol. Some still had a globular shape and in these cases both maximum and minimum diameters were measured and the mean value used as an indication of overall egg size. Although comparisions cannot be exact due to the method of preservation it would seem that the oocyte of the Greenland *Littorina* is considerably larger than that of similar specimens from west Europe. Not only is the oocyte larger but also the diameter of the complete egg was greater than in southern populations.

In some animals however, very small eggs were found. In these cases the albumen formed only a thin layer around the oocyte, so that the total size of the egg was only slightly greater than that of the oocyte itself. The young developing from these small eggs will only be able to attain a small size before hatching. These small eggs were more commonly found in small females, where sexual actvity had only just started, than in larger animals.

Development of Embryos

The embryos found in a brood pouch can be divided into several 'generations' of roughly the same degree of development. Within a 'generation' not all the embryos are at exactly the same degree of development, and the fact that sometimes generations may follow in quick succession, means that the distinction between them is often not clear. However data from those that could easily be ascribed to discrete generations is shown in Table K2.1.

Thorson(1946) found that in Danish waters three or four generations were most commonly encountered. Comparision with figures from Denmark indicate that there is a slight tendency towards a smaller number of generations in Greenland.

There is no difference in the number of generations contained by females of different sizes.

In almost all females it was found that the most advanced embryos were about to hatch. Shortly before hatching, the egg membrane is pierced by the radula of the embryo. In most cases hatching takes place shortly afterwards and no further growth occurs until the young have left the brood pouch. In a large number of females the size of young without egg membranes contained in the brood pouch was measured. Comparative measurements were also made on animals collected from Portsmouth, England and Northern Kattegat and The Sound, Denmark. Most of the Greenland material investigated came from Nûk, but some *Littorina* from east Greenland (Naporsarsuak and Tasiusaq) were also measured. There is a significant difference in the size of hatching embryos between the southern localities and Greenland (Figure K2.13).

The Portsmouth and Kattegat samples have similar sized hatching young, although the Icelandic animals have young hatching within the range of those from The Sound in Denmark. The young on hatching are significantly larger in Greenland than from the other southerly locations. Although the maximum size of hatching young is greater in Upernavik than in Nûk the mean size is less. The largest size hatching young come from Tasiusaq in east Greenland, just south of their northern limit there (Figure K2.12).

Considerable variation also occurs in the sizes of young about to hatch from a single female i.e. within one 'generation'. Thus a female from Nûk Fjord contained 241 embryos out of which 110 were ready to leave the brood pouch. The range of sizes of these was 410 - 790 µm.

In European waters the shell will have about 1.5 whorls at the time of hatching whilst in Greenland the embryos most frequently hatch with 2.0-2.5 whorls. A few embryos were discovered that were considerably bigger than this. These 'giant' embryos occurred in females together with normal size embryos, but at a much lower frequency - usually only one or two per brood. The giant embryos had a distinct growth line on the shell some distance from the aperture, corresponding to the size at which they would normally have hatched and left the female. In normal sized hatching young these growth lines were never found. It would thus seem that these giant embryos emerge from the egg membrane at the same time as normal young, but stay within the female and continue growing, presumably for some period of time as they often had 3 whorls and measured up to 1200 - 1400 µm in length. In a single female, giant embryos of several sizes might be found together with the normal embryos.

Although giant embryos were not rare, the bulk of females contained only normal sized embryos, but it was also evident that the occurrence of giant embryos varied between populations. Giant embryos were far more frequent in east Greenland than in west Greenland, and in north-west Europe, the Kattegat and south England they seem to be entirely absent. One giant embryo was found, however, in The Sound (measuring 1000 µm in length). From this it might be supposed that these giant embryos are an adaptation to adverse environmental conditions such as low temperature in Greenland and low salinity in The Sound.

The additional growth of these giant embryos is sometimes very great, but it seems that this is accomplished on the reserves of the one egg. There was no evidence that the embryos were eating other eggs in the brood pouch. In some oviparous prosobranchs (e.g. *Planaxis sulcatus*; Thorson 1940) nurse eggs are known to occur, however on dissecting a number of giant young no such eggs were found to have been eaten by them. It would seem an unlikely source of nutrition for these giant embryos, since eggs of *L. rudis* are large and their consumption by even a giant embryo would be difficult.

Fecundity

The numbers of embryos carried by females were counted at a variety of different sites. Not only was there considerable variation in numbers in similar sized females but also variation in brood size between populations. The average number of embryos related to the size of the female is shown in Figure K2.14. There is an increase in average brood size with increasingly severe littoral conditions and at Upernavik and Tasiusaq, close to the northern limit of the species, the greatest number of young per female were found.

The size specific fecundity at Nûk and Upernavik is shown in Figure K2.14. A general trend of increasing brood size with size of female is apparent at both sites. The brood size of animals of similar size is greater at Upernavik than at Nûk (cf. Figure K2.13), and the slope of the increase of size of brood with female size is greater in the Upernavik population than at Nûk, pointing again to the greater reproductive output of the more northerly animals.

It was not possible to collect data on any changes in fecundity at one site over the course of the summer. However at several sites females collected a few days after their appearance in spring were found to contain embryos ready to hatch as well as newly laid animals (in the same proportions as later in the summer and autumn). Thus the females spend the winter with a full brood pouch, and although it is not known if any young are born in the course of the winter this possibility cannot be entirely ruled out. In studies on Welsh *L. rudis* it was found that eggs kept at 10°C took 5 weeks to hatch whilst eggs at 5°C took 10-12 weeks (L. Sharp pers. comm.). If there is a linear response, which is unlikely, between temperature and hatching time, then on the basis of these figures eggs within animals frozen in the ice foot (at about -1.5°C) will take about five months to hatch. Thus it is quite possible that eggs laid into the brood pouch soon after the animal is frozen in will take the entire winter to develop.

In the light of the earlier findings that there seem to be two distinct populations at different levels on the shore at Sisimiut, it is unfortunate that there are few details on the collections sites of the 1936 samples. The extent to which the populations at different shore-levels are self supporting and whether there are any differences in fecundity between populations will have to await further examination fo the Sisimiut material. Samples from the same shore population taken at monthly intervals are needed to determine the extent to which there are seasonal changes in fecundity. However for the time being one must assume that the data on between-site variation in brood size and size of hatching young (Figures K2.12 and K2.13) have ecological significance.

DISCUSSION

The bare zone on the shore is caused by the action of the winter "ice-foot". This forms when the air-temperature falls below about -2°C and seawater starts to freeze in the littoral fringe where splash and spray strikes the cold rocks. The "ice-foot" gradually builds up over the winter and produces a solid bulwark of ice frozen fast to the shore. Petersen (1977) considered that the ice-foot in itself did not have a great effect on shore zonation, rather, it protects shore organisms from the scouring action of free moving floes of ice. The areas most affected by winter ice are those very low on the shore where the sea ice scrapes the rocks which lack a protective cover of ice. The ice-foot does, however, have an important biological effect in that it reduces the length of the growing season.

" In spring the effect is that the organisms are frozen solid in the ice and cannot start their growth until the ice has thawed. In the autumn the season ends with cold, darkness and being frozen into the ice; and it would seems that animals with pelagic larvae cannot reach the settling stage before the rocks are covered with shore-ice. The most northerly examples of *Balanus balanoides* in the Upernavik District, and of *Mytilus edulis* in the Thule District live close to the L.W.M. and originate from larvae carried north by the West Greenland Current. For sedentary *Littorina rudis* and its food, the sessile algae on the rocks, the shortening of the productive season is the limiting factor for the northerly distribution in west Greenland." (Petersen 1977). Steven (1938) notes that in more sheltered waters (e.g. at this site), there may be a covering of ice on the rocks as early as October whilst the open shore of Ametdloq Fjord to the south is usually frozen by December. The ice remains in the bays until the end of April, finally melting in June. Thus at this site there is probably an ice-free summer season of only four months.

Petersen (1962) briefly described the life cycle of *Littorina rudis* in Greenland. In summer they can be found over most of the shore from LWST to the littoral fringe, but in autumn (at the beginning of September), they begin to aggregate in dense clusters in cavities and crevices about halfway between LWM and MTL, to MTL. During this time algae get a chance to settle on those parts of the upper shore vacated by winkles. The winter is spent by the rough winkles completely frozen into the ice-foot, although some may still be free at low shore levels where they can be exposed to extremely low air temperatures during low tide. There is evidence that some animals either spend the winter at greater depths, or possibly there are sublittoral populations. Odhner (1915) mentions specimens dredged from depths of 35 - 46 m at Eisfjord, Spitzbergen on 4 August, and Thorson (1944) reports *L. rudis* collected in east Greenland from depths of up to 46 m. Bertelsen (1937) quotes an unpublished record of Jensen of rough winkles living sublittorally in west Greenland during spring and autumn. These records seem to indicate that, at least in some places, *L.rudis* may be found at a considerable distance from the shore, even in summer. In temperate waters they are also sometimes found sub-

littorally, having been dislodged and swept out by wave action, however it may be that the phenomenon is more common at high latitudes where it is used either as a wintering strategy or as a means of extending the range northwards when littoral conditions become too severe (Steven 1938).

At the end of May, when the air temperature in the middle of the day rises to about 10 - 15°C, the winkles leave their winter quarters. Madsen (1940) recorded at Upernavik that they were found on southerly facing rocks on 6 June (20 days after the ice had melted). In more southerly areas they probably emerge slightly earlier. The large and medium size animals are the first to move, while the smallest animals usually remain longer in the crevices. The mid-shore wintering *Littorina* which emigrate divide into two groups: one literally eats its way up to the HWM whilst the other eats down in a broad front towards the LWM (Petersen 1962). Petersen (1962) gave photographs of these two advancing fronts of animals removing the layer of green algae from the rocks as they migrate to their summer shore areas (loc. cit. Plate 1). He found that the algae on the low shore were the most vigorous, a fact he associated with larger low shore animals. However at Sisimiut the low shore *L. rudis* were found to grow to the same maximum size as those from the high shore.

Both Petersen's information and the data presented here point to the presence of two populations on the shore. Encrustations of green algae and the lichen *Verrucaria mucosa* occur to a significant extent only on low shore animals, but since both high and low shore *Littorina* spend their winter together, it would appear that these only grow in summer. In this context it is interesting to note that the majority of high shore animals have their innermost whorls (the first two or three years growth) encrusted. Together with information from age and size classes, it would seem that *L. rudis* spend their first few years low on the shore before moving up to join the high shore population. Thereafter they undertake an annual migration up and down the shore, and although they no doubt mix with the low shore population in winter, they seem to remain separate from them in summer. That there is some movement of mature animals between populations is indicated by the presence of animals in the littoral fringe with at least one recent year's shell growth encrusted; however these do not occur with any appreciable frequency.

When not actively grazing, *L. rudis* frequently retires into crevices in the rock or other natural shelters. This aids in resisting desiccation during emersion and in reducing predation. Raffaelli and Hughes (1978) found that in Wales there was a very strong correlation between the size frequency of a *L. rudis* population and the size frequency of crevices available, and also that shore level changes in size frequency of littorinids were frequently caused by corresponding changes in crevice avilability, particularly on cliff faces. An alternative interpretation of the Sisimiut data could therefore be that the availability of crevices varies at different levels on the shore and that this in turn gives rise to the differences in size frequency (Figure K2.8). Unfortunately there is no information available to test this, but the following notes may be of significance in this context. There were relatively few *Littorina* seen sheltering during the low tide periods and many hundreds were seen on exposed rock faces even in sunny conditions. This may in part be due to the high relative humidity nearly always found in this part of coastal west Greenland. During August 1979 there had been only four days with no sea mist, and this will reduce the risk of desiccation during emersion. There are few if any avian predators and mortality from this source will be similarly low. Crevice availability is of significance mainly on cliffs, and thus at this sampling site it is likely to be of significance only to the high shore animals. The mid- and low shore samples were taken from topographically heterogenous areas, with many boulders strewn with fucoids. In these situations crevices have little or no importance in determining size frequencies of *Littorina* found (Raffaelli and Hughes 1978)

ACKNOWLEDGEMENTS

John Bell and Phil Davies assisted in the collection of samples at Sisimiut in 1979. Thanks are due to Dr, Finn Salomonsen for the collection of *Littorina* in north-west Greenlnad in 1936 and additional collections were made by Mr G Johnsen, Mr K Marckmann, Mr E Rasmussen and Mr E Ursin. Dr G Thorson gave valuable help and advice to JK, and Dr Høpner Petersen and Dr J M Warnes gave useful comments on draft manuscripts. Lynne Sharp kindly supplied information on the rate of growth of eggs at different temperatures and Dr J D Fish provided help and advice, and improved several manuscripts.

SUMMARY

1. Analysis of samples taken from different shore levels at Sisimiut indicate the presence of two populations: a high shore population containing animals predominantly older than five years and a low shore population containing mainly young animals.

2. *Littorina* seem to spend the first three years of their life in the low shore population before moving up to join the high shore animals.

3. Between the ages of five and a maximum of thirteen years of age there was density independant mortality.

4. The growth rate is appreciably slower than that found in European populations.

5. The females grow to an older age and larger size than the males.

6. Males become sexually mature at a smaller size than the females.

7. The mean diameter of eggs from Greenland was considerably larger than that from southern populations.

8. The size of hatching young was much larger in Greenland than in Denmark and South England.

9. A small proportion of embryos remain in the brood pouch and attain a much larger size than normal. These giant embryos were more commonly found in east Greenland.

10. There was an increase in fecundity of females towards the northern limits of the range.

11. Females apparently spend the winter with a full brood pouch, hatching taking place shortly after the spring thaw.

K3 LITTORAL AND SUB-LITTORAL OSTRACODA FROM SISIMIUT, WEST GREENLAND

R. C. Whatley

Abstract

From a study of 19 samples of sediment and algae collected from the littoral and sub-littoral of a west facing embayment just south of Sisimiut, west Greenland, 17 podocopid and one cladocopid ostracod species were recovered. Three of the former, Acetabulatoma hyperboreum (Scott), Heterocypris salinus (Brady) and Cytheropteron pyramidale Brady are new to Greenland. In addition, the unpublished first Greenland records of two species, Semicytherura nigrescens (Baird) and Cytherura atra Sars by Hawley (MS 1980) are confirmed in the present study. The distribution and ecology of each species present is commented on and the overall significance of the present fauna is discussed.

INTRODUCTION

Twenty samples of sediment and algae were collected by D.A. Stroud between 22 and 24 August 1979 from the littoral and sub-littoral of Sisimiut (Holsteinsborg), west Greenland, (66°57'N, 53°41'W).

The sampling locality is in a west facing embayment, just south of the town, largely protected by an offshore island. Further protection from wave action is afforded by the existence of large banks of *Laminaria* offshore. Some 1 km to the north-west a sewage works discharges into the sea, resulting in dystrophication in the immediate region of the outfall and in the growth of many unicellular green algae on the rocks immediately adjacent. A small stream discharges into the bay in its south-east corner. The samples were taken in the centre and north-east corner of the bay at a distance sufficient to negate any major effects of pollution or diminution in salinity (Figure K2.2).

Of the 20 samples, one was lost in transit. All except one of the remainder yielded Ostracoda, although usually in very low incidence.

The approximate positions from which the samples were obtained is given in Figure K2.2.

Their provenance and nature is listed below:

Samples A/12/252 to A/12/258 inclusive were of largely sandy sediment taken with a dredge some 10 m out from L.W.S.T. and in approximately 2 m (below L.W.S.T.).
These samples are not homogeneous and details of each one is given below:

A/12/252 :	Fine to medium sand composed mainly of heavy mineral grains with a small proportion of coarse debris. Algae and algal debris absent.	556.1 g
A/12/253 :	As for A/12/252	606.2 g
A/12/254 :	Fine to coarse sand with small pebbles and large shell fragments. No algae or algal debris.	438.0 g
A/12/255 :	Medium to coarse sand with small pebbles (max. 2 cm). Fewer shell fragments. No algae or algal debris.	706.8 g
A/12/256 :	Fine to coarse sand with some shell debris. No algae or algal debris.	534.6 g
A/12/257 :	Fine to medium sand with some shell debris. No algae or algal debris.	504.8 g
A/12/258 :	Fine sand with much algal debris, particularly of green filamentous algae and whole molluscs and shell debris.	135.6 g

Sample A/12/259 was a collection of young *Laminaria saccharina* holdfasts taken from the side of the jetty in Sisimiut Harbour at approximately 3 m below L.W.S.T. 01.7 g

Sample A/12/260 was a collection of *Laminaria* holdfasts from a beach just outside the town. Some were collected from where they had been washed up on the strand line and others as they drifted just below the surface. The sample also contained bryozoan fragments. 29.2 g

Samples A/12/261 - A/12/271 were collections of algae, mainly *Cladophora* and other tufted rhodophyceans, taken at or near L.W.S.T., inshore and slightly to the south-east of where the sediment samples were collected. These samples are all very similar in character. All contain a small proportion of fine sediment and numerous amphipods and small molluscs. The weights of the samples are given below.

A/12/261	108.5 g	A/12/267	117.8 g
A/12/262	92.5 g	A/12/268	176.6 g
A/12/263	82.1 g	A/12/269	69.3 g
A/12/264	205.8 g	A/12/270	Sample not received
A/12/265	84.9 g	A/12/271	137.9 g
A/12/266	69.7 g		

The tidal range of the collecting site is 4.9 m and the shore fauna and flora is very much the same as that described by Steven (1938) for Amerdloq Fjord, immediately to the south. Steven also gives details of the climatic and physiographical conditions obtained in this area.

METHODS

The algal samples were collected by hand while the sediment samples were collected using a simple conical dredge designed and constructed in the Dept. of Geology, U.C.W., where it is known as the "Arklow Dredge". The samples were preserved in a solution of buffered formalin.

In the laboratory the samples were washed and dried and dry sieved through a nest of sieves with mesh sizes 30, 60, 100/inch (500, 250, 152 microns). All of each fraction was then examined under a stereoscopic binocular microscope and the Ostracoda removed using a moistened fine camel-hair brush.

PREVIOUS STUDIES ON GREENLAND AND ARTCIC OSTRACODA

The marine Ostracoda of Greenland and adjacent areas remain imperfectly known. Brady (1866) listed and described the fauna of a sample collected near the Hunde Islands, west Greenland at approximately 68°52'N, 53°07'W. The same author (1868) published a further list of species from the Hunde Islands and additonal species from the Cumberland Inlet (66°10'N, 67°15'W) and in the Davis Strait (67°17'N, 62°21'W). In 1870, Brady reported on the Ostracoda of the Gulf of St. Lawrence.

Dredge samples were taken by H.M.S. *Valorous* in 1875 in Sisimiut Harbour, in Godhavn Harbour, Disko Island (69°15'N, 53°31'W) and at three localities in the Davis Strait (66°54'N, 55°21'W; 64°05'N, 56°47'W and 67°50'N, 55°27'W). A list of the Ostracoda in these samples was published by Norman (1877).

Brady (1878) published lists of ostracod species collected by H.M. ships *Alert* and *Discovery* from high latitudes in 1875 and 1876. The principal localities were Franklin Pierce Bay (79°25'N, 75°00'W); off Victoria Head (79°15'N, 75°27'W); off Hayes Point (79°42'N, 71°36'W); Smith Sound (78°37'N, 74°00'W); and off Cape Frazer (79°44'N, 71°15'W).

In their Monograph of the Ostracoda of the North Atlantic, Brady and Norman (1889) re-listed most of the localities mentioned above and added several other localities in the Greenland area: Dobbs (or Dobbins) Bay (79°35'N, 73°00'W), samples in the Davis Strait (69°31'N, 56°01'W; 66°55'N, 53°30'W), and from "off Bache Island at about latitude 70°N". Stephensen (1913, 1936) compiled a list of the Ostracoda recorded from the Greenland area, mainly from the earlier works of Brady and Norman.

Hazel (1967a, 1967b, 1970) considered the Ostracoda from the area in his work on the fauna of north-eastern North America.

Other important works on Arctic Ostracoda or in which Arctic Ostracoda are considered are by Sars (1866, 1928, Norway); Elofson (1941, Sweden and Arctic species); Atakova (1946, Novosiberian Shelf); Neale and Howe (1975, Novaya Zemlya, and other high latitude faunas); and Joy and Clark (1977, abyssal faunas from the central Arctic Ocean).

An important recent study of Greenland Ostracoda is to be found in an unpublished Magister thesis of the University of Wales by Hawley (MS, 1980), who studied the taxonomy, anatomy and ecology of nine species of benthic Ostracoda from Lysefjord, west Greenland (64°00'N, 51°00'W).

Relevant to any study of Recent Ostracoda of Arctic regions are a number of works concerning cold water fossil faunas of Pleistocene age from north-west Europe and North America such as: Brady, Crosskey and Robertson (1874, Britain), Swain (1963, Alaska), Whatley (in Colhoun and McCabe 1973, Ireland; in Kidson *et al.* 1978 and with Kaye 1971, England); Lev (1969, Soviet Union).

From the published works on the benthic Ostracoda of west Greenland and adjacent regions (Brady 1866, 1868, 1878; Brady and Norman, 1889; Norman 1877; Hazel 1967a, 1970; Neale and Howe 1975), the following list of species can be derived. Some of the early records of species are somewhat suspect and have been omitted as have references to pelagic species.

1. *Cythere lutea* O.F. Müller
2. *Hemicythere borealis* (Brady)
3. *Semicytherura undata* (Sars)
4. *Finmarchinella* (*B.*) *angulata* (Sars)
5. *Finmarchinella* (*B.*) *curvicosta* Neale
6. *Finmarchinella* (*F.*) *finmarchica* (Sars)
7. *Robertsonites tuberculata* (Sars)
8. *Xestoleberis depressa* Sars
9. *Baffinicythere emarginata* (Sars)
10. *Sclerochilus contortus* (Norman)
11. *Semicytherura rudis* (Brady)
12. *Eucytheridea bradii* (Norman)
13. *Baffinicythere howei* Hazel
14. *Paradoxostoma arcticum* Elofson
15. *Rabilimis septentrionalis* (Brady)
16. *Cytheropteron paralatissimum* Swain
17. *Finmarchinella* (*B.*) *barentzovoensis* (Mandelstam)
18. *Jonesia simplex* (Norman)
19. *Eucytheridea punctillata* (Brady)
20. *Palmenella limicola*
21. *Hemicytherura clathrata* (Sars)
22. *Elofsonella concinna* (Jones)
23. *Heterocyprideis sorbyana* (Jones)
24. *Argilloecia* sp.
25. *Cytheropteron* sp.
26. *Muellerina mananensis* Hazel and Valentine
27. *Normanicythere leioderma* (Norman)
28. *Xestoleberis* sp.
29. *Cluthia cluthae* (Brady, Crosskey and Robertson)
30. *Cytheromorpha* sp.
31. *Eucytheridea macrolaminata* (Elofson)
32. *Paradoxostoma* sp.
33. *Pseudocythere caudata* Sars
34. *Sclerochilus* sp.
35. *Hemicythere pulchella* (Brady)
36. *Cytherura* sp.
37. *Eucythere* sp.
38. *Cytheropteron inflatum* Brady, Crosskey and Robertson
39. *"Patagonacythere" dubia* (Brady)
40. *Cytheropteron angulatum* Brady and Robertson

Hawley (MS, 1980) found only nine species at Lysefjord, although most of these occurred in some abundance. Of those in the list above he records seven species:

1. *Hemicythere borealis*
2. *Baffincythere emarginata*
3. *Finmarchinella B. angulata*
4. *Finmarchinella B. curvicosta*
5. *Paradoxostoma arcticum*
6. *Sclerochilus contortus*
7. *Xestoleberis depressa*

In addition he records two species, *Semicytherura nigrescens* (Baird) and *Cytherura atra* Sars both of which are first records of the species in Greenland and, in the case of the former [illegible] a considerable westward extension of its range in the Arctic. In the case of *Cytherura atra* Hawley's record represents a considerable extension both northward and westward of its known range. Hawley's material contains numerous live individuals of both species. The present work confirms the presence of these two species in west Greenland. At Sisimiut they were rare, although both occurred live.

The present study further augments the number of species known in west Greenland and adjacent areas in that the following are added to the list:

1. *Acetabulastoma hyperboreum* (Scott)
2. *Cytheropteron pyramidale* Brady
3. *Heterocypris salinus* (Brady)

THE OSTRACODA

Order : PODOCOPIDA G.W. Müller, 1894
Sub Order : PODOCOPINA Sars, 1865
Super Family : CYPRIDACEA Baird, 1845
Family : CYPRIDIDAE Baird, 1845
Sub Family : CYPRIDINAE Baird, 1845
Genus : *HETEROCYPRIS* Claus, 1893

Heterocypris salinus (Brady) 1868

1868 *Cypris salina* Brady; p.368, pl.26, figs. 8-13.

1927 *Cyprinotus salinus* (Brady), Sars; p.122, 123.

Material

A single live female from sample A/12/261.

Distribution

This is probably the first record of the species from Greenland and certainly the first from west Greenland. Brady (1868) first described it from freshwater and marine environments in England and Scotland. Brady and Robertson (1870, 1872) describe it as brackish or estuarine in Britain. Sars (1928) found it in brackish water around Christiana Fjord in Norway and Alm (1915) recorded it in Sweden. It is widely known from north-west Europe but not well documented in the Arctic.

Ecology

Although the species can live in freshwater and I have cultured it successfully in this medium over several generations in my laboratory at Aberystwyth, it is frequently encountered in marginal marine environments with a maximum penetration to salinities of oligohaline and mesohaline character.

The present specimen may have been introduced from the stream flowing into the bay or it may be a representative of a population locally adapted to tolerate higher salinity regimes than is usual for the species. In any case, the specimen was alive and well at the time of collection.

Superfamily : CYTHERACEA Baird, 1850
Family : CYTHERIDAE Baird, 1850
Genus : *CYTHERE* O.F. Müller, 1785

Cythere lutea O.F. Müller, 1785

1785 *Cythere lutea* O.F. Muller; p.65, pl. 7, figs. 3, 4.

1835 *Cythere reniformis* Baird; p.98, pl. 3, fig. 5.

1874 *Cythere lutea* O.F. Muller, Brady, Crosskey and Robertson; p.148, pl. 3, figs. 1-6.

1925 *Cythere lutea* O.F. Muller, Sars; p. 167-168, pl. 77.

Material

The species is represented by only five dead valves.

Distribution

Cythere lutea is an extremely widely distributed species in the Northern Hemisphere. It occurs in the Mediterranean and Black Sea and widely in north-west Europe; throughout the Arctic; the north eastern coast of North America and in the Pacific South to ?Japan and the west coast of North America to Vancouver Island (Lucus 1931). The species has been previously described from Greenland and the Davis Strait by Brady (1868) and Norman (1877). It is also commonly encountered in Pleistocene marine deposits in Europe.

Ecology

Although in the Baltic Elofson (1941) recorded *C. lutea* from salinities as low as 10‰ its salinity range is usually more limited and Whittaker (MS, 1972) records this range as 25-35‰. Throughout its wide range, the species is principally phytal in habit and is found in the European littoral in association with such tufted algae as *Cladophora* and *Enteromorpha* and in the holdfasts of *Laminaria* spp. (Whatley and Wall 1969, 1975). It is obviously very eurythermal.

It is somewhat surprising not to have encountered the species live in the present samples since so many of them were phytal, notably *Cladophora*, and other tufted rhodophyceans. Equally surprising, Hawley (MS, 1980) who examined samples from Lysefjord, including some phytal samples, failed to encounter this species live or dead.

The present author has encountered dead specimens of this species at a number of stations in the north-east Atlantic down to 600 m.

Family : CYTHERIDEIDAE Sars, 1925

Sub family : CYTHERIDEINAE Sars, 1925

Genus : *EUCYTHERIDEA* Bronstein, 1930

Eucytheridea bradii (Norman) 1863

1852 *Cytheridea papillosa* Bosquet; p. 42.

1863 *Cythere bradii* Norman; p. 262.

1961 *Eucytheridea bradii* (Norman), Van Den Bold; p. 288, pl. 8, figs. 1-13.

1975 *Eucytheridea bradii* (Norman), Neale and Howe; pl. 4, fig. 10.

Material

The species is represented by two dead valves in sample A/12/265.

Distribution

This species has been recorded from around the British Isles (Brady and Norman 1889) and from Scandinavia (Sars 1928; Elofson 1941). Hazel (1970) reports it from the Continental Shelf of the United States and Canada from Cape Cod to off Baffin Island. Other Arctic localities include Franz Josef Land (Scott 1899); Novaya Zemlya (Neale and Howe, 1975); Novosiberian Shelf (Atakova 1946). Neale and Howe also record the species from around Greenland and the north-west Arctic and from the Colville Delta, Alaska.

The species is a common constituent of Pleistocene deposits in Britain and Ireland. (Brady, Crosskey and Robertson 1874; Whatley, in Colhoun and McCabe 1973; Jasin (MS, 1976); Morris (MS, 1977)). The present author has seen the species in Quaternary sediments from the Forties Field, North Sea.

Ecology

This is a eurythermal species whose temperature tolerance is from subzero in the Arctic to 19-20°C in the southern parts of its range. It occurs from the littoral to the middle shelf and usually occurs on mud or fine sand substrates. Although usually fully marine, in the Baltic it can tolerate salinities as low as 10‰ (Elofson 1941).

The two dead specimens which constitute the present material were from an algal sample, mainly *Cladophora*.

Family : CYTHERURIDAE G.W.Muller, 1894

Genus : *CYTHERURA* Sars, 1866

Cytherura atra Sars, 1866

1865 *Cytherura atra* Sars; p. 75.

1869 *Cytherura atra* Sars, Brady and Norman; p. 197-198, pl. 17, figs. 22,23.

1928 *Cytherura atra* Sars, Sars; p. 205-206, pl. 95.

1929 *Cytherura cochlearis* Klie; p. 303, figs. 1-8.

1977 *Cytherura atra* Sars, Rosenfeld; p. 31, pl. 8, figs. 93-96.

1980 *Cytherura atra* Sars, Hawley; MS, p. 87-96, pl. 9, figs. 1-17.

Material

Three specimens, two of which were live.

Distribution

The species has been recorded from the Lofoten Islands by Sars (1866, 1928) and from the Baltic by Klie (1929, 1938), Rosenfeld (1977). It has also been recorded from Heligoland by Klie (1929) and from Shetland by Sars (1928).

Neale and Howe (1975, p. 427, pl. 5, fig. 6) illustrate a right valve which they call *Semicytherura* sp. nov? Hawley (MS, 1980, p. 94) suggests that this specimen from Russian Harbour, Novaya Zemlya may be the male of *C. atra* . The present author agrees that this is a strong possibility.

Hawley found adults of both sexes and juveniles down to the A-4 instar at Lysefjord. His unpublished record is the first of the species from Greenland.

The species has also been recorded from Pleistocene marine deposits in Norway and Scotland (Brady, Crosskey and Robertson 1874).

Ecology

Sars found the species off the Lofoten Islands on a sandy substrate at depths of 3-8 fathoms. Rosenfeld (1977) records it from depths of 8-13 m on sandy and coarser substrates with an extreme depth range of 23 m. He quotes salinity values of 14-25‰. However, since these figures apply to the Baltic, one would not expect them to be typical for the species which other records would suggest to be much less euryhaline. Hawley found the species at a number of stations in Lysefjord but it was more abundant in his sample 4, which is from 10 m and with a coarse sand substrate and in an area where, at least in summer, there is some freshwater influence.

The present material is somewhat anomolous in that the two live specimens were recovered from samples of *Cladophora* and other rhodophyceans on a rocky shore at or near L.W.S.T. The sediment samples, largely of coarse to medium sand, yielded only a single dead valve.

Genus : *SEMICYTHERURA* Wagner, 1857

Semicytherura nigrescens (Baird) 1838

1838 *Cythere nigrescens* Baird; p. 143, pl. 5, fig. 27.

1868 *Cytherura nigrescens* Baird, Brady; p. 440, pl. 32, figs. 50-55.

1957 *Semicytherura nigrescens* (Baird), Wagner; p. 81, pl. 37.

1974 *Semicytherura nigrescens* (Baird), Whittaker; p. 69-76.

1980 *Semicytherura nigrescens* (Baird), Hawley, MS; p. 97-105, pl. 10, figs. 1-12.

Material

The species is represented by two specimens, only one of which is live.

Distribution

Hawley (MS, 1980) recorded this species from Greenland for the first time and the present record confirms its presence in west Greenland. The species is a common constituent of the littoral and sub-littoral of north-west Europe, particularly in areas of abundant algal growth. It ranges from the Bay of Biscay (Brady and Norman 1889; Yassini 1969) to north Norway (Sars 1866). The present record and that of Hawley represent a major westward extension of the range of the species in the Arctic.

Brady, Crosskey and Robertson (1874) record it from Pleistocene deposits in Britain, Norway and Canada and the present author has found it in similar deposits in England (Selsey Bill, Whatley and Kaye 1971; Somerset Levels, in Kidson *et al.* 1978; Shotlalstown, Wexford, Ireland, in Colhoun and Mitchell 1971). Wagner (1957) has recorded it from the Holocene of Holland and Lev (1969) from the post- Kazantsevian of the U.S.S.R.

Ecology

Given its rather wide latitudinal range within the littoral, the species is obviously very eurythermal. Elofson (1941) suggests a temperature range of $0^{o}C$ - $22^{o}C$ and a salinity range down to less than 3‰. Hagerman (1966) records the species in the Øresund to be particularly associated with *Fucus serratus*, noting that it is probably herbivorous, feeding on the small green algae and diatoms which inhabit *Fucus*.

Hawley (MS, 1980) found live specimens in both sediment and algal samples in Lysefjord. The present material is from algal samples, mainly *Cladophora* at or near L.W.S.T.

Genus : *CYTHEROPTERON* Sars, 1866

Cytheropteron pyramidale Brady, 1868

1868 *Cytheropteron pyramidale* Brady; p. 34, pl. 5, figs. 11-14.

1969 *Cytheropteron pyramidale* Brady, Lev; pl. 3, fig. 1, pl. 4, fig. 2.

1975 *Cytheropteron pyramidale* Brady, Neale and Howe; pl. 6, figs. 2, 4, pl. 7, fig. 8.

1979 *Cytheropteron pyramidale* Brady, Whatley and Masson; p. 250, 251, pl. 6, figs. 1, 2, 4, 8.

Material

The species is represented by a single dead adult carapace.

Distribution

Whatley and Masson (1979) discuss the distribution of this species in some detail and also give a full synonomy. The species is known from Norway and Neale and Howe (1975) record it from the Norwegian Sea, Novaya Zemlya, and Franz Joseph Land. The present record is the first from Greenland.

As a fossil, *C. pyramidale* has been recorded from Late Glacial deposits of Benderloch, near Oban (Morris 1977 MS.) and from the Pleistocene of northern Russia (Lev 1969).

Ecology

The live specimens of this species recorded by Elofson (1941), from the Baltic, probably belong to *C. nodosalatum*, Neale and Howe (1975). There are no other records of live specimens in the literature. Empty valves have consistently been found in Arctic and sub-Arctic latitudes and it is to be expected that eventually living material of the species will be encountered. It has been recorded at water depths of 8 to 143 fathoms (Neale and Howe 1975). The present specimen is from a medium to coarse sand at about 2 m below L.W.S.T. The present author has encountered this species in the north-east Atlantic at a number of stations down to 1 963 m. All of this material was dead and would seem to have been derived from shallower waters.

Family : HEMICYTHERIDAE Puri, 1953

Genus : *HEMICYTHERE* Sars, 1928

Hemicythere borealis (Brady), 1868

1868 *Cythere borealis* Brady; p. 31, pl. 4, figs. 1-4, 6, 7.

1872 *Cythere borealis* Brady, Brady and Robertson; p. 57, 68.

1889 *Cythere borealis* Brady; Brady and Norman; p. 147, figs. 18, 19.

1963 *Hemicythere villosa* (Sars); Swain (pars); p.828, pl.99, fig.4; Non pl.99, fig.6 or text fig.10c.

1967 *Hemicythere borealis* (Brady), Hazel; p. 15, pl. 2, figs. 3, 5, 6, 10, 11.

1970 *Hemicythere borealis* (Brady), Hazel; pl. 46, table 1.

1980 *Hemicythere borealis* (Brady), Hawley, MS; p. 21-30, pl. 1, figs. 1-8, pl. 2, figs. 1-10.

Material

The species is represented by four specimens, all dead.

Distribution

Hemicythere borealis was first recorded by Brady (1868) from Iceland. Brady and Norman (1889) record it from the Davis Strait (67°17'N, 62°21'W), Sisimiut Harbour (66°55'N, 53°30'W), Qerqertarsuaq (Godhavn) (69°31'N) and Dobbs Bay (79°35'N). Hazel (1967, 1970) has recorded the species from a number of localities along the north-eastern coast of North America from the Gulf of Maine (44°36'N) to Baffin Bay. The most enigmatic records of *H. borealis* is by Brady and Robertson (1872) from Seaton Carew near Hartlepool at 54°40'N, 1°10'W, in the littoral. This record must be in some doubt.

Hawley (MS, 1980) records the species in Lysefjord, west Greenland. The species is used by Neale and Howe to delimit the western part of their Arctic Province.

Ecology

Very little ecological data exists concerning this species. Brady and Norman record it from west Greenland down to 100 fathoms and Hazel's records range between 3 and 31 m. All these records seem to be from sandy substrates as is that of Hawley who found it more abundantly and mostly live in his sample 2, a shelly sandy gravel with an abundant molluscan macrofauna and a small quantity of *Fucus* taken from a depth of some 4 m. The present material was recovered from both algal and sediment samples.

Genus : *BAFFINICYTHERE* Hazel, 1967

Baffinicythere emarginata (Sars), 1866

1866 *Cythereis emarginata* Sars; p. 38.

1928 *Hemicythere emarginata* (Sars), Sars; p. 183, pl. 85, fig. 1.

1941 *Cythereis (Eucythereis)emarginata* Sars, Elofson; p. 283.

1967 *Baffinicythere emarginata* (Sars), Hazel; p. 17, pl. 2, figs. 1, 2, 8, 9, pl. 9, fig. 2.

1975 *Baffinicythere emarginata* (Sars), Neale and Howe; pl. 2, figs. 18-21.

1980 *Baffinicythere emarginata* (Sars), Hawley, MS.; p. 33-43, pl. 3, figs. 1-7, pl. 4, figs. 1-7.

Material

Six specimens, of which two are 'live' represent the species in the present fauna.

Distribution

Neale and Howe (1975, p.409) regard this species as a member of a group of ostrocods which, although they occur further south, reach their maximum abundance in the Arctic. The species has been recorded from the west Greenland area by Brady and Norman (1889, Franklin Pierce Bay 79°25'N, 3 fathoms; Qerqertarsuaq), by Norman (1877, in Sisimiut Harbour from 7-35 fathoms) and by Brady (1868, Davis Strait). Hazel (1970) records it from Baffin Island to as far south as Vineyard Sound (41°20'N, 70°00'W), Brady (1868) records it from Iceland and the species is also known from Spitzbergen (Klie 1942), Franz Joseph Land (Scott, 1899; Neale and Howe, 1975), and Shetland (Norman 1869). The present author has encountered the species off western Britain, always dead, to depths of 160 m.

In Pliestocene deposits, the species is encountered in Britain, Norway and Canada (Brady, Crosskey and Robertson 1874); in Russia (Lev 1969).

Ecology

Elofson (1941) reports the species as being mainly associated with substrates of coarse gravel and shell. Hawley's material from Lysefjord was from both sediment and algal samples and it occurred live in both of these habitats. Five of the six specimens in the present study were from sediment, including the two live individuals.

Genus : *FINMARCHINELLA* Swain, 1963

FINMARCHINELLA Swain, 1963

Finmarchinella (Finmarchinella) finmarchica (Sars), 1866

1866 *Cythereis finmarchica* Sars; p. 41.

1925 *Hemicythere finmarchica* (Sars), Sars; p. 185, 186, pl. 85, fig. 3.

1963 *Finmarchinella finmarchica* (Sars), Swain; p. 814.

1974 *Finmarchinella finmarchica* (Sars), Neale; p. 84, pl. 1, figs. 6, 7, pl. 2, figs. 1, 5, 11.

1975 *Finmarchinella finmarchica* (Sars), Neale and Howe; p. 381-431, pl. 2, fig. 14, pl. 3, fig. 1.

Material

A single dead specimen.

Distribution

Neale (1974, p.84,85) details the Recent and Quaternary distribution of the species. It is widely distributed in high latitudes and extends south to Brittany in the eastern Atlantic and south to the Gulf of Maine in the west. It has been recorded from three localities in the Davis Strait and also from Sisimiut Harbour and the Hunde Islands. There are numerous Quaternary records from Europe and Hazel (1968) has found it in submarine Pliestocene deposits from off the eastern seaboard of North America.

Records not quoted by Neale (1974) are the Eemian of Selsey, Sussex (Whatley and Kaye 1971); Pleistocene of Cardigan Bay, Irish Sea (Jasin MS, 1976) and the Pleistocene of Benderloch, Argyll (Morris MS, 1977). Hawley (MS, 1980) did not encounter the species in Lysefjord.

Ecology

The species is evidently somewhat eurythermal and from the literature its temperature tolerance is in the order of 0° to 11°C. The depth records of the species fall between 0 and 122 m (Hazel 1970). Although the species is normally found in normal marine salinity, in the Baltic it has been encountered in salinities as low as 18‰ (Elofson 1941). The latter author suggests an association with soft substrates but a general review of the literature would seem to suggest a wider tolerance of sedimentary substrates.

The single dead specimen in the present material is from a sample of algae but with a large amount of contained quartz and shell sand.

Subgenus : *BARENTSOVIA* Neale, 1974

Finmarchinella (Barentsovia) angulata (Sars), 1866

1866 *Cythereis angulata* Sars; p. 46.

1868 *Cythere angulata* (Sars), Brady; p. 409, pl. 26, figs. 39-42.

1925 *Hemicythere angulata* (Sars), Sars; p. 187-188, pl. 86, fig. 2.

Non 1946 *Hemicythere angulata* (Sars), Atakova; p. 227, fig. 5 = *F. (B.) barentzovoensis* (Mandelstam), 1957.

Non 1963 *Finmarchinella angulata* (Sars), Swain; p. 813, pl. 97, fig. 22 = juvenile indet. pl. 99, fig. 9 and text-fig. 11c = *F. (B.) curvicosta* Neale 1974.

Non 1967 *Nereina angulata* (Sars), Hazel; p. 19, pl. 1, figs.7, 11. = *F. (B.) barentzovoensis*, pl.1, figs. 8, 9, 10. = *F. (B.) curvicosta.*

1974 *Finmarchinella (Barentsovia) angulata* (Sars), Neale, p. 88-89, pl. 1, fig. 8, pl. 2, figs. 2, 4, 6, 10.

1980 *Finmarchinella (Barentsovia) angulata* (Sars), Hawley, MS; p. 46-55, pl. 3, figs. 8-12.

Material

A single dead valve.

Distribution

Neale (1974, p. 89) gives a detailed account of the Recent and Quaternary distribution of the species. It occurs in the Bay of Biscay but probably as a relict of glacial maxima (Yassini 1969). It has been recorded around the Scottish and Irish coasts and Neale (1974, p. 89) has recorded it from the Celtic Sea although he suggests that the specimens may not be indigenous. It occurs widely in high latitudes and it has previously been recorded from Sisimiut Harbour (Brady and Norman 1889). Hawley records the species in Lysefjord.

The species has also been noted from Quaternary deposits in England (Brady and Norman, 1889; Whatley and Kaye, 1971; Whatley, in Kidson *et al.* 1978); Scotland (Brady and Norman 1889; Morris, MS, 1977); Ireland (Brady and Norman 1889); Russia (Lev 1969).

Ecology

Most records of this species are from depths of less than 50 fathoms. Sars (1925, p. 188) records it from the Laminarian Zone of the Norwegian coast and Elofson (1941) remarks on it being a phytal species common in the laminarian zone. Elofson gives a temperature range of -2°C to 18° or 20°C and a salinity range of normal marine down to 18‰.

Hawley (MS, 1980) encountered the species living in association with *F. (B.) curvicosta* in Lysefjord and Neale (1974, p. 89) notes that material studied by Brady and Norman (1889) from Sisimiut Harbour contained almost equal numbers of *F. (B.) curvicosta* and *F. (B.) angulata* . The former species was absent from the present samples and the latter was recovered, as a single dead valve from sample A/12/264, an algal sample consisting mainly of *Cladophora*.

The present author has encountered this species at one station in the north-east Atlantic at 500 m.

Genus : *NORMANICYTHERE* Neale, 1959

Normanicythere leioderma (Norman), 1869

1869 *Cythere leioderma* Norman; p. 255, 291.

1889 *Cythere leioderma* Norman, Brady and Norman; p. 139, pl. 15, figs. 12, 13.

1913 *Cythere leioderma* Norman, Stephensen; p.363.

1959 *Normanicythere leioderma* (Norman), Neale; p. 78-91, pls. 13, 14, text-figs. 1-5.

1967 *Normanicythere leioderma* (Norman), Neale and Schmidt; p. 348, text-figs. 1-6 (with complete and annotated synonymy).

Material

A single dead female valve.

Distribution

This is given in some detail by Neale (1959) and Neale and Schmidt (1967). In synthesis, the species is known from northern Britain, Norway, the Norwegian Sea, Iceland, Spitzbergen, Novaya Zemlya (Neale and Howe 1975), north-west Greenland and along the eastern seaboard of North America south to the Gulf of Maine. Fossil, the species occurs in the Pleistocene "Bridlington Crag" of Yorkshire, and the Quaternary of Canada and New England. Hawley (MS, 1980) did not encounter this species at Lysefjord.

Ecology

Elofson (1941) notes that the species is very stenohaline and its distribution indicates it to be a cold-water species. British specimens are known from 'very deep water' in Unst Haaf, Shetland (Norman 1869) and from Portree, Skye (see Neale, 1959, p.89, 90). The material from Greenland was encountered at depths of 35-80 fathoms. Blake (1933, p. 239) found the species in 10-40 feet water depth. The latter record was from an argillaceous substrate although the majority of records are from sand.

The present author has encountered this species, always dead, down to 600 m, in the north-east Atlantic.

Family : PARADOXOSTOMATIDAE Brady and Norman, 1889

Subfamily : PARADOXOSTOMATINAE Brady and Norman, 1889

Genus : *PARADOXOSTOMA* Fischer, 1885

Paradoxostoma arcticum Elofson, 1941

1899	*Paradoxostoma variable*	(Baird), Scott; p. 88, 89.
1941	*Paradoxostoma arcticum*	Elofson; p. 123-124, figs. 28, 29.
1975	*Paradoxostoma arcticum*	Elofson, Neale and Howe; p. 395, 396, 409, table 2, text-fig. 9.
1975	*Paradoxostoma arctica*	Elofson, Neale and Howe; pl. 4, fig. 5.
1980	*Paradoxostoma arctica*	Elofson, Hawley, MS; p. 68-74, pl. 7, figs. 7-16, pl. 8, figs. 1-3.

Material

This is the second most abundant species in the present fauna with 87 specimens of which 57 were live on collection. It constitutes 26.5% of the live and 27% of the total fauna.

Distribution

The species is high Arctic in its distribution. It was earlier confused with *Paradoxostoma variable* (Baird), 1855 but as Elofson (1941, p. 123) points out, all Arctic records of *P. variable* prior to 1941 probably apply to *P. arcticum*. Elofson gives its distribution as near Franz Joseph Land (Scott 1899), Spitzbergen, Bear Island, east Greenland and Jan Mayen. Neale and Howe (1975) report the species from Russian Harbour, Novaya Zemlya and from the Hunde Islands. Hawley (MS, 1980) found a large fauna of *P. arcticum* in Lysefjord, the majority of which were live and which included adults of both sexes down to the A-4 instar.

Neale and Howe use this species as an indicator of their Arctic Province.

Ecology

There is little ecological data on this species. The material described by Scott (1899) from off Cape Flora, Franz Joseph Land, was dredged at depths of 2-10 fathoms. The material recorded by Neale and Howe from Russian Harbour, Novaya Zemlya, was from a silty-sand obtained from 8 fathoms of water.

Hawley's Lysefjord material is almost confined to his Sample 5, collected from a bay on the southern side of the fjord and consisting almost entirely of the green alga, *Desmarestia aculeata*.

In the present material the species occurs in 11 samples (Table 1) but is most abundant in samples A/12/260 (from loose holdfasts of *Laminaria* washed up on the strand line or drifting just below the surface) and A/12/262 (from collections of *Cladophora* and other tufted rhodophyceans). Although present in the sublittoral sediment samples, it was only recovered live from one of them (A/12/258) and this sample contained abundant algal debris. It was consistently more abundant in the algal samples but often not represented live.

Paradoxostoma sp. 1.

This species is represented by one live and one dead specimen in sample A/12/260. The specimens, which consist of an adult male (L. 0.68, H. 0.32, W 0.14 mm) and a dead A-1 instar are unlike any other member of the genus known to the author. The posterior margin is truncated and the anterior very acuminate with a sharp ventral extremity. The dorsal margin is very regularly arched and on the ventral margin there is a pronounced oral incurvature.

Paradoxostoma sp. 2.

This species is represented by a single live specimen in sample A/12/253. Its dimensions are: L. 0.55, H. 0.30, W. 0.20 mm. It is probably not an adult. It has a rounded anterior and an arcuate dorsal margin. The posterior margin is pointed with a sub-ventral extremity. It does not resemble any *Parodoxostoma* species known to the author.

Genus : *SCLEROCHILUS* Sars, 1865

Sclerochilus contortus (Norman), 1862

1862	*Cythere contortum*	Norman; p. 48, pl. 2, fig. 15.
1889	*Sclerochilus contortus*	(Norman), Brady and Norman; p. 225.
1874	*Sclerochilus contortus*	(Norman), Brady, Crosskey and Robertson; p. 212, pl. 10, figs. 33-35.
1928	*Sclerochilus contortus*	(Norman), Sars; p. 247, 248, pl. 112.
1980	*Sclerochilus contortus*	(Norman), Hawley, MS; p. 77-84, pl. 8, figs. 4-12.

Remarks

Some of the juvenile specimens in this study may belong to the allied species, *Sclerochilus bradyi* Rudjakov, 1962. It is also possible that some of Hawley's Lysefjord material may belong to this species.

Material

This species is the fourth most abundant in the present material, represented by 17 specimens of which 8 are live. They represent 5.26% of the total fauna and 5.13% of the live fauna.

Distribution

The distribution of this species, at least in the lower latitudinal parts of its range is uncertain because of its confusion with other species of the genus. It may be summarized thus:

Greenland area	:	Sisimiut Harbour, Norman (1877) Davis Strait, Brady and Norman (1889) Lysefjord, Hawley (MS, 1980) Clavering Island, Elofson (1941)
Spitzbergen	:	Klie (1942), Müller (1931), Neale and Howe (1975)
Bear Island	:	Elofson (1941)
Novaya Zemlya	:	Neale and Howe (1975)
Franz Joseph Land	:	Scott (1899)
Norwegian Coast	:	Sars (1866), Norman (1891)
Skagerak	:	Elofson (1941)
British Isles & Holland	:	For summary of authors see Elofson (1941, p. 119)
Inner Hebrides	:	Harris (MS, 1977)
North America	:	South to Gulf of Maine, (Blake 1933)

The present author has seen the species at a number of localities in the north-east Atlantic, particularly in the region of the Wyville-Thompson Ridge and the Rockall Bank.

The species is also of common occurrence in Quaternary deposits of Britain and has also been recorded from deposits of similar age in Norway and Canada.

Ecology

Elofson (1941), although conceding that it is frequently found in coarse detrities below the vegetation zone, considers that the depth and range for this species corresponds to the lower algal zone. A review of the literature demonstrates, however, that in fact the species is found as often in neritic environments as it is in the littoral. Hawley (MS, 1980) found at Lysefjord live specimens of adults of both sexes and penultimate instars but the species constituted less than 10% of his total fauna.

The present specimens occurred much more abundantly on algae than in sediment (15 specimens in the former; 2 in the latter). Adults of both sexes and instars to A-2 were present alive.

Genus : *ACETABULASTOMA* Schornikov, 1970

Remarks

This genus was erected by Schornikov to accommodate a group of paradoxostomatid Ostracoda with anteroventral gape which are parastic or commensal on Amphipoda. The exact nature of the relationship of these ectoparasites to their hosts is uncertain although it is thought that they are most probably parasitic.

Schornikov discusses five new species of the genus:

1) *A. littorale littorale* , parasitic on *Gammarus oceanicus* from the littoral zone of the East Murman Coast.
2) *A. littorale robustum* , parasitic on *Gammarus setosa* from the littoral zone of the East Murman Coast and in Cross Bay, Bering Sea.
3) *A. arcticum* , parasitic on *Gammarus wilkitzkii* in the Arctic Basin.
4) *A. longum* , parasitic on *Amphitoe djakonovi* , Providence Bay, Bering Sea.
5) *A. kurilensis*, littoral zone of Urup Island.
6) *A. rhomboideum* , Posjet Bay, Sea of Japan.

Hosts of the latter two species were not recorded.

Schornikov noted that these ectoparasites are found either on the ventral side or in the incubation chambers of their hosts and implied that they were attached by their sucker-like mouths. The ostracod, which, in common with other paradoxostomatids possesses a styliform mandible, is thought to use this to penetrate the exoskeleton of the host. The ostracod deposits its eggs on the gills of the amphipod and the ostracod is thought to be distributed by contact. Baker and Wong (1968) concluded that in what they called *Paradoxostoma rostratum* Sars (= *Acetabulastoma arcticum* Schornikov), the ostracod lives and reproduces only during the season March - September and that it winters as eggs attached to the gills of the amphipod.

Neale (1978) re-investigated the single live specimen from Franz Joseph Land described by Scott (1899) as *Pontocypris ?hyperborea* which, from the original description and illustration (pl. 4, figs. 12-14) would, particularly in its antero-ventral gape, appear to belong to *Acetabulastoma*. Neale's excellent description and illustration of the carapace and appendages clearly confirm this.

Other records of the genus are by Sars (1866, 1928 as *Paradoxostoma rostratum*) represented by two empty valves from Øxfjord, Norway. Brady and Norman (1889) illustrated the species using figures provided by Sars (pl. 23, figs. 3, 4). Norman (1891) found three specimens of the same species in intertidal weeds at Vadso, Norway but did not illustrate them.

The present author agrees with Neale (1978, p. 70) in his suggestion that Elofson's (1940) material of *Paradoxostoma rostratum* Sars from Varangerfjord in northern Norway is of a different species and that they are conspecific with *Pontocypris ?hyperborea* Scott and *A. littorale littorale* Schornikov.

Acetabulastoma has also been described by Macginitie (1955, as *Paradoxostoma* sp.) and also by Leung (1972) and Joy and Clark (1977) from the Arctic. All these records are of *A. arcticum* Schornikov. Baker and Wong (1968) record this species parasitic on the same amphipod as did Schornikov, *Gammarus wikitzkii* Birula, but they also record a secondary infestation on *Gammaracanthus loricatus* (Sabine). Joy and Clark (1977) do not record the host but they obtain specimens of *A. arcticum* at considerable depths (more than 2000 m) in the central Arctic Ocean.

The present record is the first of the genus from Greenland.

Commensal and parasitic Ostracoda are not uncommon but, with the exception of the Entocytheridae, a family commensal (and perhaps also parasitic) on freshwater crayfishes, freshwater and marine isopods and marine amphipods, little has been written on the subject. A discussion on the subject and references to the relevant literature can be found in Harding (1966) and McKenzie (1972). Whatley (1976) also touches on the subject of symbiotic associations between some Ostracoda and other animals.

Acetabulastoma hyperboreum (Scott), 1899

1899 *Pontocypris ?hyperborea* Scott; p. 83, pl. 4, figs. 12-15.

1940 *Paradoxostoma rostratum* Sars, Elofson; p. 3-8, figs. 1-11.

1970 *Acetabulastoma littorale littorale* Schornikov; p. 1133-1135, fig. 1.

1978 *Acetabulastoma hyperboreum* (Scott), Neale; p. 69-75, 2 pl., 13 figs..

Material

This is the most abundant species in the present fauna with 155 specimens of which 69 are live. It represents 47.99% of the total fauna and 44.23% of the live fauna.

Distribution

The species has a wide distribution throught the Arctic from north Norway (Elofson 1940), Franz Joseph Land (Scott 1899) and the East Murman Coast (Schornikov 1970). The present record is the first of the genus and the species from Greenland.

Ecology

The original specimen, described by Scott (1899, p. 84) as dead was from a dredge sample taken between 2 and 10 fathoms in West Bay, Cape Flora, Franz Joseph Land. Neale (1978, p. 69) on opening the carapace found the specimen to have been live. No other data are available.

The present samples, particularly the algal, abounded in amphipods. Dr J.D.Fish of the Dept. of Zoology U.C.W., has kindly examined these and tentatively concludes that they are *Gammarus oceanicus* Segerstrale. Since this is the host species of *A. littorale littorale* it confirms the present author's identification of the ostracod species on both its hard and soft part characteristics.

Although rare in the sediment samples, this species was common in those from algae. It was particularly abundant in sample A/12/262. It occurred as adults of both sexes and as juveniles to the A-4 stage. Although usually found free, in a few cases it was still attached antero-ventrally to its amphipod host.

PLATE K3.1 (Opposite)

1 *Heterocypris salinus* (Brady), 1868: Live female carapace, right lateral view x80.

2 *Cythere lutea* O.F. Müller, 1785: Female right valve, external lateral view x60.

3,6 *Eucytheridea bradii* (Norman), 1863: 3 Female right valve, external lateral view x70.
6 Male left valve, external lateral view x68.

4,5,7, 8,9 *Cytherura atra* Sars, 1866: 4 Live female carapace, right lateral view x120*.
5 Live male carapace, right lateral view x135*.
7 Live female carapace, left lateral view x100*.
8 Live female carapace (the same specimen as 4), detail of adductor muscle scar impression seen on external surface of left valve x575 approximately*.
9 Female right valve, internal view x145*.

10,11 *Semicytherura nigrescens* (Baird), 1838: 10 Live male carapace, right lateral view x159*.
11 Live female carapace, right lateral view x150*.

12 *Cytheropteron pyramidale* Brady, 1868: Adult carapace, right lateral view x110.

13,14, 16,17, 18 *Hemicythere borealis* (Brady), 1868: 13 Live female carapace, right lateral view x71*.
14 Live female carapace, dorsal view x63*.
16 Live male carapace, left lateral view x78*.
17 Live female carapace, left lateral view x71*.
18 Live male carapace, right lateral view x78*.

15,19, 20,21 *Baffinicythere emarginata* (Sars), 1866: 15 Live female carapace, dorsal view x63*.
19 Live male carapace, left lateral view x69*.
20 Live male carapace, right lateral view x69*.
21 Live female carapace, left lateral view x80*.

*indicates specimen from Hawley Collection, Lysefjord.

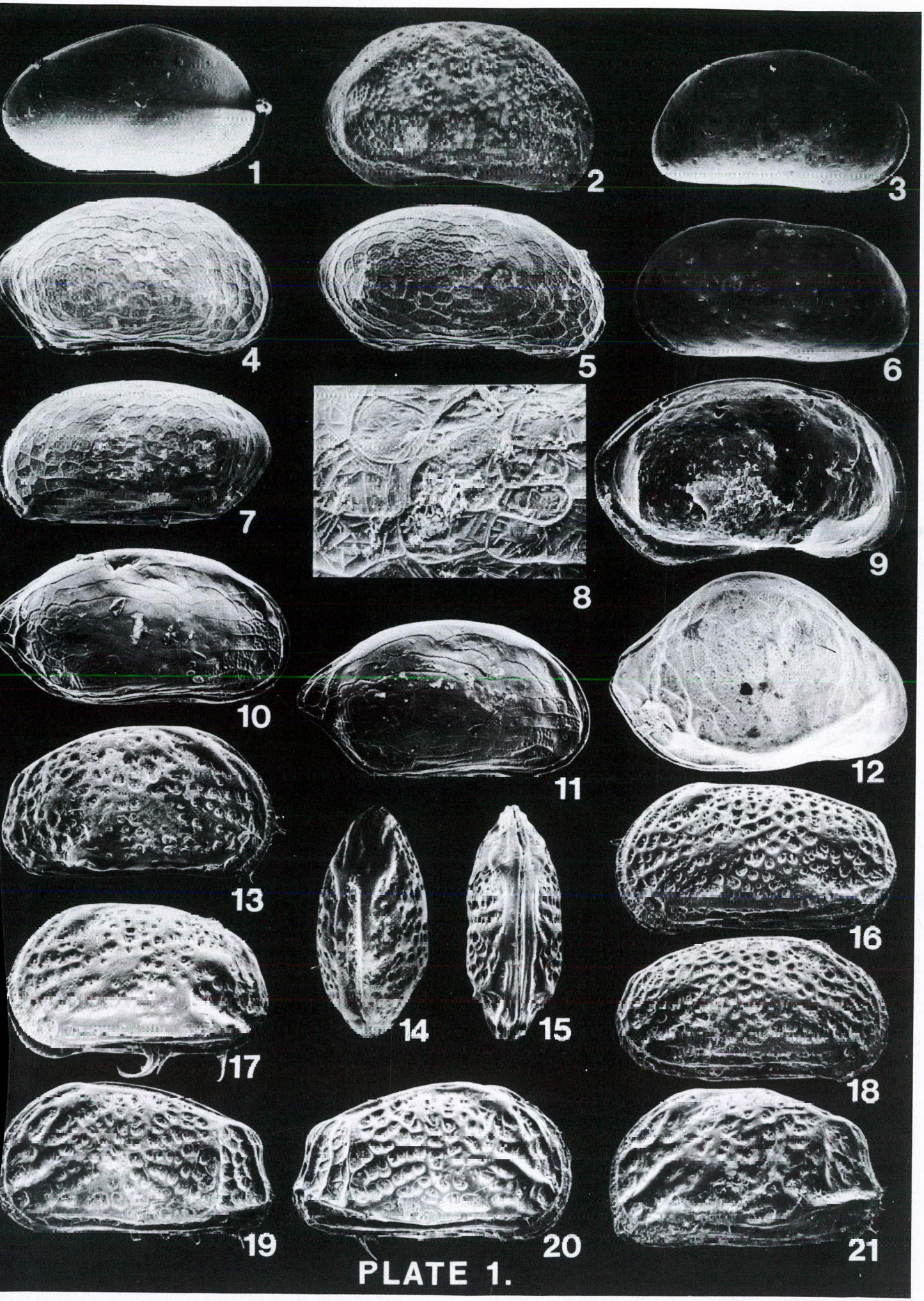


PLATE 1.

Family : XESTOLEBERIDAE Sars, 1928

Genus : *XESTOLEBERIS* Sars, 1866

Xestoleberis depressa Sars, 1866

1866 *Xestoleberis depressa* Sars; p. 68.

1868 *Xestoleberis depressa* Sars, Brady; p. 438.

1874 *Xestoleberis depressa* Sars, Brady, Crosskey and Robertson; p. 190.

1928 *Xestoleberis depressa* Sars, Sars; p. 244-245, pl. 111, fig. 2.

1941 *Xestoleberis depressa* Sars, Elofson; p. 116-118.

1975 *Xestoleberis depressa* Sars, Neale and Howe; p. 388, 390, 394, 396, 409, pl. 3, fig. 3, table 2, text fig. 9ii.

1980 *Xestoleberis depressa* Sars, Hawley, MS; p. 108-115, pl.11, figs. 1-17.

Material

This is the third most common species in the fauna with 33 specimens of which 14 are live. It represents 10% of the total and 9% of the live fauna.

Distribution

The species is Arctic in its distribution and extends southwards on both sides of the Atlantic to Maine (Cushman 1906; Blake 1933) and Biscay (Brady and Norman 1889). It has also been recorded in the north-eastern Pacific (Lucus 1931) although this record, and that from off Madeira (Brady 1911), must be regarded with some doubt.

Elofson (1941, p. 117) gives details of the distribution of the species known to that date. Subsequent records are: Novaya Zemlya, Neale and Howe (1980) and (p. 409) Greenland; Lysefjord, Hawley (MS, 1980); Inner Hebrides, Harris (MS, 1977); Outer Hebrides and St. Kilda, Pearce (MS, 1977). The species has been previously described from Sisimiut Harbour (Norman 1877) from a depth of 10 fathoms.

Ecology

The species is mainly phytal in habit as noted by Elofson and subsequent authors, notably Pearce (MS, 1977) who encountered the species in considerable abundance on littoral algae from North Uist. Hawley's Lysefjord material was principally from algal samples. The present material yields the species about as commonly in sediment as in algal samples but, in the former, it is most abundant in sample A/12/258, which contains abundant algal debris.

PLATE K3.2 (Opposite)

1 *Finmarchinella finmarchia* (Sars), 1866: Female left valve, external view x83.

2 *Finmarchinella angulata* (Sars), 1866: Female left valve, external view x90.

3 *Normanicythere leioderma* (Norman), 1869: Female right valve, external view x70.

4 *Paradoxostoma arcticum* (Elofson), 1941: Live female carapace, left lateral view x95.

5 *Sclerochilus contortus* (Norman), 1862: Live female carapace, left lateral view x80.

6,7,8,9, 10,11, 12 *Acetabulastoma hyperboreum* (Scott), 1899: 6 Live female carapace, right lateral view x88.
7 Live female carapace, detail of antero-ventral gape x275.
8 Male left valve, detail of central muscle scars x235.
9 Specimen as 7, detail of antero-ventral gape x185.
10 Specimen as 8, internal view x88.
11 Live female carapace, dorsal view x83.
12 Specimen as 7 & 9, ventral view x80.

13,14, 15,16, 17 *Xestoleberis depressa* (Sars), 1866: 13 Left carapace, right lateral view x118.
14 Specimen as 13, ventral view x118.
15 Live male carapace, left lateral view x130.
16 Female left valve, internal view x108.
17 Live female carapace, dorsal view x95.

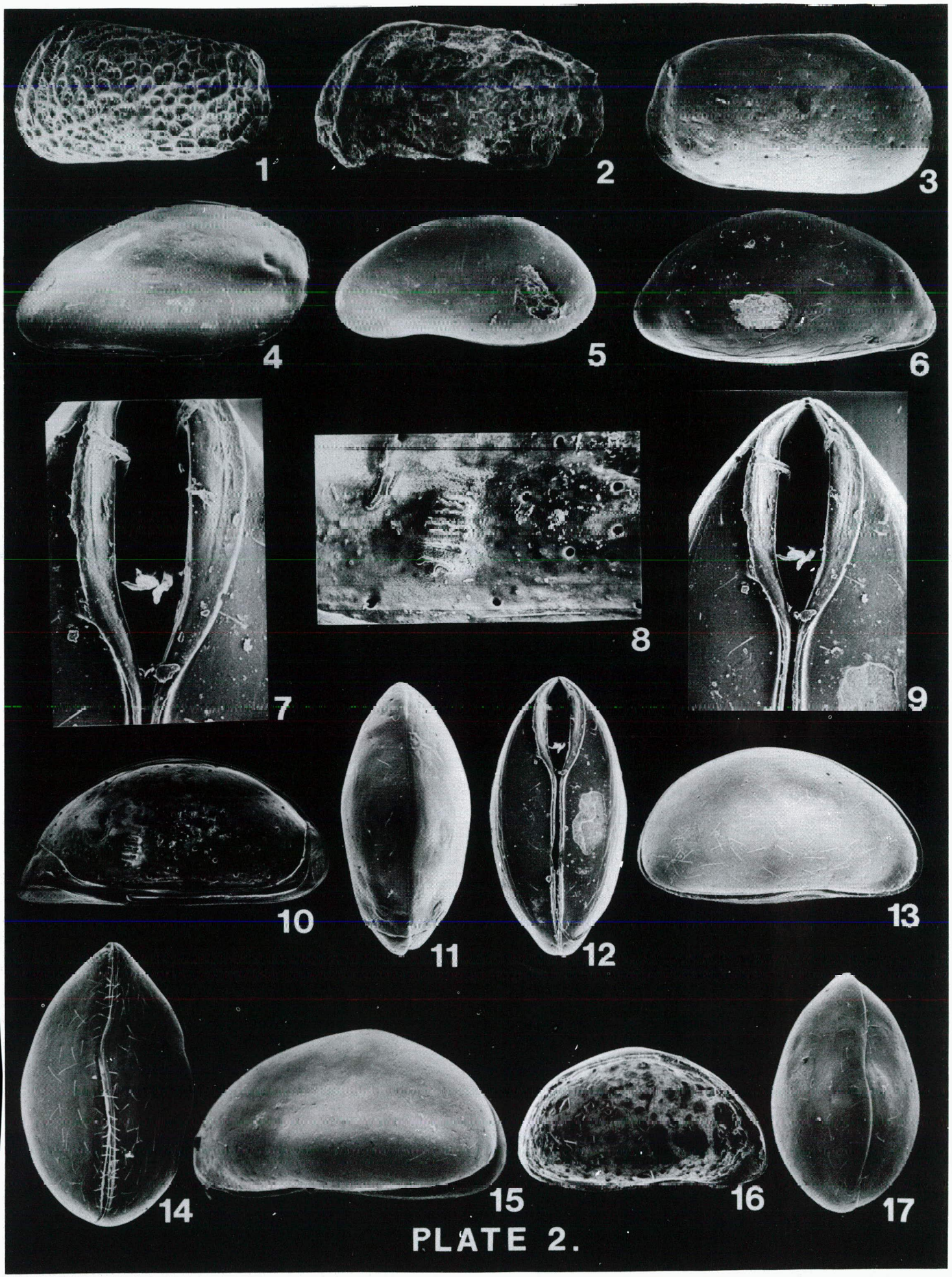


PLATE 2.

The species, given its wide latitudinal range within the littoral, is obviously eurythermal. Elofson gives figures of -2° to 22°C; he also regards it as euryhaline to some extent. The species is not confined to the littoral and such records as that of Brady and Norman (1899) from the Davis Strait are from 100 fathoms.

Xestoleberis depressa seems to be the only Arctic member of the genus. In Britain, its range overlaps with a number of other species. In North Uist, for example, it occurs together with *X. aurantia* (Baird), 1838 and *X. rubens* Whittaker, 1978, although it was by far the more abundant species. Further south in Britain the usually abundant littoral phytal xestoleberid fauna almost always lacks *X. depressa*.

Order : MYODOCOPIDA Sars, 1866

Suborder : CLADOCOPINA Sars, 1866

Family : POLYCOPINAE Sars, 1866

Genus : *POLYCOPE* Sars, 1866

Polycope sp. cf. *Polycope orbicularis* Sars, 1866

1866 *Polycope orbicularis* Sars; p. 122.

1928 *Polycope orbicularis* Sars, Sars; p. 31, 32, pl. 14, pl. 15, fig. 1.

1941 *Polycope orbicularis* Sars, Elofson; p. 22, 23.

Material

A single live specimen from sample A/12/269.

Distribution

Elofson (1941) gives the distribution of this species in some detail. In this work he discounts most Arctic records as being of another undescribed species. He does so having seen material from these regions (Swedish Arctic Expedition and Scott's material from Franz Joseph Land). He considers the species to be confined to Scandinavian and possibly British waters.

The present single specimen may well belong to the same Arctic species which Elofson differentiates from *P. orbicularis* Sars. Since, however, Elofson did not name or describe this species and since the present specimen most closely resembles *P. orbicularis* the present author is content to leave it as designated above. It does not resemble any of the other four Scandinavian species of the genus described by Sars (1866, 1870, 1928) nor any of the seven new species described by Joy and Clark (1977) from deep water in the central Arctic Ocean.

Ecology

The present specimen is from an algal sample (mainly *Cladophora*) from the littoral at or near L.W.S.T.

DISCUSSION

Although only 323 individual ostracods were collected in the present study, of which almost half were live (156), the fact that 18 species, belonging to 15 genera are represented is, for the Arctic, a reasonablyhigh level of diversity. Many authors' species lists from high latitude stations record a considerably lower diversity. For example, Hawley (MS, 1980) records only nine species from Lysefjord from ten samples of both sedimentary and algal origin. His fauna, however, totalled 870 individuals, most of which were live. He concludes that, at least in part, reduced salinity in his sampling locality could account for the low diversity of the Lysefjord fauna.

Neale and Howe (1975) in a summary of Arctic faunas clearly illustrate their generally low diversity when compared to those of lower latitudes. In their table 6, for example, of Holocene Ostracoda from Greenland and nearby areas, they list the podocopid species recorded from 20 stations. Of these, ten stations yielded ten or less species, and only three stations yielded more than 20 species, the highest diversity being 21 species. Of the 20 stations, only the following four yielded an equal or greater diversity of podocopid species to that of the present study (17):

Hunde Island (68°52'N, 53°07'W) 17 species (7 common with present study) 25-70 fm

Ungava Bay, Labrador (60°08'N, 67°47'W) 20 species (5 common with present study) 40 fm

Shannon Island (75°20'N, 19°00'W) 21 species (3 common with present study) 110 fm

H.M.S. Vidal Station 46 (75°11.2'N, 22°14'E) 21 species (5 common with present study) 35 fm

The laststation is at some considerable distance from Greenland.

Probably the most abundant and diverse Arctic fauna ever described is from a single sounding sample in 8 fm from Russian Harbour, Novaya Zemlya. This sample yielded to Neale and Howe (1975) 4 004 specimens belonging to 45 species. This is probably many times the normal incidence of specimens and more than twice the maximum diversity usually encountered in Arctic localities.

Neale and Howe examined material in the British and Hancock Museums which had been collected by H.M. ships 'Alert', 'Discovery' and 'Valorous' from Greenland and the north-west. The most commonly occurring species from these samples, which ranged in depth from 10-110 fm, were (in order of the number of samples in which they occurred): *Eucytheridea bradii*, *Finmarchinella (B.) angulata*, *Baffinicythere howe* Hazel, *Robertsonites tuberculata* (Sars), *Hemicytherura clathrata* (Sars), *Normanicythere leioderma* and *Semicytherura undata* (Sars). Only three of these species (those without authors' names) occur in the present study where they occur rarely and dead. Their absence is most probably due to the shallow water nature of the present material.

The 14 species recorded from a total of 233 specimens by Neale and Howe (1975, table 6) from Sisimiut Harbour at 10 fm are:

Cythere lutea, *Hemicythere borealis*, *Semicytherura undata* (Sars), *Finmarchinella (B.) angulata*, *F. (B.) curvicosta* Neale, *F. (F.) finmarchica*, *Robertsonites tuberculata* (Sars), *Xestoleberis depressa*, *Baffinicythere emarginata*, *Sclerochilus contortus*, *Semicytherura rudis* (Brady), *Eucytheridea bradii*, *Baffinicythere howei* Hazel and *Paradoxostoma arcticum*. Five of these species (those for which the author name is given) do not occur in the shallower water of the present study.

SAMPLES / OSTRACODA (live / dead)	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	Number specimens live / dead	% of live Total / % of Total specimens	Number of samples in which species occurs
Acetabulastoma hyperboreum (Scott) 1899	/2	1/27							4/4	2/2	45/45	1/6	/3	9/35	/2	2/5	2/6	1/7	/11	69/155	44.23 / 47.99	13
Paradoxostoma arcticum Elofson, 1941	/2	/2					4/9		21/21	1/1	30/30		/2	/12		1/5	/2		/1	57/87	36.54 / 26.93	11
Xestoleberis depressa Sars, 1865	/1	/3	1/3	/1	/2		6/10			1/1				1/4		1/1	1/3	2/2	1/2	14/33	8.97 / 10.22	12
Sclerochilus contortus (Norman) 1862			/1				1/1		1/6			1/1	1/2		1/1			2/2	1/3	8/17	5.13 / 5.26	8
Baffinicythere emarginata (Sars) 1865	/1		/2				2/2					/1								2/6	3.85 / 1.86	4
Cythere lutea Mueller, 1785		/1					/2										/1		/1	0/5	3.21 / 1.55	4
Hemicythere borealis (Brady) 1868							/2							/1		/1				0/4	2.56 / 1.24	3
Cytherura atra Sars, 1865							/1					1/1			1/1					2/3	1.92 / 0.93	3
Paradoxostoma sp. 1									1/2											1/2	1.28 / 0.62	1
Eucyheridea bradii (Norman) 1863															/2					0/2	0.00 / 0.62	1
Semicytherura nigrescens (Baird) 1838																		1/1		1/2	0.64 / 0.62	2
Paradoxostoma sp. 2		1/1																		1/1	0.64 / 0.31	1
Normanicythere leioderma (Norman) 1869						/1														0/1	0.00 / 0.31	1
Cytheropteron pyramidale Brady, 1868						/1														0/1	0.00 / 0.31	1
Heterocypris salinus (Brady) 1868									1/1											1/1	0.64 / 0.31	1
Finmarchinella (Barentsovia) angulata (Sars) 1866													/1							0/1	0.00 / 0.31	1
Finmarchinella (Finmarchinella) finmarchica (Sars) 1866																				0/1	0.00 / 0.31	1
Polycope sp. cf. orbicularis Sars, 1866																		1/1		1/1	0.64 / 0.31	1
Number of specimens (live / dead)	/6	1/34	1/6	/1	/2	/2	13/27	0/0	28/34	4/4	75/75	3/9	1/8	10/54	2/5	4/12	3/12	7/13	2/19	156/323		
Number of species per sample	4	5	3	1	1	2	7	0	4	4	2	4	4	5	4	4	4	5	6			
Number of genera per sample	3	3	3	1	1	2	7	0	2	3	2	4	3	4	4	3	3	4	5			

TABLE K3.1 Distribution of Ostracoda species between samples taken from marine sediment samples from Sisimiut, west Greenland. See text for full description of sampling sites.

Neale and Howe (1975 pp. 409-411) discuss the faunal provinciality of high latitude sublittoral ostracod faunas. They recognise "a community of fauna that merits the designation of Arctic Province". This province is characterised by a fauna which includes the following species: *Finmarchinella (B.) barentzovoensis* (Mandelstam), *F. (B.) curvicosta*, *Eucytheridea macrolaminata* Elofson, *Paradoxostoma arcticum*, *Cytheropteron paralatissimum* Swain, *C. arcticum* Neale and Howe, *C. nodosalatum* Neale and Howe and *C. cf. C. nodosalatum* Neale and Howe, all of which it is claimed are confined to the Arctic. Subsequent work in the main supports this contention although the present author has seen a specimen of *F. (B.) barentzovoensis* recorded by Harris (MS, 1977) from the Minch. This may, however, have been derived from Quaternary sediments.

In addition to the species listed above, Neale and Howe include as representative of their Arctic Province other species which, although their ranges extend southwards, achieve their maximum abundance in the Arctic. These include *Robertsonites tuberculata* (Sars), *Baffinicythere emarginata*, *B. howei* Hazel, *Normanicythere leioderma*, *Cytheropteron pyramidale*, and the genera *Roundstonia* Neale and *Cluthia* Neale.

Although the fauna of this Arctic Province is circumpolar, there are some differences between east and west, particularly the restriction of *Hemicythere borealis* and *Muellerina mananensis* Hazel and Valentine to the latter.

The work of Joy and Clark (1977) has shown that the deep waters of the Arctic are distinct with a fauna dominated by distinct species of *Cytheropteron*, *Polycope*, *Pseudocythere* etc.

Any future designation of an Arctic province based upon Ostracoda must take into account the distribution of the important parasitic/commensal genus *Acetabulastoma* and should also taken note of the present record and that of Hawley (MS, 1980) of *Semicytherura nigrescens* and *Cytherura atra* in west Greenland. The former, according to Neale and Howe, is an index species for the recognition of the northern boundary of the Norwegian Province, which succeeds the Arctic Province to the South in the east.

The ostracod faunas of the Arctic remain imperfectly known and there is considerable need for further studies in Greenland and particularly in east Greenland.

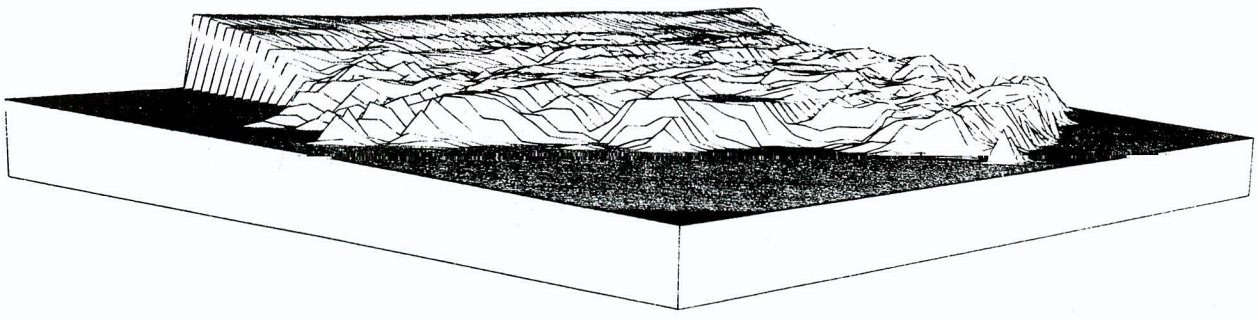
ACKNOWLEDGEMENTS

My grateful thanks are due to Mr David Stroud of the Botany Department, U.C.W., for kindly collecting the material and to Dr J.D. Fish of the Department of Zoology, U.C.W., who identified the amphipod host of *Acetubalastoma hyperboreum*. Dr David Horne suggested the possible presence of *Sclerochilus bradyi*. Miss Christine Grainger performed most of the technical preparation and the paper was typed by Mrs Marian Rivers. Mr Duncan Hawley was kind enough to allow me to quote extensively from his Magister thesis and also to use some of his S.E.M. photographs. Mr Howard Williams photographed the plates and Miss Alicia Moguilevsky dissected several specimens of *Acetabulastoma*.

My grateful thanks are extended to them all.

As a long standing member of WAGBI, I wish particularly to applaud their support of the Greenland White-fronted Goose Study.

Dr R.C. Wnatley, Department of Geology, University College of Wales, Aberystwyth, Dyfed, Wales.



SECTION L TECHNICAL REPORTS

L 1 DETAILS OF FREIGHT AND TRAVELLING ARRANGEMENTS

W. J. Higgs

WEATHER AND MONEY

Greenland is a huge, arctic area, and its small population lives in a string of widely-spaced coastal settlements mainly on the western side. Travelling in such a place is obviously going to be expensive, time-consuming and liable to disruption especially by the weather. We were very lucky in this respect, and our travel arrangements went without a hitch.

The country has a good network of scheduled ship and helicopter services between the settlements, briefly described below, but for the expedition with special requirements, or for anyone wishing to visit areas away from the settlements, large amounts of money are required for charter. This, and luck with the weather, are the Greenland traveller's chief requirements.

OPTIONS AVAILABLE

Only a general outline can be given, because arrangements change from year to year. Send for your timetables well in advance, and *don't* rely on last year's.

1) *Europe to Greenland*

As far as it was possible to ascertain, it is not possible to obtain a sea passage to Greenland, so that travellers must use the flights from Copenhagen or Reykjavik. Some money can be saved by using the boat/train services from Britain to these cities instead of flying.

Freight

The KGH (Den Kongelige Grønlandske Handel: The Royal Greenland Trade Department) send between four and nine cargo ships to Greenland each month from Aalborg, Denmark. Each ship calls at several ports in Greenland so that most towns are covered by the service although in winter sea-ice prevents visits to the more northerly towns. Goods can of course be transferred to the passenger ship network within Greenland. To get your freight to Aalborg, DFDS Line sails from Newcastle and Harwich, and provides road services on to Aalborg, and no doubt other North Sea ferry services provide similar facilities.

2) *Within Greenland*

There is a frequent helicopter service run by Grønlandsfly which covers all the larger towns, and a comprehensive network of coastal steamers is operated by the KGH.

Charter (a) Boats: Small motor boats are widely owned and used in all Greenlandic settlements. It is usually possible to charter or temporarily buy these. Larger boats such as large fishing boats can also be chartered at a wide variety of rates - we were offered a 20 tonne, 7 knot boat with capacity for 12 people and 15 tonnes of cargo for 2000 D.Kr. per day, but after becoming friendly with a local person we were offered his boat which was 'bigger and faster' for 1000 D.Kr. per day.

(b) Helicopters: The usefulness of such transport is obvious, but the cost can quickly become astronomical. Grønlandsfly offers four models, ranging from four to twenty five seats, costing from £450 to £1200 per hour at 1979 prices. Remember that you have to pay for the helicopter to come from its base in Nûk or Søndre Strømfjord Air Base even though you only want to be lifted 50 km out of, say, Sarqaq. Beware also of mysterious surcharges on the final bill!

(c) Sledges: In the winter, or well into the spring if the sea-ice persists, dog-sledges can be easily hired in any town north of Sisimiut.

It is a good idea for the prospective user of the above forms of local transport to stay a few days in town before chartering since it is difficult to make local contacts otherwise. The people are generally friendly, but business is done at a leisurely pace and much better results will be obtained by fitting in with this pace rather than expecting to have everything arranged an hour after arrival.

OUR ORIGINAL PLANS

Given the above state of affairs, we had to plan our expedition around the scheduled transport available, as we could not afford to charter, except perhaps a boat to take us a few miles out of town. We were therefore restricted to a coastal base-camp. The White-fronted Goose lives in the interior in the south of its range, and nearer the coast in the north, and although the interior is penetrable by the large fjords of the south, these would have been ice-bound in early May, and would in any case have involved too long a journey out of town.

As a result our plan was to send food and equipment via Aalborg to one of the towns of Disko Bay (where we had discovered three sites reputed to hold breeding White-fronts), and to follow by air via Copenhagen and the internal helicopter service. Then we would charter a boat to take us and our gear to the isolated area where the geese lived.

WHAT ACTUALLY HAPPENED

Although the decision to proceed as above was taken early in the preparations for the expedition, research continued into reliable reports of breeding concentrations of geese and alternative means of transport. Both these avenues proved fruitful; the group surveying the Caribou population in 1977 told us of substantial numbers of geese in the interior, not far north of Søndre Strømfjord Air Base, and we were offered trans-Atlantic transport plus an air-drop by the RAF. We

acted on both these leads, and had our supplies air-dropped, while we used the money saved on air-fares to charter helicopters to get ourselves in and out of Eqalungmiut Nûnat. After leaving Base Camp on 20 August we took a trip on the coastal steamer M.S. Disko, calling at Sisimiut and Âusiât to visit local people. We arrived back at Søndre Strømfjord Air Base in time for our spectacular ride home in Hercules 191 on 1 September.

Although we were very lucky with the weather, it is perhaps pertinent to give details of two nearly-disasterous bureaucratic hitches. Things began to get rather hectic during the last few weeks in Britain, and I omitted to inform the Ministeriet for Grønland of our change in destination. Thus we did not have permission to camp where we did, and the RAF did not have permission to air-drop there. This led to a stiff reprimand after our return, and some unpleasant moments for our second party when they arrived in Søndre Strømfjord Air Base to find themselves carrying the can for our misdemeanours.

Secondly, and also during this hectic period when everything seemed to be sewn up as regards overall logistics, I failed to respond to a letter from the office co-ordinating the RAF air-lift, thinking that I had already made those particular arrangements with the aircrew themselves. This almost lost us the air-lift on the day before departure because the co-ordinating officer had no details of our requirements.

There is really nothing anyone can say except "Get it right !", but these examples do draw attention to the responsibility of the secretary for keeping lines of communication absolutely clear and up to date, and making sure that all correspondents are fully informed of the intentions of the expedition.

L 2

PROVISIONS

A. M. V. Higgs

"You are what you eat."

"It is very strange this domination of our intellect by our digestive organs. We cannot work, we cannot think unless our stomach wills so."

PLANNING

No factor has a greater effect on the morale and health of an expedition than the food. My enquiry to the group 'what would you like to eat?', received the useful reply 'as much as possible'. To this I added 'of as much as possible' and this became my aim.

Initially, it was assumed that all supplies would have to be backpacked from the coast to an inland site, with forays restricted by the rations that could be carried. Calculations showed that on a six day journey, the maximum weight per man-day was 680 g (24 oz). Such a weight restriction meant taking the greatest variety of dehydrated foods whilst maximising calorific content. I estimated a minimum of 3 000 kcal per man-day should be sufficient and the daily ration was set (Table L2.1) including eight different savoury dinners, four types of carbohydrate source, six desserts, four lunch-time treats and a selection of tinned meats, fish, spreads and biscuits (Tables L2.2). A typical menu is shown in Table L2.3. The same menu should have occurred only twice during sixteen weeks.

In addition to our daily allowance, a supply of various filling foods was planned for Base Camp to augment the basic ration.

The necessity of keeping costs to a minimum further restricted items chosen. We found it impossible to obtain dried savoury meals at reduced price, but were fortunate to be given supplies of textured vegetable protein which, mixed with various dried vegetables, herbs and spices, gave five different meals.

ORDERING

It is the aim of expedition quartermasters to obtain food at the lowest possible cost, petitioning firms of every description to this end. Having been afflicted with an injunction to chew menthol-flavoured gum continuously on a previous expedition because it had been donated, at the same time living on a teaspoonful of potato powder for dinner because it hadn't, I decided to stick firmly to the food planned.

Our precise requirements were obtained at low cost wherever possible; most foods were either donated, supplied at specially reduced prices direct from the manufacturers or bought through catering suppliers, although a few items which I felt to be particularly valuable in the diet were bought at retail prices. Considerable expense was saved by mixing and packing our own meals.

Although ordering began in September 1978, very little food was donated to us before we received recognition from the Royal Geographical Society. Our most successful requests were individually typed letters listing details of the project, our major contributors, and a good reason for wanting a specific product. Often, we ordered food which was never invoiced and once the expedition had established a degree of credibility, firms were extremely generous with goods, help and advice.

PACKING

On such a long and isolated undertaking, the threat of seven fat weeks followed by seven lean ones is very real. Strict control over the issue of stores is essential, but the job of quarter-master is time-consuming and tedious, tending to result in one expedition member becoming Base-

TABLE L2.1 Details of one man-day pack

ITEM	WEIGHT	
Porridge	80 g	3 oz
Sugar	80 g	3 oz
Milk (full cream)	50 g	2 oz
Tea bags	25 g	1 oz
Cheese	50 g	2 oz
Biscuits	80 g	3 oz
Treat	25 g	1 oz
Soup	25 g	1 oz
Savoury meal	50 g	2 oz
Carbohydrate	80 g	3 oz
Sweet	25 g	1 oz
TOTAL WEIGHT	570 g	1 lb 6 oz

TABLE L2.2 Food Varieties

SAVOURY DINNERS:	Chicken Supreme
	Steak and Kidney
	Dairy Meals - Cheese and Onion
	- Scrambled Egg with Cheese
	* Stew
	* Mince
	* Spaghetti Bolognese
	* Beef Stroganoff
	* Curry
CARBOHYDRATES:	* Dumplings
	Potato
	Wholemeal Spaghetti
	Plain Spaghetti
	Brown Rice
DESSERTS:	Dried Fruit
	Yorkshire Biscuits
	Jordan's Crunchy
	Alpen
	Instant Whip
	* Fruit Cake
BISCUITS:	McVitie's Digestives
	Ryvita
	Crawford's Cheddars
	Krackawheat
	McVita
TREATS:	Chocolate Bars (Mars, Twix, Bounty etc.)
	Chocolate Biscuits
	Dried Fruit
	Nuts

* = Home made

TABLE L2.3. TYPICAL DAY'S MENU

Breakfast

Tea

Porridge with milk and sugar or syrup, (or salt) (*Yuk - Ed.*)

Tea

Lunch

Tea

Ryvita and Cheddars with Cheese and Jam

Digestives and a Chocolate Biscuit

Tea

Dinner *

Tea

Leek Soup

Beef Stroganoff with Spaghetti

Stewed Apricots

Tea

Tea

Tea

* *Alternative Dinner*

Tea

Leek Soup

Tea

Beef Stroganoff with Spaghetti

Tea

Stewed Apricots

Tea

Tea

Tea

(From data supplied by P.C.Davies & A.D.Fox)

bound. We thus decided that food should be pre-packed so that issue would be a simple matter of collection of a bag of rations, a tin of margarine, cutting a hunk of cheese and counting out a biscuit ration. This made for a good deal of pre-expedition work, but should have freed the quartermaster for scientific work. The dried components of a four man-day pack were sealed in individual polythene bags using paper covered wire twists and packed together in a large numbered bag. In the field, each pair started with bag 1 and took a consequentively numbered bag every other day. Thus the six identical ration packs labelled 31 were all being consumed on 30/31 July. The ration bags were packed carefully in tea chests for transportation to RAF Lyneham in preparation for the air-drop. On the advice of the suppliers, the biscuits and cheese were kept in the manufacturers' containers for transportation.

ASSESSMENT OF RATION PACK SYSTEM

It is difficult to assess the success of the ration pack system as a means of avoiding over-consumption and cutting down work, as over half our food reached the tundra at near terminal velocity. Many heart-breaking hours were spent salvaging, measuring and repacking foods so that the time-saving advantage was lost completely, stock-taking became a nightmare and the food was never again adequately distributed. However, once repacked, the system worked well, although it is surprising how few graduates can count from one to fifty-six, and a strict system of recording issues would have been useful.

Most of the losses caused by the air-drop were due to bags splitting (not just at the seams) on impact so mixing the contents of the four man-day packs. I now know that leek soup with sugar is only slightly more pleasant than sugar with leek soup, and a great deal of this unpleasant mess would have been reduced by using sturdier packing materials. As the possibility of a disastrous air-drop can never be ruled out, a further precaution would be to pack all rations of one kind together. Once in the field, it would take a few hours to reassemble the four man-day packs. In this way, the hazards of bulk stock-taking in the field would be minimised without risking the disaster we experienced.

ASSESSMENT OF DIET

The major criticism throughout was of insufficient food. This was not entirely due to the air-drop losses, although the bulk supplies planned for Base Camp were effectively lost. Most people would have gladly carried greater weights of food, although the amounts suggested ranged from twice the amount to an extra Mars bar per day. It was generally agreed that a fourth meal was missing which could easily have been eaten on the march or during a night watch. Probably an additional 230 g (8 oz) per man-day of chocolate, dates, nuts, muesli , cake, coconut ice, raisins or fudge would have been acceptable to most people, bringing the calorific intake to 4 000 kcal per day, while for the constitutionally undernourished, the bulk supplies planned for Base Camp would have brought their diet up to the required level.

Throughout, individual preferences varied tremendously and there seemed sufficient variety to please all people some of the time. Most foods were generally liked; a few attracted devoted followers but only one, Springlow Dairy Meals, earned the contempt, if not dread, of all. Several foods stood out as especially successful: amongst meat-eaters, Batchelors steak and kidney ranked highly, while the home-made Spaghetti Bolognese was overall favourite. Tinned tomato puree was well worth the weight; brown rice and wholemeal spaghetti were included for roughage, but were enjoyed for their flavour and texture. For the same reason, the most successful dessert was

Jordan's Original Crunchy, easily the most-enjoyed food of the expedition. It was easy to eat dry on the march and with milk at main meals; we were given two cases, but twice this amount would have been happily consumed.

Dumplings were made from stone-ground flour and suet, eaten as a savoury or cooked in boiling water and served with syrup or jam; both proved very popular. Steamed puddings made from dried egg, milk, flour, dried apple or jam took time to make but were well received, and flat cakes of soda bread cooked in floured frying pans made a welcome change from biscuits. Digestives were prized above most things and rations of these could easily have been tripled (*or a packet per day EACH - Eds.*). They remained in good condition throughout the four months. The cheese proved easy to carry and an important protein source, although cutting the large blocks could have been made easier by using a cheese wire.

Other popular items were corned beef, jam, peanut butter, honey and Marmite. Orovite and Redoxon effervescent vitamin C tablets were used as enjoyable fruit drinks and as sweets. Herbs and spices were used to a great extent; indeed, anything to ring the changes and create the occasional culinary masterpiece is thoroughly recommended.

I cannot leave the subject of food without mentioning some of the strange eating habits born out of hunger and tedium during the four months. Tea drinking became a major social event; we drank our way through 20 000 tea-bags in sixteen weeks and the only constraint on consumption was the availability of sugar and milk. Porridge, as our main surplus food, was devoured in great quantities and, towards the end, it was not unusual to see someone sit down to a large billy of porridge after the main meal. Oats were used to bulk up savoury dishes, and the appalling 'Grot' - the sieved mixture of all salvaged food from the drop - was used in both porridge and stews, although fortunately the dreaded 'Super Grot' - equal quantities of mixed foods, splintered tea-chests and tundra - never had to be eaten. We had so much essentially bland food that several people developed cravings for very hot items, such as extremely strong lime pickle. This eventually led to a curry Oxo cube eating competition in which ADF chewed five cubes in less than a minute!

The greatest change in our eating habits was the propensity for eating fatty foods, with suet eaten in handfuls, and margarine taken in vast quantities in everything. I would recommend future expeditions to remember that fat at *c.* 200 kcal/28 g (8 oz) provides twice as much energy for the same weight as sugar or flour and the body seems well aware of the fact!

LOCAL FOOD SUPPLY

It was once said that taking food to the arctic was like taking coals to Newcastle. Thanks to the ecological lobby, Newcastle is now a smokeless zone and half of Greenland a National Park. However, on the west coast, licences to hunt and fish can be bought and if a locality is known to be good for Char or Caribou, permits are a wise investment. Porsild (1953) gives details of edible plants to be found in the arctic. Those few who tried found *Angelica* scarcely edible, so don't rely on this! *Boletus* toadstools were common and extremely tasty to jaded palates. In towns, dried meat and fish can be bought at reasonable cost and indeed, we found food little more expensive than in Great Britain.

L 3 MEDICAL REPORT

J. E. Bell

INTRODUCTION

Before embarking on an expedition, prospective members should make sure that they are fit to do so, and it is wise to have both dental and medical examinations so that foreseeable problems can be avoided. It is also worthwhile for each expedition member to complete a form giving brief details of his medical history, blood group, allergies etc.. In the event of an emergency this information may save valuable time, especially in a foreign hospital, and therefore no details should be omitted.

The aim of our medical supplies was to provide cover for small, wide-ranging field parties, as well as a central supply at Base Camp. Thus several items were duplicated (particularly bandages and dressings); Table L3.1 is comprehensive, and although we did not use much of the equipment we might have needed to do so had we been unlucky.

In addition to the hardware taken (Table L3.1), it should be noted that a number of individuals possessed extensive dissecting kits containing forceps, mounting needles, scissors, scalpels etc.. I have listed only that which was set aside specifically for first aid usage. From this assortment of bandages, drugs and hardware, six small bags were made up with the intention of providing cover for a party of two people who would be no more than 10 hours walk from Base Camp. Their contents are given in Table L3.2. For trips away from Base Camp which were scheduled to last longer than a day, the items listed in Table L3.3 were taken *in addition* to those mentioned in Table L3.2.

The rationale behind this planning was that most injuries were likely to be minor cuts, bites, stings, strains etc, and thus were catered for in the day bags. For more severe injuries, deep cuts, very severe sprains or fractures the invalid would have to have been left *in situ* (assuming that his partner was unable to assist his return to base) and await a rescue team bearing suitable equipment. Obviously a balance has to be struck between overloading and not providing enough first aid equipment. In the event we had no more serious accident than a mildly sprained ankle - to some extent reflecting the gentle nature of the terrain and the equable climate. If we had had to work on steep or unstable ground, or in harsh weather, then more extensive precautions would have been necessary.

The extra items added to the day bags for longer journeys were only of a first aid nature to relieve pain. In the event of a serious accident or illness, evacuation of the patient to Søndre

TABLE L3.1. Medical Equipment taken to Greenland

BANDAGES AND DRESSINGS

Item	Size	Quantity
Triangular bandages	90 x 127 cm	24
Crepe bandages	7.5 x 450 cm	6
Crepe bandages	10 x 450 cm	10
Lint dressing	No. 8	24
Lint dressing	No. 9	12
Ambulance dressing	No. 1	12
Ambulance dressing	No. 2	12
Jelonet paraffin gauze dressing	10 x 10 cm	100
Melolin dressing	10 x 10 cm	100
Bandaid dressing	assorted pack	2
Zinc plaster	2.5 x 500 cm	6
Elastoplast	2 x 3 inches	100
Elastoplast	3 x $\frac{7}{8}$ inches	100
Elastoplast	120 assorted	1
Absorbent lint	25 g carton	6
Cotton wool	500 g roll	3
Cotton wool	buds	100
Seton dumb bell sutures		100
Aseptor gauze swabs	7.5 x 7.5 cm	10
Blenderm surgical tape	2.5 x 500 cm	6
Crinx conforming bandage	7.5 x 300 cm	12
Steristrip closures	$\frac{1}{2}$ x $\frac{1}{4}$ inches	24
Steristrip closures	$\frac{1}{4}$ x 3 inches	12
Tubegauze (fingers and toes)	size 12	20 m
Tubegauze (hands and arms)	size 56	20 m
Elastoplast strip	7.5 x 450 cm	5

DRUGS AND OTHER PREPARATIONS

Amfipen	250 mg	250
Omnopon	20 mg/ml ampules	8
Uvistat cream	50 g tube	6
Antihistan cream	50 g tube	8
Alcin antacid	360 mg tabs	1000
Senakot	7.5 mg tabs	1200
Histofax cream	50 g tube	1
Mogadon	5 mg tabs	100
Phenergan cream	25 g tube	11
Rozalex barrier cream no. 8	450 ml tube	1
Dettol solution	500 ml bottle	2
Optrex solution	500 ml bottle	2
Immodium	2 mg capsules	60
Cetavlex cream	50 g tube	14
Compocillin VK	250 mg tabs	500
Xylocaine 1%	2 ml ampules	3
Distalgesic tablets		500
Septrin tablets		100
Phenergan	10 mg tablets	500
Ventolin	4 mg tablets	100
Otrivine nasal spray	14 ml	3
Canestan (antifungal) cream	20 g tubes	2
Mycota cream	25 g tubes	5
Mycota powder	70 g tins	5
Fortral	5 mg tabs	100
Lomotil tablets		500
Erythrocin	250 mg tablets	100
Caladryl cream	42 g tube	6
Cicatrin antibiotic powder	15 g tin	1
Savlon solution	500 ml bottle	1
Tanderil Chlotamphenicol 10%	5 g tubes	3
Betnesol N, nasal drops	5 ml bottle	5
Cetrimide cream	30 g tubes	6
Dettol cream	25 g tubes	3
Surgical spirit	500 ml bottle	1
Sensodyne toothpaste	125 ml tubes	2
Oil of cloves	4 ml bottle	1

TABLE L3.1. (continued)

HARDWARE

Spencer Wells artery forceps	straight 5 ins	2
Scissors dissecting, fine point	5 ins	6
Mosquito artery forceps	curved small	1
Hypodermic needles	38 x 0.8 mm	7
Hypodermic needles	23 x 1.0 mm	12
Syringes	2 ml disposable	11
Syringes	10 ml disposable	2
Clinical thermometers		4
Clinical thermometer (low reading for hypothermia)		1
Safety pins	assorted	24
Wooden splints		5
Surgical sutures and needles	38 cm	10
Inflatable splints	hand/wrist	1
" "	foot/ankle	1
" "	full leg	1
" "	full arm	1
" "	repair patches	1
Finger stalls, plastic	assorted 10 pack	1
Eye baths		2
Tubegauze applicators	Sizes F & D	1 each

TABLE L3.2. Day Bags

Item	Size	Quantity
Ambulance dressing	4 x 5 inches	1
Triangular bandages	90 x 127 cm	2
Crepe bandage	10 x 450 cm	1
Sterile lint dressings	No. 8	2
Cetrimide cream	30 g tube	1
Lint pads	25 g	2
Lint dressing	No. 9	1
Elastoplasts	6.3 x 2.2 cm	8
Elastoplasts	7.5 x 5.0 cm	8
Bandage, open weave		1
Adhesive strapping tape		1
Ambulance dressing	8 x 7 inches	1

TABLE L3.3. Additional items for day bags for long trips away from Base Camp.

Item	Size	Quantity
Phenergan cream	25 g tube	1
Steristrip closures	½ x ¼ inches	6
Crepe bandage	5 x 450 cm	1
Scissors	pair	1
Uvistat cream	50 g tube	1
Omnopon ampules		2
Sterile syringes	2 ml	2
Sterile needles	both sizes	1 each

Strømfjord Air Base would have been necessary since none of the team was medically qualified, and thus we would have been unable to provide long-term treatment of disease or severe wounds. This did not happen, although the experience of appendicitis during a similar expedition (Darlow 1978) is a warning to be prepared for the worst.

Apart from minor problems such as cuts and bruises there were only a few more serious accidents, detailed below.

June 1: During hide watch the patient suffered a severe burn on his left forearm caused by spilling boiling tea over himself. The scalded area rapidly blistered, particularly below the metal wrist-watch which was not removed fast enough. This had the effect of conducting and maintaining heat on the skin. Three hours after the accident Jelonet dressings were applied without any other medication - the area being clean and sterilised by the burn - and kept in place for 24 hours. The next day clean lint dressings held in place with a gauze bandage were applied and changed at regular intervals to prevent further damage or infection. The burn healed quickly on that part of the arm kept warm by clothing but took over seven weeks to heal on the exposed hand. To aim for rapid (or rather, normal) healing of wounds in the arctic they should be kept as warm as possible to increase peripheral blood circulation.

June 2: The patient started a very severe headache for which two Disprin were given. A few minutes later he vomited and started sweating profusely whilst feeling giddy and nauseated. After a couple of sips of tea he retired to bed only to vomit four more times, both violently and copiously. Following this he slept continuously for 18 hours after which he was completely restored and was able to eat and drink heartily.

There are two probable causes; the patient had been continuously at work for the previous 40 hours without sleep and this would undoubtedly have had a general debilitating effect. Secondly he recalled drinking a small amount of possibly foul water from a stagnant pool in Upper Marsh eight hours before the onset of the headache. This could have resulted in poisoning exacerbated by the general state of tiredness.

July 17: Numerous small white eruptions, about 3 mm in diameter appeared on the back of the patient's hands, similar in appearance to nettle rash. These were first attributed to mild allergic reaction and he was given a tube of Antihistamine (Mepyramine) cream. However the spots remained on the backs of the hands causing no irritation or similar inconvenience to their owner. With the onset of cooler weather towards the end of the expedition they slowly disappeared and were probably caused by excessive sweating, although why they should be confined only to the backs of the hands remains unknown.

August 1: The same individual was also prone to suffer from bouts of acute cramp in both calf muscles and thighs rendering him totally unable to walk. This condition first became apparent on 1 August when he had to be carried back to Base Camp. Upon examination the areas showed no sign of bruising or inflammation indicating muscular damage. However hard knots of contracted muscle could be felt and to alleviate this his legs were massaged with hot soapy water - usually affording relief. Upon resuming exercise the cramp rapidly returned with equal intensity. The patient was rested for several days and the condition eventually wore away.

A suggested cause at the time was salt deficiency due to excessive sweating (see above) but as this is usually accompanied by general weakness and vomiting (whilst the patient was otherwise in excellent condition) it would not appear to be the major cause. In the previous week the patient had walked well over 100 miles on various exploratory and ringing trips and had then spent three days prior to the first attack resting and drinking tea at Base Camp. It is probable that the extensive walking had resulted in much myofibrilar damage which had started to heal in the inactive period. On resuming exercise once more cramps resulted. It may be of significance that similar cramps appear to inflict highly trained race-horses when their training programme is disrupted.

Heat and Cold

Heatstroke on an arctic expedition is an eventuality which is unlikely to have been given much forethought, but which, however, is a very real possibility. Many times during July and August individuals performed tasks of extreme physical exertion. The risk of heatstroke during these was increased since one of the best ways of guarding against biting insects was to cover as much of the body as possible, thus impeding the normal sweating/cooling processes. Despite the fact that we did not have a case of heatstroke, I believe we came quite close on a number of occasions. Individuals complained of dizziness and slight nausea, and those affected were seen to stumble and lag silently behind when walking. Great care must be taken to prevent this situation from worsening by taking frequent rests (with plenty of food and water to replace sweat loss) instead of 'pressing on for another hour'. These symptoms may not be remarked upon by the sufferer and so it is necessary for people to watch each other for signs of incipient heatstroke.

Equally insidious, but perhaps more obvious, are the effects of cold and the risk of hypothermia. Only on two occasions was it necessary to warm people suffering from the early stages of hypothermia. Invariably cold attacks because of inadequate clothing - either not enough, or by warm clothes becoming wet and thus less effectively insulating. It can be guarded against simply by taking adequate clothing for the prevailing conditions together with some extras in the event of the weather worsening. Nonetheless individuals will insist they have enough and will not be swayed, except perhaps when it may be too late !

Much has been written about guarding against hypothermia and it would be pointless to duplicate this here, however, important items to be taken on *all* walks away from Base Camp, especially when alone, are some form of emergency ration (see Section L2), a whistle and a light metallic coated survival bag. For a fuller and more detailed exposition of this topic the booklet *Safety on Mountains* (British Mountaineering Council 1975) is highly recommended.

The medical supplies were generally approved by members although there were complaints about the voluminous nature of the day bags, although small items can be stored in the hollow frames of most rucsacs. Where any semi-permanent establishments are made, it is wise to establish as a precaution a small supply there, particularly items such as Phenergan cream which should be applied as soon as possible after an accident. Because of the unfamiliarity of the drugs to most people, everyone should be made aware of, or be able to find information on, the use and dosage of every preparation available. This can be done by either placing central lists in the medical chests or issuing separate lists to all individuals - thus avoiding overdosage or use of the wrong drug. If placed in the first aid box, the book will also act as a record of all injuries which occur and an inventory of equipment available.

ACKNOWLEDGEMENTS

We were given a series of talks and demonstrations by members of the Aberystwyth St, Johns Ambulance Brigade to whom we are most grateful. Dr R.A. Stroud also gave much helpful thought to and advice on our likely requirements and quantities needed as well as assisting in supplying many of the above listed items. We are most grateful for his helpful suggestions.

L 4 RADIO REPORT

J. E. Bell

Communications for the expedition were planned with three different aims in mind: to facilitate contact with Britain via the radio telephony network of the Grønlands Tekniske Organisation (GTO), to allow contact between three field parties, and to enable a large group of people to move in unison when surrounding geese on a lake.

All the radio equipment was kindly loaned to the expedition by Racal-Tacticom Ltd. We are extremely grateful for this loan, without which the expedition would have been severely hampered, and for the good offices of Messers E.J. Peett and P. Freitag through whom it was co-ordinated. The following items were taken to Greenland:

3 Comcal TRA 922 HF sets
3 Hand generators
3 Spare rechargeable batteries
3 Dipole masts and antennae
3 VHF PRM 4160 sets and dry cell batteries
Accessories and spares for the above.

During the parachute drop, two of the hand generators were damaged when their crate fell free about 30 m onto the frozen ground. Fortunately their function was not seriously impaired.

The GTO allocated us four frequencies for use in the field. These were:

2090 kHz	Contact with GTO Sisimiut (ship to shore frequency)
2182 kHz	International distress frequency
2784 kHz	For use between expedition field parties
3350 kHz	

Despite an arranged regular schedule with GTO Sisimiut, we were unable to contact them for the entire duration of our stay in Eqalungmiut Nunât. Communication was well within the capability of the sets, and failure was probably due to the 120 km range falling between maximum ground wave and minimum sky wave propagations. Between separate field parties there were no problems, but bad local reception on 3350 kHz soon after our arrival led to our using 2784 kHz for local transmissions thereafter. The only difficulty encountered was that reception was often weak between two parties on either side of a large massif, for example in deep valleys with a ridge between, and this was exacerbated by a low battery charge.

On 24 June we managed to contact the Grønlankske Geologiske Undersøgle (GGU) using 3350 kHz. Initially we spoke only to a field party 'lying high' on a mountain south of Søndre Strømfjord Air Base, but as reception improved we managed to talk directly with their radio station at Søndre Strømfjord Air Base. The GGU operate in this region from June to August, and following our initial conversation we established twice weekly schedules during which we passed messages to the GTO, Grønlandfly, and Mr Steen Malmquist. We are indebted to the GGU and their radio operator Mr Torben Westergaard for this line. Without it, arrangements for our departure would have been virtually impossible to make. As it was we were able to adapt our plans to suit the date of the RAF flight from Søndre Strømfjord Air Base. All the work there, such as buying tickets, sending telegrams, and co-ordinating with Grønlandsfly, was done by Mr Malmquist, without whose help we would have been much hindered.

For co-ordinating the goose catches we used three hand-held PRM 4160 'walkie-talkies' operated on 40.5 MHz. These were most useful and, although on several of the smaller lakes we could have managed with whistles and hand signals, they were invaluable when surrounding larger lakes or when pre-determined tactics changed half way through a catch. In all we had three VHF sets and three HF sets. With a control operator having one set of each frequency, four other sets were available for parties engaged in surrounding the lake. This was usually adequate when used in combination with whistle signals, but ideally each member of a round-up party should have had a VHF set operating on a common frequency. It is necessary to take a large supply of dry cells, since prolonged use of the VHF sets drains them, particularly in cold weather.

We were able to obtain the BBC World Service on 5795 kHz (Short Wave) between 20.00 and 04.00 hours GMT. During the day this frequency is used by Radio Greenland which swamps BBC transmissions (but offering such delights as Ralph McTell's 'Streets of London' sung in Greenlandic !). At night between 01.00 and 07.00 hours GMT we could also receive the BBC from their Caribbean Relay Station on 6175 kHz. The reception was very weak on all Short Wave frequencies and was much improved by attaching a ten metre coaxial cable to the aerial of the transmittor radio. This is recommended to future parties in this region who wish to keep in touch with world events,

L 5 GENERAL EQUIPMENT ACCOUNT

A. P. Fowles

The equipment requirements of the expedition were governed mainly by the following factors: the duration of our stay, the air-drop assistance from the RAF, the climate and geography of the area and the nature of the scientific work. The moderate climate of continental west Greenland makes a four month expedition quite feasible and, combined with invaluable aid from the RAF, we were able to make preparations for the 1086 man-days in the field to be as comfortable as possible. The equipment taken for Base Camp is given in Table L5.1.

A great variety of equipment was taken by the expedition members and without dwelling on the suitability of each brand, it is best to generalise by stating that all goods of a decent quality performed well. The conditions are not harsh in the region and hence the high quality and expensive items that are so essential in the high arctic were not considered worth the additional outlay by many members. An advisory list was drawn up prior to departure and is given in Table L5.2.

TABLE L5.1. Communal equipment taken to Greenland

Quantity	Item
1	Vango Force Ten Mk 3 lightweight tent
4	Vango Force Ten Mk 3 standard tents
1	Vango Force Ten Mk 2 flyweight tent
1	Fjallravn lightweight tent
1	Blacks Niger mess tent
2 dozen	Spare 7" alloy tent pegs (*You can't take enough - Ed.*)
1	Mallet
2	Collapsible entrenching tools
1	Hurricane Lamp
3 dozen	Candles
3	Canvas buckets (14 pint)
2	Polythene buckets
200	Toilet rolls
2	Totem Backpacker pack frames
1 roll	Heavy duty polythene sheeting (5 m x 70 m)
2 dozen	Heavy duty polythene bags(ex-fertiliser)
1	Repair kit (hammer, Stanley knife, hacksaw, glues etc.)
15 m	3 mm Karrimat
2 kg	Nikwax
6	Silva 15T compasses
6	Silva 2NL compasses
2 pairs	Uniroyal Keenfisher waders
80 items	Assorted insect repellents
6	96L Optimus stoves (½ pint)
3	Optimus stoves (1 pint)
	Primus spares (washers, prickers, locking caps, roses etc.)
6 sets	Nesting billies (5 pint, 3 pint, 2 pint)
4	5 gallon jerry cans
3	Thermos flasks (1 litre)
300 boxes	Matches
6 packs	Lifeboat flarers (waterproof matches)
18 'Baby'	Can openers
	Cleaning utensils (pan scourers, brillos etc.)
90 gallons	Paraffin (55 gallons used in 1086 man-days)
60 packs	Metafuel (40 bar packs)
8	1 pint Army water bottles (used for paraffin)
2	150' climbing ropes
6	Clog Karabiners
6 sets	Miniflares
6	Lifejackets
2	Inflatable dingies (lightweight, plastic)
2	Collapsible canoes
1	Two-man portable canoe
8	Bernina ice-axes
2	Collapsible chairs
1	Short wave transistor radio

TABLE L5.2. Personal equipment recommended to members.

Quantity	Item
1 pair	Walking boots
1 pair	Wellington boots
6 pairs	Woollen socks
2 pairs	Warm trousers
4	T-shirts
1 set	Thermal underwear
2	Thin pullovers
1	Balaclava or hat
2 pairs	Gloves
1	Cagoule
1 pair	Waterproof overtrousers
1 pair	Gaiters
1	Rucsac (>45 litre capacity)
1	Sleeping bag
1	7 mm roll of Karrimat
2	Plates
2 of each	Knife, fork and spoon 1 pint mug
	Towel toiletries
4 pairs	Underpants
1	Whistle
1	Survival bag
	Needle and thread
1 tube	Lip salve
1 pair	Snow goggles
1	Pocket knife
3 pairs	Spare boot laces
1	Torch
1	Warm jacket
	Notebooks, novels and stationery

COMMENTS

Tentage

The relatively mild conditions of Eqalungmiut Nunât allowed almost any tent to be used, but the rainfall of mid-summer necessitated the use of a flysheet. The major problems arose from the presence of the permafrost layer in May and early June - frustration and deformed tent pegs prevailed at the pitching of each tent. A mallet is an essential aid and we suggest that patience and spares should be taken along in good measure. Steel tent pegs would have performed better in these conditions than aluminium ones. There are few handy boulders in the valleys and the tents must be pitched firm against the 100kmh^{-1} föhn winds. In addition to the eight tents listed in Table L5.1 we constructed two others; one of parachute SEAC, the other of polythene sheeting and these provided valuable storage and work space. The 2.5 m poles taken for this purpose proved invaluable since no *Salix* grows sufficiently tall or straight.

Miscellaneous communal equipment

The canvas buckets were of great value but the polythene buckets cracked along the folds after little use and also had a tendency to collapse when full. Jerry cans (strictly 5 gallon plastic containers) were useful for the transportation and storage of water and fuel, however much spillage could have been avoided had we fitted taps to the containers. Plastic containers have the advantage over metal jerry cans of being light when empty and combustible if one has problems with baggage allowances.

The Karrimat served a dual purpose; not only did it provide necessary insulation from the cold of the permafrost, but it also protected sleeping bags from the large amount of groundsheet condensation generated in these conditions. Most people had a roll of 7 mm mat in addition to the floor coverage. Together these ensured a good night's sleep on even the roughest surface and reduced heat loss tremendously.

All the various mosquito repellents were effective to a greater or lesser extent. The 'stick' types were messy but gave protection for approximately four hours per application; creams were not as effective, generally lasting only for 1-2 hours and a repellent spray worked for a similar duration. The traditional Oil of Citronella gave only ten to fifteen minutes protection, but had the advantage of at least smelling pleasant. Although we had roughly sufficient quantities, had mosquitoes, black-flies and midges maintained their activity till the end of August we would have run short. It is best not to skimp on this item !

Ice axes were an unnecessary item in the relatively snow-free conditions of continental west Greenland. However they were more effective than the collapsible entrenching tools for digging latrine pits, and as emergency tent pegs.

As it happened the RAF supplied several kilometres of string and cord in the form of parachute cords which proved just about sufficient for our needs. This item is invaluable for virtually every purpose from DIY tents and transect lines, to repairing rucsacs and using as bootlaces. Had it not been for the parachutes, our three balls of string would have been ludicrously inadequate and it is recommended that future expeditions equip themselves with large amounts of a range of cord items.

Cooking

For various reasons we had a great deal of trouble with primuses, and without a comprehensive repair kit and an inventive handyman we could have found ourselves in some difficulty. All of the stoves had been thoroughly serviced prior to our departure from Britain and yet all suffered from one fault or another during the expedition, particularly leakage of pressure at the base of the burners and clogging of the jets with soot. Had only moderate quantities of metafuel been used to start the primuses, then this trouble might have been lessened. The Bulldog nesting billies were excellent and easily withstood the almost incessant boiling required to keep the expedition supplied with tea.

Personal equipment

The cheaper makes of down sleeping bags proved quite adequate throughout the period, even in temperatures of about -10°C. Several members of the expedition took Hollofill bags and these were excellent, even when wet. However, during late July and August they were found to be too effective, proving almost too hot to sleep in at times. The members of the second party, who were only present for this latter half, found that 38 oz. polyester bags were quite adequate.

Fitzroy duvet jackets were excellent but by no means essential. A windproof cagoule and sweaters are quite sufficient.

Strong walking boots are essential and it is advisable to have them well broken-in before going to Greenland. The tussocky nature of the terrain is very hard on the ankles and makes walking slow and difficult. From June onwards, as the permafrost melts, the lowland areas quickly become very wet underfoot and the continual soaking (good as Nikwax is) can quickly damage boot-leather. For this reason Wellingtons proved to be very valuable and the Uniroyal Royal Hunters that were kindly donated to us were excellent for the conditions. However when walking in snow it quickly froze onto the metal studs of the Royal Hunters, building up to form an ice ball on the bottom of the boot. For this reason non-studded Uniroyal Hunters are recommended for another expedition. The abrasive effect of the heath vegetation on wet boot-leather caused large holes to be quickly worn in the toes of most boots. This was exacerbated by the lack of footpaths, and it took only six weeks to wear through the toe of one brand new pair of boots completely, less for boots that had been used before. There would seem to be no means of avoiding this, except perhaps to advise that Wellington boots be worn more often in conditions where walking boots are liable to get wet. It would be a serious problem for longer stays in this region.

The expedition was donated a dozen pairs of breeches from Cambrian Fly Fishers, which were suitable being both warm and mosquito proof, but moleskins were found to wear out much quicker than tweed or cord. Some members preferred to wear jeans and experienced no discomfort, especially when worn with long-johns. A spare pair of trousers is strongly advised.

Although we did not have the snow conditions to necessitate the wearing of gaiters, many members chose to wear them with breeches for a variety of reasons. They kept the calves warm and mosquito free, protected socks from snagging on the tundra vegetation, and prevented boots from filling up with leaf litter as one walked. However, the five pairs of Karrimor gaiters in use all failed at one time or another because of breakages to the zip.

D. A. Stroud

The main items of equipment taken are given in Table L6.1. Generally we had sufficient of all essentials, however it is surprising where the specimen tubes go, and there can never be too many of these. Each member of the expedition should have been issued with a set of Pesola balances and Vernier Callipers as much egg morphometric data was lost as a result of having just one set of balances. However, equipping an expedition of this size with a range of balances is expensive unless members of the ringing fraternity are already equipped.

An acquisition code was used and is greatly recommended for use on other occasions. Each acquisition was marked or labelled with a three part code: A(cquisition)/(collector number)/(serial number). Details of the collection site and identification were entered in an acquisitions log at Base Camp, as well as in the collector's notebook. A standard system saves much confusion when collections get accidentally mixed.

Notebooks are also in great demand on occasions like this. We were generously supplied by Waverly-Cameron Ltd. with notebooks and logbooks with *Alwych* all-weather covers. It is easy to have a smashing time with thermometers, and we soon went through our stock. It is advisable to take a large number of spares. Mounted thermometers are generally more robust than straight lab thermometers, although max/min thermometers are generally less accurate. The choice will depend on the project.

A wide selection of field guides and keys was taken, although we could have cut down on these had we had to carry them any distance.

Laboratory

John Bell ingeniously constructed a large polythene 'greenhouse' extension to the mess tent. A large working space was made from air-drop base boards, and benches alongside from packing cases. In the event this lab. proved invaluable especially for the dry storage of specimens, and for sorting and classifying collections. We were fortunate in having several master carpenters and handymen with us, who could make such a structure out of odds and ends as we had not realised how important 'lab space' would be; with some forethought it should be easy to produce a pre-fabricated laboratory which would be even easier to construct.

We took with us twenty 2.5 m poles cut from Birch and Ash trees in Wales. These were to have been used as walking stakes for crossing large rivers. In fact they were used for a wide range of purposes, not least of which was as frameworks for various DIY tents and the 'greenhouse'. It was lucky we were able to strap them without difficulty to the tops of the larger parachute loads. They were worth their weight in gold, and certainly more useful to us.

Hide

The wooden hide used in the continuous watch (see Section D6) was designed and built by Mr A Jennings and Mr S Halls (see Section L7). It was most suitable for our purpose: an extended study through severe weather conditions.

When originally planning the behavioural study, several alternatives were considered. Polythene and canvas conventional hides were soon discarded because of the unknown severity of the weather conditions and the problem of ensuring that they did not flap in severe winds. The use of a tent as a hide has many advantages. It is highly portable, easy to erect, storm-proof and cheap. It is an item of equipment that expeditions will already have, so does not need to be purchased specially. However most expeditions to remote areas opt for brilliantly coloured flysheets, which may mean substituting a more sombre coloured one when the tent is being used as a hide. A green tent was used as a photographic hide for nesting White-fronts at Muddersbugt, Disko Island by Mr Otto Plantema in 1975. The tent was moved forward over a period of time and by the third day the geese had not deserted although it was only 15 - 20 m from the nest.

The two major problems of hide use in a long study are observer comfort and access. The former is not really of importance for short photographic sessions, but we felt (and after the experience fully confirm) that observer comfort should be a major consideration, especially when long shifts are involved. The access problem is more acute. Every time the tent used by Mr Plantema was entered, the goose flushed from the nest to return later. Clearly this is unacceptable in a behavioural study. Even a tent with a rear entrance would be difficult to enter out of site of the geese. Although a wooden hide is more conspicuous, once in position it was possible to leave and enter unseen from the nest.

The hide design we used has many features to recommend it. It is pre-fabricated and breaks up into sections that are easily portable. When it is made up it can be carried in upper and lower halves by several people (>5 recommended !). If securely roped down it is stable in high winds (when it was blown away on 12 June it was unroped and placed on a windswept ridge). There is ample room for one observer in comfort, and two without too much of a squeeze. The head room is ample except for large people.

We make the following suggestions for improvement, however, in the light of its performance. The window flaps should open inwards instead of outwards to ease opening and hinged perspex windows should be fitted, or be capable of being fitted to all sides. The marine ply should be varnished on the outside to improve water-proofing, and roofing felt used as a covering if much rain is to be expected - polythene inevitably tears or punctures. If the hide is to be used at one site for a length of time then putty or mastic, inserted between the sections as it is put together, will reduce leaking and the entry of driving snow. Extra wood should be taken for *ad hoc* internal fittings such as shelves for primus stoves, log books and telescope stands. (We used a G-clamp telescope attachment on a shelf which increases leg room considerably).

TABLE L6.1 List of basic scientific equipment taken to Eqalungmiut Nunât.

1 x binocular microscope	1000 envelopes for seeds and lichens
1 x monocular microscope	3 x plant presses
3 x thermometers	1000 tie-on labels
2 x max/min thermometers	200 glass vials
4 x 30 m tapes	1.5 kg, 300 g, 50 g and 5 g Pesola balances
3 x 3 m tapes	
5 litres 40% formaldehyde	Many collecting bottles, tubes and containers of assorted sizes and shapes

L 7

HIDE DESIGN

A. J. Jennings

BRIEF

A sectional hide was required, reducible to easily erected light sections suitable for back packing but tough enough to be air-dropped, of standing height, and with a floor area large enough to accommodate a bed (as base hospital), having a 360° viewing capability and hopefully being both fire-resistant and warm.

SOLUTION

As weight and unit size dominated the design, a cube of internal size 1.84 m and built from stiffened ply modules, size 0.94 m^2 emerged as most suitable. The lower panels consisted of 5 mm external ply and softwood framing, size 50 x 37 mm, glued with a resistant adhesive and closely nailed with 37 mm thin wire nails. One module contained the door which was lightly framed and glued, and hinged to the outside of its module so that it would not easily jam. It was operated and held in position by a nylon cord to maintain flexibility and permit easy escape.

Top sections, constructionally a repeat of the lower, accommodated window openings and shutters at seating level. These were string-operated and hinged as the door. The opening size permitted escape in case of a fire.

As wall sections were to be bolted together with 5 mm bolts (interchangeable with canoe bolts - see Section L8), sealed pockets for the bolts and other accessories were provided.

The flat roof, consisting of four equal sections and edged with softwood framing, was arranged for on-site fixing by nails and screws. A light tie beam provided a ridge piece to support a low pitched polythene covered roof surface. Guy ropes with fixings provided anchorage, while four spare modules of ply were packaged for flooring or repairs. Insulation or fireproofing was eventually considered unnecessary.

The design was agreed in a very short time and my friend S. Halls and I constructed and pre-erected the hide in a weekend of about 40 - 50 man hours.

L 8

BOATS

A. J. Jennings & W. J. Higgs

PORTABLE CANOE DESIGN

Brief

I allowed myself to be persuaded to build canoes because of the novelty of the specification.

The brief was cryptic; a one man, dismountable, stable, manouverable, easily assembled (in cold condititions), cheap framework weighing about 8 kg to accept a preformed fabric skin. Each canoe should be capable of supporting in emergencies two humans and baggage.

Solution

Calculations provided displacement and stability solutions which resulted in the development of a flattish hard chine underwater profile with excess freeboard for emergency overload and a size of length 4 m, beam 0.375 m and greatest depth 0.35 m. The boat, divided into three longitudinal sections, was built from aluminium tubulars supported by four plywood bulkheads. The keelson, of 20 mm tubing was bent to form stem and stern posts. 16 mm chine and gunwale tubulars were strained around the notched bulkheads and bolted to aluminium gussets at stem and stern. Two extra intermediate tubulars were bolted between end bulkheads forming bilge strakes the distance between tubes to the design maximum of 175 mm. The two inner (major) bulkheads were set to a comfortable distance for the canoeist and provided support for a tube-and-platform seat and footrest. Fore and aft tubular supports, from stem/stern posts to the top of the inner bulkheads provided vertical triangulation. As the simplest solution, all tubulars were bolted with round headed bolts to the 12 mm ply bulkheads, which were lightened by the removal of the bulkhead inner, unnecessary, area. Tube connections were socketed and held in place by wire, from a coil, bent through location holes.

The skins of the boats, a separate undertaking, were to include one spare and were designed to be laced into position as this was considered to be the least complicated method.

Assembly operations were hoped to be the simplest for arctic conditions. In England assembly and dismantling frame times were 15 minutes each, without haste by one man.

Construction time for the two canoe frames, undertaken by W.J. Higgs, and myself, was of the order of 120 man hours and I probably enjoyed my part. As an interesting comment, rail weight including packaging for a complete canoe frame, was 8.5 kg.

THE BOATS IN USE

Unfortunately, all the boats were severely damaged in the airdrop, due to their being strapped across the two units of a 'one ton' load. On impact these loads separated and shifted slightly, wrenching and breaking most of the long parts of the canoes. However one homemade canoe was salvaged from the remaining parts and performed well in 'recreational' trips, but proved too heavy and cumbersome for use on catching trips, despite its good economical design and ultra-lightweight materials.

For goose-catching activities the cheap, light easily assembled plastic inflatables were unbeatable. They occupied only $\frac{1}{4}$ - $\frac{3}{8}$ of a rucsac complete with paddles, pump and repair kit, and carrying one during a ringing trip was definitely a 'soft option' compared to the nets or a large radio. There were two disadvantages - one was the effort required to inflate them at each lake, and the other was their relative flimsiness and ease of puncture.

Boats are necessarily bulky objects however, and in making them portable you are inevitably going to be involved in some inflating or assembling at the waterside. The time taken to prepare for action was in fact about 30 - 40 minutes, which was really no problem since it took longer than this to erect the nets. As to the punctures, these were never dangerous but always a slow 'pinhole', but their frequency was a little irritating. This was excusable on the grounds that these boats were not designed for the type of use they got, being no more than elaborate li-los for holiday/beach use. The punctures were very easily repaired with the small, light repair kits. The inflatables were unsuitable for long distance travel, being slow and difficult to keep on a straight course.

In summary, therefore, for actual travel over water use canoes, but when portage is of prime importance, lightweight inflatables have considerable advantages.

L 9 TIME-LAPSE PHOTOGRAPHY

D. A. Stroud

INTRODUCTION

It was difficult to maintain continuous observations at more than one nest so time-lapse photography was used at other sites to supplement the data from the hide (see Section D6). The use of time-lapse photography for wildlife studies was largely pioneered in America as a means of studying the nesting behaviour of falcons (e.g. Temple 1972; Enderson, Temple and Swartz 1972; Jenkins 1975, 1978). The technique has also been modified in order to investigate the food taken by White-tailed Eagles in south Greenland (Kampp and Wille 1979) and there have been many similar studies. There are few purpose built time-lapse cameras suitable for field use, although both Minolta and Kodak make cameras for surveillance applications. Initially because of considerations of cost, two systems were made up roughly following the methods of Temple (1972), but at a later date two Kodak 'Analyst' cameras were purchased.

METHODS

The principles behind a home made time-lapse unit are simple and involve three main parts: an electric timer, a solenoid and a camera. These are usually all housed in a waterproof outer casing. The camera is attached to the solenoid so that one frame is taken every time the solenoid fires. This is affected by the specifications of the electric timer.

The timer should, for extreme accuracy, be analogous to a present day electronic wrist-watch; that is, it would have a very accurate quartz crystal master reference oscillator followed by an integrated circuit binary frequency divider chain to split the high frequency oscillations. The output pulse would then go to the solenoid circuit and automatic resetting. The fact that frames containing a picture of the 'instantaneous' behaviour of the geese were required, rather than ultra-accurate timing of these, meant that a simpler circuit was desirable in terms of time needed for construction and the cost involved.

Due to difficulties in obtaining some of the components used by Temple (1972), modifications were necessary although the concepts involved remained the same. A very similar relaxation oscillator was devised using a unijunction transistor. All the components selected were easily available from one mail order company (except for the solenoids). Twelve volt rotary solenoids were not available so 112 v Ledex rotary solenoids which had been rewound with 750 turns of 36 swg were used instead. These operated at the circuit voltage.

The circuit used is shown in Figure L9.1. The TIS.43 unijunction transistor is used as a relaxation oscillator. The timing period is determined by the values of the capacitor and charging resistors at the emitter junction. Although the timing oscillation occurs when the capacitor is being charged at the almost flat part of the characteristic exponential curve, tests at various temperatures gave quite reliable and related intervals of operation. Each time the charge on the capacitor reaches a critical voltage the unijunction transistor passes a large enough pulse of current at B_2 to energise the relay coil, the capacitor is discharged and commences to recharge repeating the cycle. The relay changes state and allows current from the battery to the solenoid, thus firing the camera.

The diodes connected across the relay coil and the output sockets to the camera control solenoid are for damping and 'back EMFs' from the inductance of these coils. The diode in series with the positive line from the battery supply protects the circuit from reversed connection. To extend the life of the batteries however, this diode can be left out. The timing of the circuit can be altered by changing the value of the variable potentiometer (RV). All circuits used in the study were preset to operate at five minute intervals.

Film Specifications

The home made 16 mm camera systems used Kodak 16 mm cartridges (25 ASA). This film has 40 frames per foot and operating at one frame per five minutes the films need changing every 2.3 days. The Analyst takes both 160 ASA Ektachrome film and MFX film. The former is 50' long and colour whilst the latter is 100' long and black and white. Because of the longer period between changing films that the MFX gives we used this. Running at the Analyst's slowest exposure speed of one frame per 90 seconds, this meant changing the film every 7.5 days. The focal length of the Analyst is variable between 13 and 28 mm. In Greenland it was used at the former setting which gave a horizontal field of view of 61' at a distance of 150'.

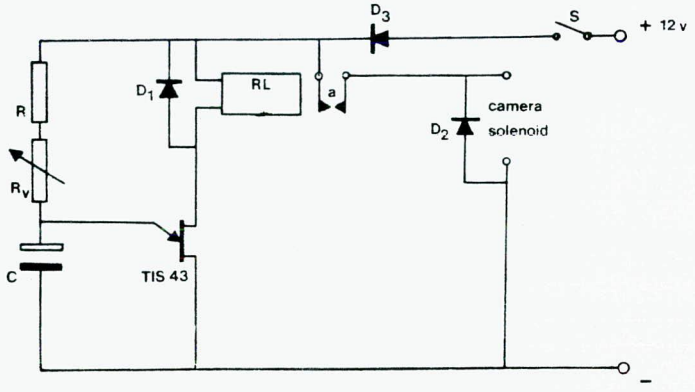


Figure L9.1. Electronic circuit of the home made time-lapse cameras.

R	133 000 Ohms
RV	22 000 Ohms
C	2 200 µF 25 Volt electrolytic
RL	RS Relay type 349-125
D_1-D_3	Diodes type 1N4007
TIS.43	Unijunction transistor (Texas Instruments)
S	Single pole on/off switch

RESULTS

The operation of both camera systems was less than satisfactory, but for different reasons. The 16 mm cameras could only accept 25 ASA film cartridges. This slow film speed was not suitable for cameras without automatic exposure control, and the result was that the 'night' periods produced very dark images hardly exposing the film. However 16 mm film was considerably easier to analyse and the images much more distinct than Super 8 mm film.

The black and white MFX film was not suitable for the conditions. The incubating goose was well camouflaged against the background vegetation of dried grasses, and when this was translated to a tiny 8 mm black and white image the definition and contrast left much to be desired. One film exposed at the Pass of Jennings nest site was definitely pointing at the nest since observers examining the eggs can be seen in the initial frames. However over the next few days it is impossible to distinguish the female on the film even though her position can be accurately determined. (She had not deserted as she was flushed when the film was changed a week later).

At the nest Base Camp 1 the camera was initially set up 30 m away, however later that day it was moved to 50 m distant. This was unfortunate since whilst the postures of the goose can be made out from frames exposed at the former position, they cannot be clearly seen at the latter position which was where the camera stood for the rest of the incubation. The camera could and should have been moved closer to the nest over a period of days to a distance of less than 20 m. However at the time it was thought unwise to cause too much disturbance to the geese in the light of possibly human- induced desertions, and indeed this was why the cameras were moved further from the nest.

The results gained however, vindicate the method which is recommended for the future with the following suggestions. Any 16 mm camera has the drawback that the film footage is used more quickly. However if a professional film camera with large reels is used (rather than 15 mm cartidges) this could be overcome, The Kodak Analyst is probably more easily obtainable than a professional 16 mm camera rig and is more versatile. Colour film should be used wherever possible even when this means more frequent visits to change film. (At a distance of 50 m the female did not flush when this was done, merely laying her head on the ground until the observer was well away from the nest again). A 50' Ektrachrome film running at one frame per 90 seconds last for 3.75 days and even at this length of time the disturbance caused on changing films, which can be quickly undertaken, will be minimal. The camera should not be placed *too* close (<5 m) since, when operating, the shutter and wind-on motor make a small click and whirr which although well silenced by the waterproof housing, could alter behaviour.

APPENDIX

Interval Timer

In order to make observations from the hide at five minute intervals without constant reference to wrist-watches, the timing circuit of the time-lapse camera (Figure L9.1) was modified to operate both a buzzer and a light (Figure L9.2). The additional components in the circuit are a relay (RL_2) which closes on the timing pulse from RL_1 and at the same time locks itself on and remains so after the relaxation oscillator pulse has ended. The locking contacts at 'a_2' are in series with the 'unlocking' or reset button switch PS. When relay RL_2 is locked on, the second set of contacts b_2 switch on the signal lamp L and/or the 12 volt audio-alarm A depending on which switches are on.

Although the audio signal could not be heard away from the hide, it was so annoying that it was soon removed from the circuit ! The red light alone and the click of the relays was quite sufficient. The duration of the signal before the reset button (PS) is pressed does not inhibit the five minute interval of the timing circuit. The circuit was powered, as was Figure L9.1, by two 6 v HP Ever-Ready dry cells. As can be seen the values of the resistors used in the basic circuit will vary with different unijunction transistors.

The interval timer was broken when it blew away with the hide on the night of 12 June. However the loss was not as serious as it might otherwise have been, since it appeared that after many days of timed observations, observers had gained a subconscious timing of the five minute period, and were thus able to judge quite accurately without constant reference to their watches.

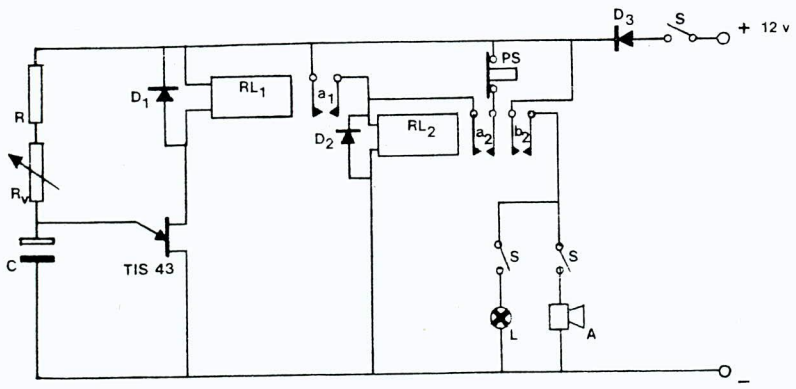


Figure L9.2. Electronic circuit of the interval timer.

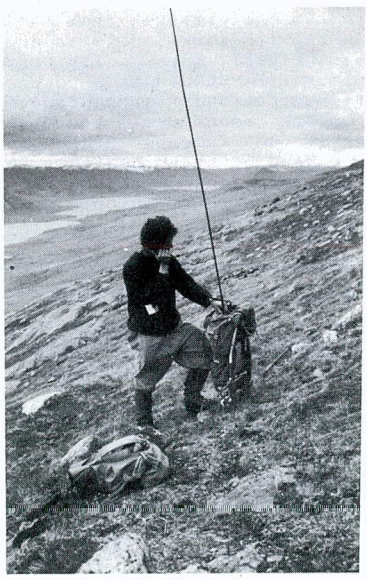
R	86 000 Ohms
RV	47 000 Ohms
C	2 200 μF 25 v electrolytic
RL_1	RS Relay type 349-125
D_1-D_3	Diodes type 1n4007
TIS.43	Unijunction transistor (Texas Instruments)
RL_2	RS Relay type 348-942
PS	RS push-button switch type 337-942
S	Single-pole on/off switches
L	12 volt panel lamp
A	RS audible warning device type 248-808

Note that values of resistor will vary with different TIS.43's. Individual selection was found to be necessary.

ACKNOWLEDGEMENTS

Mr Archie White gave much invaluable time and effort in designing and constructing the timing circuits for both the cameras and the interval timer. Without his sound advice and explanations of the electronic principles involved I would have been considerably out of my depth. He also contributed descriptions of the circuits to the above account, and I thank him very much for all his help.

Ever Ready donated batteries for the circuits. Mr P. Tapley designed the cases for the cameras, and these were made most expertly by Mr Gordon Walker of the Department of Physics, UCW. Drs S.A. Temple and M.A. Jenkins kindly answered various queries on their methods.



JB using Racal-Tacticom Comcal TRA 922 HF set on the slopes above Eqalungmiut tasë

FINANCIAL REPORT

A. D. Fox

The following is a summarised list of income and expenditure of the Greenland White-fronted Goose Study in the period 1 July 1978 to 30 June 1980. The accounts have been audited by W.L. Smart, Accountant at the University College of Wales, Aberystwyth and are available in more detail on request.

INCOME

Expedition members (personal contributions)			2043
Private donations			201
Donations from grant-giving bodies:			
Bass Charrington Ltd.	20		
British Ecological Society	100		
Conder Trust	500		
Dept. of Forestry and Fisheries, Dublin	968		
Drapers Company	100		
Dulverton Trust	200		
Dyfi and District Wildfowlers Association	100		
Dyfi Wildfowl Management Panel	50		
Ernest Kleinwort Charities	250		
Fauna Preservation Society	200		
Gilchrist Educational Trust	400		
Mount Everest Foundation	400		
NATO Eco-sciences Panel	2064		
Owen Owen Estates	100		
Premier Polish	20		
Scott Polar Research Institute	50		
Scottish Ornithologists Club	100		
Vincent Wildlife Trust	658		
Welsh Plant Breeding Station	100		
West Wales Naturalists' Trust	25		
West Worcestershire and District Rough Shooting and Wildfowling Club	32		
Whitley Animal Trust	500		
Wildfowlers Association of Great Britain and Ireland	1351		
Anonymous	250		
			9223
Expedition fund raising schemes			257
Interest			140
Miscellaneous			9
		TOTAL	£11 873

EXPENDITURE

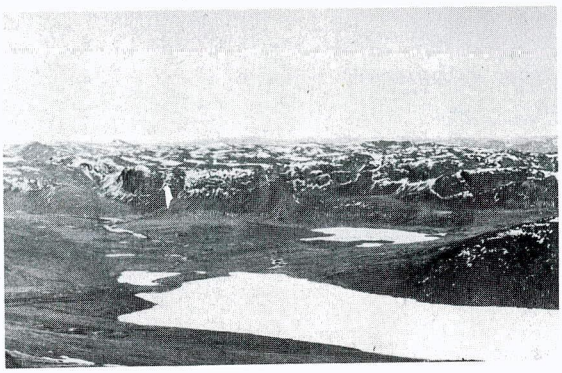
Preliminary trip to Copenhagen	269	
Travel in the United Kingdom	296	
Winter study trips to Scotland	624	
Air Travel to Greenland	666	
Helicopter hire in Greenland	3072	
Purchase of equipment etc.		
Boats	735	
Photographic	1068	
Flares	125	
Medical	168	
Maps	128	
Ringing equipment	150	
General equipment	1229	
Food	620	
Fuel	55	
General expenditure in Greenland	1165	
Insurance	250	
Miscellaneous office expenditure	279	
Printing	125	
Expenditure on Preliminary Report and initial expenditure on Final Report	223	
	£11 247	

Excess of Income over Expenditure as at 30 June 1980 £626

Since the accounts were audited, there has been further expenditure up to 1 June 1981 as follows:

Final Report advance orders	7	
Excess of Income over Expenditure (30 June 1980)	626	
Final Report Expenditure		96
Winter study trips to Scotland		203
Balance in hand		£334

In addition to the grant-giving trusts acknowledged above, the Winston Churchill Memorial Fund gave financial support to AMVH on a personal basis.



View south-east from the Crusties peaks, early May 1979. Note frozen East Eqalungmiut tasia in the foreground and the sharp distinction between upland and lowland areas beyond Ridgeway Marshes.



PCD and ADF inflating the light-weight inflatable dingies at Atanârssuk.

SECTION M ACKNOWLEDGEMENTS

The expedition was the end result of a vast amount of hard work and goodwill given freely by a large number of groups and individuals. Without their help, advice and assistance, the whole project would have been impossible and we extend to all of them our most sincere and grateful thanks. The following deserve particular gratitude:

FINANCIAL SUPPORTERS

Bass Charrington Ltd., British Ecological Society, Mr. Hugh Boyd, Conder Conservation Trust, Dept. Fisheries and Forestry, Dublin, Drapers Company, Dulverton Trust, Dyfi and District Wildfowlers Association, Dyfi Wildlife Management Panel, Ernest Kleinwort Charities, Fauna Preservation Trust, Gilchrist Educational Trust, Mr, A.Gosler, H.R.H. The Duke of Edinburgh, Mount Everest Foundation, NATO Eco-sciences Panel, Owen Owen Estates, Premier Polish Ltd., Scott Polar Research Institute, Scottish Ornithological Club, Vincent Wildlife Trust, Wildfowlers Association of Great Britain and Ireland, World Wildlife Fund (Denmark), Welsh Plant Breeding Station, West Wales Naturalists Trust, Whitley Animal Protection Trust, an anonymous trust fund and of course, all our Adopters of Geese and Friends of the Expedition.

MORAL SUPPORT

The Wildfowl Trust, The Royal Geographical Society, The Scientific Exploration Society, The University College of Wales, and especially our families, wives and friends.

FOOD AND EQUIPMENT

Aber Gun Supplies, Associated Yeast Co. Ltd., Aymers Ltd., Bell and Howell Ltd., Bencard Ltd., BrookeBond Oxo Ltd., Bryant and May Ltd., Cadbury Typhoo Ltd., Cambrian Fly-fishers Ltd., Colman Foods Ltd., Co-operative Wholesale Society Ltd., Cash'n'Carry Ltd., Damart Ltd., Energen Food cp., Ever-Ready Ltd., Field and Trek Ltd., Mrs D L Fox, Henri-Lloyd Ltd., W. Jordan & Son (Biggleswade) Ltd., Mr R D Lewis, S. Mayall & Son Ltd., McDougalls Catering Foods Ltd., Morning Foods Ltd., Maeth-y-Maesydd, Nabisco Ltd., L.E. Pritchitt & Co. Ltd., Quaker Co. Ltd., Racal-Tacticom Ltd., The Royal Air Force, Royal Geographical Society, RHM Foods Ltd., Roche Products Ltd., Ryvita Ltd., Tate and Lyle Refineries Ltd., Uniroyal UK Ltd., Unilever Exports Ltd., United Biscuits UK Ltd., Waverley Cameron Ltd., Weetabix Ltd., J.E. Wilson & Sons (Kendal) Ltd., Whitworths Holdings Ltd., Yorkshire Biscuits Ltd.

ADVICE AID AND TIME SPENT ON OUR BEHALF

Gregers E. Andersen, Mr P.G. Argyle, Dr G.P. Arnold, Dr K.E. Bannister, Dr R. Beasley, Miss H. Bigwood, Mr C.G. Booth, Mr Robin Bovey (for an original idea), Mr D. Boyd, Mr H. Boyd, Mr B. Brewer, Mr J. Broon, Mr W.M. Buckie (Søndre Strømfjord), Dr David Causton, The Chance Master, Mr Thomas Cobbley snr., Dr M.J. Cotton, Mrs J. Crawford, Mr P. Davey, Mrs Coral Davies, Mr Peter E. Davis, Mrs Jane Dawson, Sgt Dean (42nd Air Dispatch Unit), Mr Brian Dolan, Dr Peter G.H. Evans, Expeditions Liason Officer (Søndre Strømfjord), Mr Ian Fawcett, Mr Hannibal Fencker, Dr J.D. Fish, Mr A.P. Fowles (proof reading), Mrs Anne E.M. Fox (Home Secretary and Heroine), Mr & Mrs Duncan Fraser, Mr Peter Frietag, Dr A. Gardarsson, Mr Harry Green, The Greenlandair pilots and crew who ferried us within Greenland, Dr J.J.D. Greenwood, Geodaestisk Institut (København), Mr A.G. Gordon, Grønlands Geologiske Undersølge, Mr & Mrs P. Grossmann (Sisimiut), Mr Peter Gurney, Mr A.B. Hall, Dr David Harrison, Mr Christopher Headlam, T.D. Healing, Dr John Hedger, Mr W.J. Higgs (editorial help), Mr & Mrs S.J. Hipkin, Mr Peter Hope-Jones, Dr G. Hopner Petersen, Mr Tony Hutson, Dr Ian Inglis, IWRB, Dr D.J. Jefferies, M.A. Jenkins, Capt. Jorgen Jensen (M.V. Disko), Professor B. Jones, Mr Haydn Jones (printing), Mr K. Kampp, Dr J. Kear, Mr J.E. Kjeldsen, Kommissionen for Videnskabelige Undersøgelser in Grønland, Laboratory for Computer Graphics, Harvard Univeristy, Dr N. Leader-Williams, Jette Lewinsky, Mr R.D. Lewis (equipment advice), Dr E.J. Lindgren, Major Angus Mackie-Forbes, Mr Matthewman, Dr W. Mattox, Mr Oscar Merne, Dr H. Milne, Ministeriat for Grønland, Mr J. Mitchell, Dr J. Monk, Dr J. Morton-Boyd, National Library of Wales, B.O. Nielsen, Mr & Mrs Neilsen (Sisimiut), Mr M.A. Ogilvie, Dr M. Owen, Mr E.J. Peett, Mr M.A. Pierce, Dr W.O. Preuss, Mr A. Pugh (printing), Dr A.S. Richford, Ann Roberts, Major R.F. Ruttledge, Professor Finn Salomonsen, Dr J.P. Savidge, Preben Schleimann (Sisimiut), Mr Bruno Schroder, Sir Peter Scott, Dr Sigurdsson, Dr H.W. Simpson, Drs Slay (translations), Agnete Steenfelt (for being there), M. Stenshoj, Mr Donald Stewart, Mr J. Stewer, St. Johns Ambulance Brigade (medical training), Dr & Mrs R.A. Stroud (Medical advice and departure arrangements), Mr J. Swift, Mr P. Tapley, Dr S.A. Temple, Mr Henning Thing, University College of Wales, Aberystwyth: Departments of Botany and Microbiology, Geography, Physics, Zoology, Alexandra Hall and the Computer Unit, Dr. C. Vibe, Mr G. Walker, Professor P.F. Wareing, Dr J.M. Warnes, Dr R.C. Whatley, Mr A. White, Mr F. Wille, Mr B. Willes, C.P.O. Williams (JSE), Mr P. Woolett, Dr R.J. Wootton, Mr Frank Wrigley, and finally to the crew and pilots of 24 & 70 Squadrons who flew us to and from Greenland, and to the men of RACT 42nd Air Dispatch Unit.

IDENTIFICATION

P. Ackery, D.M. Ackland, Dr A.D.Q. Agnew, Dr T.W. Bocher, British Museum (Natural History), Dr R. Burliegh, Commonwealth Institute of Helminthology, R.W. Crosskey, J.P. Dear, Dr N.J. Evans, Dr J. Hedger, H.R. Honey, Tony Hutson, Dr J. Jewell, Alvin Jones, Dr Simon Laegaard, Bent Lorentzen, Viggo Mahler, Dr Mogensen, Charlotte Munksgaard, Boy Overgaard Nielsen, Ebbe Schmidt Nielsen, Søren Achim Nielsen, Dr John Savidge, Dr M.C. Sheldrick, K.G.V. Smith, N.D. Stork, Dr A.E. Stubbs, Søren Toft, Dr Roy Watling, Dr Solene Whybrow, Zoologisk Museum (København).

ART WORK

Jens Frimer Andersen, Caroline M. Crawford, R.D. Bennion , Ged Quinn, Gill Webb.

A SPECIAL THANK YOU TO:-

Dr A.D.Q. Agnew for his infectious enthusiasm and tremendous help throughout all stages of the expedition; Mr Steen Malmquist for constantly bailing us out of trouble in Greenland and generally acting as our front-man in Søndre Strømfjord; Flight Lt. Tom Norcross, Flight Lt. Herbie Sutcliffe, Flight Lt. Sharman and Sqd. Ld. Underwood for cheerful help over and above the call of duty and for saving the day after a near disasterous mistake on our part; The Royal Air Force for their most generous logistic support; Department of Botany, University College of Wales for providing us with office space and facilities throughout the preparation of the expedition; Mr Torben Westergaard for being a comforting and predictable voice in the wilderness; USAF Søndre Strømfjord gave us the greatest hospitality whenever members of the expediton were on the Base; Anne Fox for maintaining appropriate tea levels in the editors, for being so tolerant whilst we were endlessly boring about Greenland during the production of the report, and as Home Secretary for holding the British GWGS Fort in spite of all with the help of Dr and Mrs. Stroud; and finally we are indebted to Dr William Sinclair and Dr Shirley Agnew for the meticulous and thankless task of commenting on and proof reading the entire report in draft form; Dr Jill Venus performed the mind-bending task of typing the entire report, and giving it its final form, and Colin Venus and the staff of the National Library of Wales printed the report. To them all we would like to express our sincerest thanks for their efforts.

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All figures in the report were redrawn by the editors who are consequently responsible for all errors. The only exceptions are the following:-

Figure F5.3, F5.6, F5.9, F5.10 and F5.12 - N.W. Hardy
Figures D8.3, D8.5, D9.1, D9.2, D9.3, D9.4, E31.1, E31.2 and E31.3 - J. Madsen
Figure B3.2 - University College of Wales Computor Graphics
Figure A4.1 - Miss Hildred Bigwood

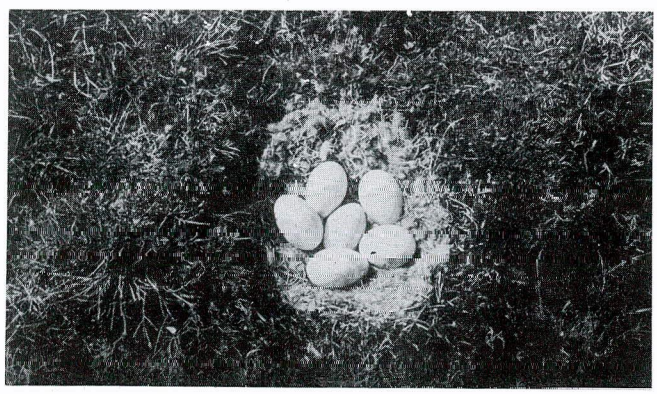
Artwood was very kindly supplied by the following:-

Caroline Crawford (pp 240, 242, 243, 244), Ged Quinn (Cover illustration, 170, 171, 173, 176, 178, 179, 183), Hop Bennion (32), Jens Frimer Andersen (4, 7, 23, 36, 62, 70, 77, 81, 107, 161, 165), ADF (27, 169, 174).

Photographs were provided by the following:-

WJH (pp 46, 300, 302), DAS (138, 257). R.C. Whatley (Plates K3.1 & K3.2), all others ADF.

Our grateful thanks goes to them all and to Sue Gwynne for interminable corrections!



Greenland White-fronted Goose nest at Rimwater Marsh.

SECTION N REFERENCE LIST AND GREENLAND WHITE-FRONTED GOOSE BIBLIOGRAPHY

* indicates that the reference is part of a comprehensive bibliography of all works mentioning Greenland White-fronted Geese, and thus they are not necessarily referred to in the text. We would be very grateful for our attention to be drawn to any Greenland White-fronted Goose references that we may have missed, such as reports of vagrants from foreign journals. Excluded from this bibliography are books solely concerned with identification, county bird reports and books, and bird observatory reports.

Abraham, K.F. (1981). Winter distribution and site fidelity of eastern Arctic Brant (*Branta bernicla hrota*). Unpublished mss. 18pp.

Abramson, M. (1979). Vigilance as a factor influencing flock formation amongst Curlews *Numenius arquata*. *Ibis* 121: 213-216.

Alison, R.M. (1975). Breeding Biology and Behaviour of the Oldsquaw (*Clangula hyemalis* L.) *Ornith. Monogr.* 18. AOU.

Alm, G. (1914). Beiräge zur Kenntnis der nördlichen und arktischen Ostracoden fauna. *Ark. Zool.* 9 (5): 1-20.

Alm, G. (1915). Monographie der Schwedischen Süsswasser - Ostracoden nebst systematischen Besprechungen der Tribus Podocopa. *Zool. Bidr. Uppsala* 4: 1-249.

* Alpheraky, S. (1905). *The Geese of Europe and Asia*. London; Rowland Hill Ltd.

Altmann, J. (1974). Observational study of behaviour: sampling methods. *Behaviour* 49: 227-267.

Ankney, C.D. (1975). Neckbands contribute to starvation in female Lesser Snow Geese. *J. Wildl. Managmt.* 39: 825-826.

Ankney, C.D. (1979). Does the wing molt cause nutritional stress in Lesser Snow Geese ? *Auk* 96: 68-72.

Ankney, C.D. & MacInnes, C.D. (1978). Nutrient reserves and reproductive performance of female Lesser Snow Geese. *Auk* 95: 459-471.

Armstrong, E.A. (1954). The behaviour of birds in continuous daylight. *Ibis* 96: 1-30.

Asbirk, S. & Franzmann, N.-E. (1978). Studies of Snow Buntings. In: Green & Greenwood (1978): 132-142.

Asbirk, S. & Franzmann, N.-E. (1979). Observations on the diurnal rhythms of Greenland Wheatear in continuous daylight. *Dansk Ornith. Forens. Tidsskr.* 73: 95-102.

Aschoff, J. (1960). Exogenous and endogenous components in circadian rhythms. *Cold Spring Harbour Symp. Quant. Biol.* 25: 11-18.

Aschoff, J. (1964). Survival value of diurnal rhythms. *Symp. Zool. Soc. London* 13: 79-98.

Atakova, N.A. (1946). K fauna Ostracoda Novosibirskogo Melkovdya. In: Toma III Tyaudov Dripfuyushchie Expeditsii Glavsevmorputi na Ledokolnov Parokhoe., G. Sedov 1937-1940 gg. *Iz Datelstro Glavsevmorputi Moskva, Leningrad* : 224-230, 8 figs. (In Russian).

* Atkinson-Willes, G.L. (Ed.). (1963). *Wildfowl in Great Britain*. London; Nature Conservancy Monograph 3.

* Atkinson-Willes, G.L. (1964). The Wildfowl situation in England, Scotland and Wales. In: Swift (Ed.) *Proc.1st. European Meeting on Wildfowl Conservation*: 25-29. IWRB.

* Atkinson-Willes, G.L. (1968). The Wildfowl situation in England, Scotland and Wales. In: *Proc. Int. Regional Meeting on Conservation of Wildfowl Resources; Leningrad* : 101-107.

Baker, J.H. & Wong, J.W. (1968). *Paradoxostoma rostratum* Sars (Ostracoda, Podocopida) as a commensal on the arctic gammarid amphipods *Gammaracanthus loricatus* (Sabine) and *Gammarus wilkitzkii* Birula. *Crustaceana* 14 (3): 307-311, figs. 1-2, pl.1.

* Ballegaard, J. (1978). (Further notes on the birds of Disko Bay). *Dansk Ornith. Forens. Tidsskr.* 30: 217-223. (In Danish).

Ballantine, W.J. (1961). A biologically defined exposure scale for the comparative description of rocky shores. *Field Studies* 1 (3): 1-19.

Balph, M.H., Balph, D.F. & Rosenburg, H.G. (1979). Social status signalling in winter flocking birds: an examination of a current hypothesis. *Auk* 96: 78-93.

* Bannerman, D.A. (1957). *The Birds of the British Isles*. Vol. VI: 204-215. Edinburgh; Oliver and Boyd.

Barry, T.W. (1970). Environmental effects on goose and swan reproduction in arctic Canada. *XVth Congress Int. Ornith. Abstr.* : 54-55.

* Bauer, K.M. & Glutz Von Blotzheim, U.N. (1963). *Handbuch der vogel Mitteleuropas*. 2. Frankfurt am Main.

Bauer, K.M. & Glutz Von Blotzheim, U.N. (1968). *Handbuch der vogel Mitteleuropas*. 3. Frankfurt am Main.

* Bayldon, J.M. (1970). Some somersaulting behaviour of Greenland White-fronted Geese. *British Birds* 63: 130.

* Baxter, E.V. & Rintoul, L.J. (1953). *The Birds of Scotland*. Edinburgh.

* Beer, J.V., Dalgety, C.T., Rankin, N., Swanberg, P.O. & Wayne, P. (1956). Some photographic studies of White-fronted and Lesser White-fronted Geese. *British Birds* 49 : 216-218.

* Belprose, F.C. (1975). *Ducks, Geese and Swans of North America*. Harrisburg; Stackpole Books.

Bengston, S.-A. (1971). Hunting methods and choice of prey of Gyr Falcons (*Falco rusticolus*) at Myvatn in North-east Iceland. *Ibis* 113: 468-475.

Bengston, S.-A. (1972). Reproduction and fluctuations in the size of duck populations at Lake Myvatn, Iceland. *Oikos* 23: 35-58.

* Bent, A.C. (1962). Life histories of North American Wildfowl. Pt. 2. New York.

Berry, A.C. (1974). The use of non-metrical variations of the cranium in the study of Scandinavian population movements. *Amer. J. phys. Anthrop.* 40: 345-358.

* Berry, J. (1939). *Wild Geese and Wild Duck in Scotland*. Cambridge.

Berry, R.J. (1968). The biology of non-metrical variation in mice and men. *Earlier Human Populations*: 103-133. London; Pergamon.

Berry, R.J. (1977). *Inheritance and Natural History*. London; Collins.

Berry, R.J., Evans, I.M. & Sennitt, B.F.C. (1967). The relationships and ecology of *Apodemus sylvaticus* from the Small Isles of the Inner Hebrides, Scotland. *J. Zool. London* 152: 333-346.

Bertelsen, A. (1932). Meddelelser om nogle af de i Vestgrønlands Distrikter mellem 60° og 77° N Br. almindeligere forekommende Fugle, saerlig om deres Ubdredelsesomraade deres Yngleomraade og deres Traek. *Medd. om Grøn.* 91: 1-74.

Bertelsen, E. (1937). Contributions to the animal ecology of the fjords of Angmagssalik and Kangerlugssuaq in East Greenland. *Medd. om Grøn.* 1 (3): 1-58.

* Bertelsen, A. (1948). (Bird-banding in west Greenland in the years 1926-1945). *Medd. om Grøn.* 142: 1-33.

Berthold, P. (1973). Presentation of data of annual events, especially of migration data. *Standardization in European ornithology*. (Ed. by J.J.M. Flegg and G. Zink). *Auspicium*, 5 (Suppl.): 49-59.

Blake, C.H. (1933). New Crustacea from Mount Desert Region. *Biol. Surv. Mount Desert Region Var. Harbour, Maine, Philadelphia:* 229-241.

Böcher, T.W. (1949). Climate, soils and lakes in continental west Greenland in relation to plant life. *Medd. om Grøn.* 147 (2): 1-63.

Böcher, T.W. (1952). Contributions to the Flora and Plant Geography of West Greenland III. *Medd. om Grøn.* 147 (9): 1-85.

Böcher, T.W. (1954). Oceanic and Continental Vegetation Complexes in South-west Greenland. *Medd. om Grøn.* 148 (1): 1-336.

Böcher, T.W. (1959). Floristic and Ecological studies in Middle West Greenland. *Medd. om Grøn.* 156 (5): 1-68.

Böcher, T.W., Holmen, K. & Jakobsen, K. (1968). *The Flora of Greenland*. Copenhagen; Haase. 313pp.

Bocher, T.W. & Laegaard, S. (1962). Botanical studies along the Arfersiorfik Fjord, west Greenland. *Bot. Tidsskr.* 58 : 168-190.

Boertmann, D. (1979). Ornithologiske observationer i Vestgrønland i somrene 1972-77. *Dansk Ornith. Forens. Tidsskr.* 73: 171-176.

* Bohemen, door H.V. (1978). Impressies van een bezock ann Greenland. *Natura* 75: 286-290.

Bond, T.E.T. (1952). *Elymus arenarius*. Biological Flora of the British Isles. *J. Ecol.* 40: 217-227.

Bonnichsen, R. (1979). Pleistocene Bone Technology in the Beringian Refugium. National Museum of Man, Mercury Series: Archaeological Survey of Canada. Paper 89: 1-297.

* Booth, C.G. (1981). *Birds in Islay*. Islay; Argyll Reproductions. 64pp. 2nd edition.

Boyd, H. (1953). On encounters between White-fronted Geese in winter. *Behaviour* 5: 83-130.

Boyd, H. (1954). Notes on the belly markings of White-fronted Geese. *Wildfowl Trust Ann. Rep.* 6: 79-81.

* Boyd, H. (1958a). The survival of the Greenland White-fronted Goose. *Wildfowl Trust Ann. Rep.* 9: 36-37.

* Boyd, H. (1958b). The survival of the White-fronted Goose *(Anser albifrons flavirostris*, Dalgety and Scott) ringed in Greenland. *Dansk Ornith. Forens. Tidsskr.* 52: 1-8.

Boyd, H. (1966). The assessment of the effects of weather on the breeding success of geese nesting in the arctic. *Statistician* 16: 171-180.

* Boyd, H. (1975). Comments on a proposed reduction in the number of Barnacle Geese wintering on Islay. Unpublished mss. 24pp.

* Boyd, H. & Ogilvie, M.A. (1971). Family Anatidae. In: *The Status of Birds in Britain and Ireland*. British Ornithologists Union. Oxford; Blackwell: 29-57.

Brady, G.S. (1866). On new or imperfectly known species of Marine Ostracoda. *Trans. Zool. Soc. London* 5: 359-393.

Brady, G.S. (1868a). Contributions to the Study of the Entomostraca. No.1. Ostracoda from the Arctic and Scandinavian Seas. *Ann. Mag. Nat. Hist.* ser.13 (4): 283-303, pls.8,9, 25 figs.

Brady, G.S. (1868b). A monograph of the Recent British Ostracoda. *Trans. Linn. Soc. London.* 26 (2): 353-495, pls. 23-41.

Brady, G.S. (1870). Contributions to the study of the Entomostraca. No.V. Recent Ostracoda from the Gulf of St. Lawrence. *Ann. Mag. Nat. Hist.* 4th Ser. 6: 450-454.

Brady, G.S. (1878). Notes on the Ostracoda. In: *Narrative of a voyage to the Polar Seas during the years 1875-1876 in H.M. Ships "Alert" and "Discovery" by Capt. G.S. Nares RN., M.C.B., F.R.S.* II: 253-256.

Brady, G.S. (1911). Notes on the marine Ostracoda from Madeira. *Proc. Zool. Soc. Lond.* : 595-601.

Brady, G.S. & Crosskey, H.W. (1871). Notes on fossil Ostracoda from the Post-Tertiary deposits of Canada and New Zealand. *Geol. Mag.* 8: 60-65, pl.2.

Brady, G.S., Crosskey, H.W. & Robertson, D. (1874). A monograph of the Post-Tertiary Entomostraca of Scotland including species from England and Ireland. *Paleontogr. Soc.* : 1-232.

Brady, G.S. & Norman, A.M. (1889). A monograph of the marine and freshwater Ostracoda of the North Atlantic and of North-Western Europe. Section 1. Podocopa. *Sci. Trans. Royal Dublin Soc.*, ser. 2, 4: 63-270, pls. 8-23.

Brady, G.S. & Robertson, D. (1870). The Ostracoda and Foraminifera of tidal rivers. With an analysis and description of the Foraminifera by H.B. Brady. *Ann. Mag. Nat. Hist.* ser. 4. 31: 1-33.

Brady, G.S. & Robertson, D. (1872). Contributions to the study of the Entomostraca. VI. On the distribution of the Recent British Ostracoda. *Ann. Mag. Nat. Hist.* ser. 4. 9: 48-63.

Braestrup, F.W. (1941). A study of the Arctic Fox in Greenland. *Medd. om Grønn.* 131 (4): 1-101.

Brakhage, G.K. (1965). Biology and behaviour of tub-nesting Canada Geese. *J. Wildl. Managmt.* 29: 751-771.

* *British Birds:* references to ringing recoveries etc. :
(1954). 41: 178.
(1962). 55: 546-547.
(1965). 58: 588.
(1966). 59: 447 & 457.
(1967). 60: 70.

British Trust for Ornithology (1976). Common Bird Census instructions. BTO; Tring.

British Trust for Ornithology (1977). Guiding principals in the analysis of Common Bird Census Returns. BTO; Tring.

Brown, J.L. (1974). Alternate routes to sociality in Jays with a theory for the evolution of altruism and communal breeding. *Amer. Zool.* 14: 63-80.

Brown, R.G.B. (1963). The behaviour of the Willow Warbler *Phylloscopus trochilus* in continuous daylight. *Ibis* 105: 63-76.

Brown, R.G.B. (1968). Seabirds in Newfoundland and Greenlandic waters, April - May 1966. *Can. Field Nat.* 81: 276-278.

Brown, R.G.B. (1970). Fulmar distribution: a Canadian perspective. *Ibis* 111: 44-51.

Brown, R.G.B., Nettleship, D.N., Germain, P., Tull, C.E. & Davis, T. (1975). Atlas of eastern Canadian Seabirds. Canadian Wildlife Service; Ottawa.

Brown, R.G.B. Barker, S.P., Gaskin, D.E. & Sandeman, M.P. (1981). The foods of Great and Sooty Shearwaters, *Puffinus gravis* and *P. griseus*, in eastern Canadian waters. *Ibis* 123: 19-30.

Browning, M.R. (1979). Distribution, geographic variation and taxonomy of *Lagopus mutus* in Greenland and northern Canada. *Dansk Ornith. Forens. Tidsskr.* 73: 29-40.

Bundy, G. (1976). Breeding biology of the Red-throated Diver. *Bird Study* 23: 249-256.

Bundy, G. (1978). Breeding Red-throated Divers in Shetland. *British Birds* 71: 199-208.

Burnham, W.A., Jenkins, M.A., Ward, F.P., Mattox, W.G., Clement, D.M. & Harris, J.T. (1974). Falcon research in Greenland, 1973. *Arctic* 27: 71-74.

* Cabot, D. (1967). The status and distribution of the Greenland White-fronted Goose, *Anser albifrons flavirostris* in Ireland, January 1967. Irish Wildbird Conservancy, Research Report No. 9. 6pp.

Cade, T.J. (1960). The ecology of the Peregrine and Gyr Falcon populations in Alaska. *Univ. Calif. Publ. Zool.* 63 (3): 151-290.

* Cadman, W.A. (1953). Winter food and ecological distribution of the Greenland Whitefront. *British Birds* 46: 374-375.

* Cadman, W.A. (1956). The Wildfowler Naturalist. *Nature in Wales* 2: 348-349.

* Cadman, W.A. (1957). *Tales of a Wildfowler.* London; Collins. 55-65.

* Campbell, J.W. (1947). The food of some British waterfowl. *Ibis* 89: 429-432.

Cassie, R.M. (1954). Some uses of probability paper in the analysis of size frequency distributions. *Austr. J. Marine and Freshwater Research* 5: 573-622.

Chapin, F.S., Cieve, K.V. & Tieszen, L.L. (1975). Seasonal nutrient dynamics of tundra vegetation at Barrow, Alaska. *Arctic & Alpine Res.* 7: 209-226.

Chaplin, R.E. (1977). *Deer.* Blandford Press. 218pp.

* Chapman, F.J. (1932). The British Arctic Air-Route Expedition (1930-1931). Appendix VI: Some field notes on the birds of East Greenland. *Geographical J.* 79: 493-496.

Christensen, J. (1979). The breeding habitat, nest-site and nest of the Greenland White-tailed Eagle. *Dansk Ornith. Forens. Tidsskr.* 73: 131-156.

Clarke, M.R.B. (1980). The reduced major axis of the bivariate sample. *Biometrica* 67: 441-446.

* Coburn, F. (1902). On the specific validity of *Anser gambelli* (Hartlaub) and its position as a British bird. *The Zoologist* 6: 337-351.

Colhoun, E.A. & McCabe, A.M. (1973). Pleistocene glacial, glaciomarine and associated deposits of Mell and Tullyallen Townlands, near Drogheda, Eastern Ireland. *Proc. R. Ir. Acad.* 73, B, 112: 165-206.

Colhoun, E.A. & Mitchell, G.F. (1971). Interglacial Marine Formation and Late-Glacial Freshwater Formation in Shortalstown Townland, Co. Wexford. *Proc. R. Ir. Acad.* 71, B; 211-245.

* Condry, W.M. (1981). *The Natural History of Wales.* London; Collins. 287pp.

Cooch, F.G. (1957). Mass ringing of flightless blue and lesser snow geese in Canada's eastern arctic. *Wildfowl Trust Ann. Rep.* 8: 58-67.

Cooke, F., MacInnes, C.D. & Prevett, J.P. (1975). Gene flow between breeding populations of Lesser Snow Geese. *Auk* 92: 493-510.

Cotton, M.J. (1971). Some observations on the fauna of an arctic tarn. In: Smart & O'Brien (1971): 49-50.

* Cramp, S. & Simmons, K.E.L. (Eds.). (1977). *Handbook of the Birds of Europe, the Middle East and North Africa: the Birds of the Western Palearctic.* Volume I, Oxford. 722pp.

Cramp, S. & Simmons, K.E.L. (Eds.). (1979). *Handbook of the Birds of Europe, the Middle East and North Africa: the Birds of the Western Palearctic* Volume II, Oxford. 695pp.

Crook, S.J. & Greenwood, J.J.M. (1978). Studies on *Lepidurus* and *Daphnia*. In: Green & Greenwood (1978): 212-220.

Cullen, E. (1957). Adaptations in the Kittiwake to cliff-nesting. *Ibis* 99: 275-302.

Cullen, J.M. (1954). The diurnal rhythm of birds in the arctic summer. *Ibis* 96: 34-46.

Curth, P. (1954). *Der Mittelsager*. Wittenberg; Lutherstadt.

Cushman, J.A. (1906). Marine Ostracoda of Vineyard Sound and adjacent waters. *Proc. Boston Soc. Nat. Hist.* 32 (10): 359-385.

Custer, T.W. & Pitelka, F.A. (1977). Demographic features of a Lapland Longspur population near Barrow, Alaska. *Auk* 94: 505-525.

Daan, S. & Tinbergen, J. (1979). Young Brunnich's Guillemots *Uria lomvia* leaving their arctic breeding cliffs: a daily rhythm in numbers and risk. *Ardea* 67: 96-100.

Dahl, E. & Krog, H. (1973). *Macrolichens of Denmark, Finland, Norway and Sweden*. Oslo.

* Dalgety, C.T. & Scott, P. (1948). A new race of the White-fronted Goose. *Bull. Brit. Ornith. Club* 68: 109-121.

Dansk Meteorologisk Institut (1978a). Provisional mean temperatures and total amounts of precipitation, 1975. København.

Dansk Meteorologisk Institut (1978b). Summaries of weather observations at Weather stations in Greenland 1966-1970. København.

Darlow, J.M. (1978). Medical Officers Report. In: Green & Greenwood (1978): 242-245.

* Davis, P.E. (1971). The Cardiganshire White-fronts. Information leaflet, Dyfi NNR, Wildfowl Management Advisory Panel. 3pp.

Dawkins, R. & Krebs, J.R. (1978). Animal signals: information or manipulation ? In: Krebs & Davies (1978): 282-309.

* Delacour, J. (1954). *The Waterfowl of the World*. Country Life.

Dementiev, G.P. & Gladkov, N.A. (1951-52). *Ptitsy Sovietskoyo Soyusa*. Moscow.

Dennis, J.G., Tieszen, L.L. & Vetter, M. (1978). Seasonal dynamics of above and below ground production of vascular plants at Barrow, Alaska. In: *Vegetation and Production of an Alaskan Arctic Tundra*. New York; Springer-Verlag.

* Dennis, R.H. & Waters, W.E. (1968). October bird migrants at North Rona. *Scottish Birds* 5: 155-170.

Dimond, S. & Lazarus, J. (1974). The problem of vigilance in animal life. *Brain Behav. Evol.* 9: 60-79.

* Donaldson, J. (1967). Winter and passage wildfowl at Lough Beg, Counties Antrim and Londonderry. *Irish Nat. J.* 15: 283-286.

Doughty, R.W. (1979). Eider husbandry in the North Atlantic: trends and prospects. *Polar Record* 19: 447-459.

Dunbar, M.J. (1968). *Ecological Development in Polar Regions*. Prentice-Hall. 119pp.

Dyke, J. (1979). Winter plumage of the rock Ptarmigan: Structure of the air-filled barbules and function of the white colour. *Dansk Ornith. Forens. Tidsskr.* 73: 41-58.

Dzubin, A., Miller, H.W. & Schildman, G.I. (1964). Whitefronts. In: *Waterfowl Tomorrow*. J.P.Linduska (Ed.). Washington, US Goverment Printing Office: 135-143.

Ebbinge, B. (1979). The significance of the Dutch part of the Wadden Sea for *Branta bernicla bernicla*. In: Smart, M. (Ed.). *Proc. 1st Technical Meeting on Western Palearctic Migratory Bird Management*. IWRB: 77-85.

* Ellis, J.M. (1966). Greenland White-fronted Geese raised in captivity in America. *Game Breeders Gazette* 14: 14-15.

Elofson, O. (1940). Über *Paradoxostoma rostratum* G.O.Sars. Bergens Museum Arbok 1939-40. *Naturv. rekke* 4: 8pp., 11 figs.

Elofson, O. (1941). Zur Kenntnis der marinen Ostracoden Schwedens mit besonderer Berücksichtigung des Skageraks. *Zool. Bidr. Uppsala* 19: 215-534, 52 text figs, 42 maps.

Ely, C.R. (1979). Breeding biology of the White-fronted Goose. Unpublished M.Sc. thesis. University of California, Davis. 110pp.

Embleton, C. & King, C. (1975a). *Glacial Geomorphology*. London; Edward Arnold. 573pp.

Embleton, C. & King, C. (1975b). *Periglacial Geomorphology*. London; Edward Arnold. 203pp.

Emlen, S.T. (1978). Co-operative breeding. In: Krebs & Davies (1978): 180-213.

Enderson, J.H., Temple, S.A. & Swartz, L.G. (1972). Time-lapse photography records of nesting Peregrine falcons. *Living Bird* 11: 113-128.

Escher, A.E., Sorensen, K. & Zeck, H.P. (1976). Nugssugtoqidian Mobile belt in west Greenland. In: Escher & Watt (1976): 77-95.

Escher, A.E. & Watt, W.S. (1976). *Geology of Greenland*. GGU, København.

Evans, P.G.H. (1981). Aberdeen University Expedition to North-west Greenland, 1974. Final Report.

Farmer, C.M. (1971). An investigation into the results of Principal Components Analysis of data derived from random numbers. *Statistician* 20: 63-72.

* Fencker, H. (1950). Den Grønlandske Blisgas (*Anser albifrons flavirostris* Scott & Dalgety) og dens ynglebiologi. *Dansk Ornith. Forens. Tidsskr.* 44: 61-65.

Ferns, P.N. (1978). General Observations on Mammals. In: Green & Greenwood (1978): 164-167.

Ferns, P.N. & Green, G.H. (1978). Observations on Pink-footed and Barnacle Geese. In: Green & Greenwood (1978): 126-129.

* Finch, D.W. (1973). The fall migration August 16 - November 30 1972. North-eastern maritime region. *Amer. Birds* 27: 24-30.

* Findlay, W.D. & Ruttledge, R.F. (1971). National Report for 1970/71, Geese,Swans and Ducks. *IWRB Bull.* 32: 30.

Finnegan, M. (1978). Non-metrical variation of the infracranial skeleton. *J. Anatomy* 125: 23-37.

* Finsch, O. (1874). Vogel.- Die Zweite Deutsche Nordpolarfahrt in den Jahren 1869 und 1870. 2: 178-239. Leipzig.

Fischer, P.-H. (1950). *Vie et Moeurss des Mollusques.* Payot, Paris. 309pp.

Fischithal, J.H. (1979). *Asmphylodona fisholsoni* sp. nov. (Trematoda: Monorchidae) from a cyprinodontid fish *Aphanius dispar richardsoni* (Boulenger), from Israel, and its allometric growth *J. Helminthology* 53: 357-562.

Fisher, J. (1952). *The Fulmar.* London; Collins.

Fisher, M.I. & Bartlett, L.M. (1957). Diurnal cycles in liver weights in birds. *Condor* 59: 364-372.

Fletcher, D.J. & Webby, K.W. (1977). Observations on Gyr Falcons *Falco rusticolus* in North-east Greenland. *Dansk Ornith. Forens. Tidsskr.* 71: 29-35.

Fog, J. (1964a). Dispersal and survival of released Mallards. *Dan. Rev. Game Biol.* 4 (3): 1-57.

Fog, J. (1964b). The Mallards from the estate of Kongsdal. *Dan. Rev. Game Biol.* 4 (3): 61-94.

* Fox, A.D. & Madsen, J. (1981). The pre-nesting behaviour of the Greenland White-fronted Goose *(Anser albifrons flavirostris). Wildfowl* 32: (in press).

* Frame, D.L.H. & Patten, J. (1981). The effect of grazing in winter by wild geese on improved grass-land in west Scotland. *J. Appl. Ecol.* 18: 311-325.

* Fraser-Darling, F. & Morton-Boyd, J. (1964). *The Highlands and Islands.* London; Collins. 405pp.

Fretter, V. & Graham, A. (1981). The Prosobranch molluscs of Britain and Denmark. Pt. 5: Marine littorinacea. *J. Moll. Studies, Suppl.* 7: 1-284.

* Freuchen, P. & Salomonsen, F. (1958). *The Arctic Year.* London; Putnam. 440pp.

Furness, R. (1978). Movements and mortality rates of Great Skuas ringed in Scotland. *Bird Study* 25: 229-238.

Furrer, R.K. (1980). Seasonal changes in nest site selection of the Fieldfare *Turdus pilaris. Ornis Scand.* 11: 60-64.

Gabrielson, I.N. & Lincoln, F.C. (1959). *The Birds of Alaska.* Wildlife Management Institute, Washington D.C. 922pp.

Gad, F. (1970). *The History of Greenland: I: Earliest times to 1700.* London, Hurst. 350pp.

* Gardarsson, A. (1975). Islenskir votlendisfuglar: 100-134. Rit Landverndar 4 Votlendi. (Icelandic Environment Union Publication No. 4: Wetlands).

Gardarsson, A. (1976). Stofnstard og frameiosls heioagaesar *(Anser brachyrhynchus)* i Thjorsarverum 1971-1974. Natturufraedistofnun Islands, Reykjavik. [Population and production of the Pink-footed Goose *(Anser brachyrhynchus)* in Thjorsarver 1970-1974. Mimeo Report, Reykjavik].

Gardarsson, A. & Sigurdsson, J.B. (1972). *Skyrsla um Rannsoknir a Heidagaes i Thjorsarverum sumarid* 1971. Fjolrit. Orkustofnun, Reykjavik.

Gelting, P. (1937). Studies on the food of the east Greenland Ptarmigan especially in its relation to vegetation and snow-cover. *Medd. om Grønn.* 116 (3): 1-116.

* Glue, D.E. (1970). An ornithological expedition to NW Iceland in the autumn of 1967. *Bird Study* 17: 247-259.

* Glue, D.E. (1972). Observation on the passage of migrant geese and waders in North-west Iceland. *Bird Study* 19: 252-254.

Godfrey, W.E. (1966). *The Birds of Canada.* Nat. Museum Can. Bull. 203: 1-428.

* Goethe, von F. (1954). Grønlandische Blassganse *(Anser albifrons flavirostris)* in Nordwestdeutschland. *Die Vogelwarte* 17: 209-211.

Gordon, I.E. (1981). Ice-scoured topography and its relationships to bedrock structure and ice movement in parts of northern Scotland and west Greenland. *Geogr. Ann.* 63A: 55-65.

Gould, S.J. (1966). Allometry and size in ontogeny and phylogeny. *Biol. Rev.* 41: 587-640.

* Gray, R. (1871). *Birds of the West of Scotland, including the Outer Hebrides.* Scotland; Murray.

Green, G.H. & Greenwood, J.J.D. (1978). Report of the Joint Biological Expedition to North East Greenland 1974. Dundee University.

Green, G.H., Pienkowski, M.W., Brown, S.C., Ferns, P.N. & Mudge, G.P. (1978). Methods used for wader studies. In: Green & Greenwood (1978): 38-51.

Greenbank, J. & Nelson, P.R. (1959). Life History of the three-spined Stickleback *Gasterosteus aculeatus* L. in Karlak Lake and Bare Lake, Kodiak Island, Alaska. U.S. Fisheries and Wildlife Service Bulletin 153: 537-559.

* Greenhalgh, M. (1975). *Wildfowl of the Ribble Estuary.* WAGBI. 72pp.

Greenwood, J.J.D. (1978). Activity patterns and habitat distributuion of tundra invertebrates. In: Green & Greenwood (1978): 168-182.

Greenwood, J.J.D., Enticott, S.W.G., Herbert, R.A. & Lochhead, G. (1978). Biological studies of tarns near Mestersvig. In: Green & Greenwood (1978): 183-211.

Grimmell, L.I. (1943). Nesting habits of the Common Redpoll. *Wilson Bull.* 55: 155-163.

Gross, H.P. (1978). Natural selection by predators on the defence apparatus of the Three-spined Stickleback. *Cand. J. Zool.* 56 (3): 398-413.

Guiness, F.E., Clutton-Brock, T.H. & Albon, S.D. (1978). Factors affecting calf mortality in Red Deer *(Cervus elaphus)*. *J. Anim. Ecol.* 47: 817-832.

Hagerman, L. (1966). The macro- and micro-fauna associated with *Fucus serratus* L., with some ecological remarks. *Ophelia* 3: 1-43.

* Hagerup, A.T. (1891). *The Birds of Greenland.* Little, Brown & Co. 62pp.

Halberg, F. (1969). Chronobiology. *Ann. Rev. Physiol.* 31: 675-725.

* Hall, A.B. & Waddingham, R.N. (1966). The breeding birds of an east Greenland valley. *Dansk Ornith. Forens. Tidsskr.* 71: 175-185.

Halliday, G., Kliim-Nielsen, L. & Smart, I.H.M. (1974). Studies on the flora of the North Blosseville Kyst and on the hot springs of Greenland. *Medd. om Grøn.* 199 (2): 1-49.

Hamilton, W.D. (1971). Geometry for the selfish herd. *J. Theor. Biol.* 31: 295-311.

Hammond, M.C. & Forward, W.R. (1956). Experiments on the causes of duck nest predation. *J. Wildl. Managmt.* 20: 243-247.

Hansen, K. (1979). Population status for the Greenland White-tailed Eagle, covering the years 1972-1974. *Dansk Ornith. Forens. Tidsskr.* 73: 106-130.

Hannaford-Ellis, C.J. (1978). *Littorina arcana* sp. nov. a new species of winkle (Gasteropoda: Prosobranchia: Littorinidae). *J. Conchology, London* 29: 301.

Hannaford-Ellis, C.J. (1979). Morphology of the oviparous rough winkle *Littorina arcana* Hannaford-Ellis with notes on the taxonomy of the *L. saxatilis* species complex (Prosobranchia : Littorinidae). *J. Conchology, London* 30: 43-56.

Harding, J.P.H. (1966). Myodocopan ostracods from the gills and nostrils of fishes. In: Barnes, H. (Ed.): *Some Contemporary Studies in Marine Science:* 369-374. Allen and Unwin; London.

Harris, C.S. (1977). MS. The distribution of Foraminifera and Ostracoda from the Minch, Inner Hebrides and adjacent lochs. *Unpublished Magister Thesis, University of Wales.*

Harris, J.T. & Clement, D.M. (1975). Greenland Peregrines at their eyries. *Medd. om Grøn.* 205 (3): 1-28.

Harrison, C. (1975). *A Field Guide to the Nests, Eggs and Nestlings of European Birds.* London; Collins.

* Harrison, J.M. (1973). *A Wealth of Wildfowl.* London; Corgi. 206pp.

* Harrison, J., Harrison, J. & Hudson, M. (1967). Melanistic White-fronted and other Grey Geese. *Wildfowl Trust Ann. Rep.* 18: 153-154.

* Harvie-Brown, J.A. & Buckie, T.E. (1892). *A vertebrate fauna of Argyll and the Inner Hebrides.* Edinburgh; Douglas.

Harwood, J. (1977). Summer feeding ecology of the Lesser Snow Goose. *J. Wildl. Managmt.* 41: 48-55.

Hawley, D. (1980). The taxonomy, anatomy and ecology of Recent marine Ostracoda from South West Greenland. *Unpublished Magister Thesis, University of Wales.*

Hazel, J.E. (1967a). Classification and distribution of the Recent Hemicytheridae and Trachyleberididae (Ostracoda) off northeastern North America. *U.S. Geol. Surv., Prof. Paper,* 564: 1-45.

Hazel, J.E. (1967b). Corrections: Classification and distribution of the Recent Hemicytheridae and Trachyleberididae (Ostracoda) off northeastern North America. *J. Paleontol.* 41 (5): 1284-1285.

Hazel, J.E. (1970). Atlantic Continental Shelf and Slope of the United States. Ostracoda Zoogeography in the Southern Nova Scotian and northern Virginian Faunal Provinces. *U.S. Geol. Surv., Prof. Paper.* 529-E,: 1-V, E1 - E20, 69 maps, 11 text-figs., 3 tables.

Heller, J. (1975). The taxonomy of some British *Littorina* species with notes on their reproduction (Mollusca: Prosobranchia). *Zool. J. Linn. Soc.* 56: 131-151.

Helms, O. (1926). The birds of Angmagssalik. *Medd. om Grøn.* 58: 205-275.

Hennig, W. (1964). Muscidae. In: Linder, E. (Ed.), *Die Fliegen der Palaearktischen Region* Vol. VII (2) Stuttgart 1110pp.

Henriksen, K.L. (1939). A revised index of the insects of Greenland. *Medd. om Grøn.* 119 (10): 1-113.

Henriksen, K.L. & Lundbeck, W. (1917). Land arthropoder (Insecta et Arachnida). *Medd. om Grøn.* 22: 481-823.

Hertz, O. (1977). *Ikerasarssuk - en boplads i Vest Grønland.* Nationalmuseat Printers Andelsbogtrykkeriet i odense.

* Hewitt, O.H. (1948). Quebec recovery of White-fronted Goose banded in Greenland. *Bird Banding* 19: 124.

* Higgs, W.J. (1978). The Greenland White-front ..... and why we intend to study it. *WAGBI Magazine Winter 1978* : 12-13.

* Higgs, W.J. (1979). In search of the Greenland White-front. *WAGBI Magazine Winter 1979* : 12-14.

* Higgs, W.J. (1980). Greenland White-fronted Goose Study Preliminary Report. 8pp, Aberystwyth.

Higgins, L.G. & Riley, N.D. (1970). *A Field Guide to the Butterflies of Britain and Europe.* London; Collins.

Hilden, O. (1964). The ecology of duck populations in the island group of Valassaaret, Gulf of Bothnia. *Ann. Zool. Fenn.* 1: 153-279.

Hilden, O. & Vuolanto, S. (1972). Breeding biology of the Red-necked Phalarope in Finland. *Ornis Fennica* 49: 57-85.

* Hjalmarsson, A.W. (1979). Fugalif i Snaefellsnes- og Hnappadalssylu. (Birdlife in Snaefellsnes- and Hnappadalssylu, West Iceland). *Natturufraedingurinn* 49: 112-125.

* Hjort, C. (1976). Notes on the bird fauna of Hudson Land and Hold-with-Hope, North-east Greenland. *Dansk Ornith. Forens. Tidsskr.* 70: 35-44.

Hohn, E.O. (1968). Some observations on the breeding of northern Phalaropes at Scammon Bay, Alaska. *Auk* 85 (2): 316-317.

Hohn, E.O. (1971). Observations on the breeding behaviour of the Grey Phalarope and Red-necked Phalarope. *Ibis* 113: 335-348.

Holm, Aa. (1967). Spiders (Araneae) from west Greenland. *Medd. om Grøn.* 184 (1): 1-99.

Hoyt, D.F. (1979). Practical methods for estimating volume and fresh weight of bird eggs. *Auk* 96: 73-77.

Hughes, R.N. (1980). Population dynamics, growth and reproductive rate of *Littorina nigrolineata* Gray from a moderately sheltered locality in North Wales. *J. Exp. Mar. Biol. Ecol.* 44: 211-228.

Hughes, R.N. & Roberts, D.J. (1980). Growth and reproductive rate of *Littorina neritoides* (L.) in North Wales. *J. Mar. Biol. Assoc.* 60: 591-599.

Hughes, R.N. & Roberts, D.J. (1981). Comparative demography of *Littorina rudis, L. nigrolineata* and *L. neritoides* on three contrasting shores in North Wales. *J. Anim. Ecol.* 50: 1-45.

Hussell, D.J.T.(1972). Factors affecting clutch size in arctic passerines. *Ecological Monographs* 42: 317-364.

* Hutchinson, C. (1979). *Ireland's Wetlands and their Birds.* IWC. 201pp.

Huxley, J.S. (1923). *J. Linn. Soc.* 35: 253-292.

Ibid, E.M. (1982). "Struthioism" - a previously undescribed behavioural response to predators. *Loco Citato* 42: 39-36, cont. p.64.

Inglis, I.R. (1976). Agonistic behaviour of breeding Pink-footed Geese with special reference to Ryder's hypothesis. *Wildfowl* 27: 95-99.

Inglis, I.R. (1977). The breeding behaviour of the Pink-footed Goose: Behavioural correlates of nesting success. *Animal Behaviour* 25 (3): 747-764.

* Iverson, J. (1952-53). Origin of the flora of West Greenland in the light of pollen analysis. *Oikos* 4: 85-103.

Ives, T.D. & Barry, R.G. (1974). *Arctic and Alpine Environments.* Methuen. 999pp.

Jackson, E.E., Ogilvie,M.A. & Owen, M. (1974). The Wildfowl Trust expedition to Spitzbergen, 1973. *Wildfowl* 25: 102-116.

James, B.L. (1968). The characters and distribution of the sub-species and varieties of *Littorina saxatilis* (Olivi) in Britain. *Cah. Biol. Mar.* 9: 143-165.

Jasin, Bin, B. (1976). MS. Pleistocene microfauna from submarine boreholes in Cardigan Bay. *Unpublished Magister Thesis, University of Wales.*

Jenkins, M.A. (1975). Gyr Falcon Breeding Biology. *Unpublished M.Sc. Thesis, Bingham Young University.*

Jenkins, M.A. (1978). Gyr Falcon nesting behaviour from hatching to fledging. *Auk* 95: 122-127.

* Jensen, A.S. (1928). *Fauna of Greenland.* London.

* Jensen, J.A.D. (1881). Beretning om en undersogelse af Grønlands vestkyst fra 66°55'N - 68°30'N i 1879. *Medd. om Grøn.* 5 (2).

* Joensen, A.H. & Preuss, N.O. (1972). Report on the ornithological expedition to North-west Greenland. *Medd. om Grøn.* 191 (5): 1-58.

* Johansen, H. (1956). Revision und entstehung der arktischen vogel fauna. Gaviae - Galli. København; Munksgaard. 96pp.

* Johns, W.E. (1957). *Biggles Flies to Eqalungmiut Nunat.* London; Collins.

Johnsgard, P.A. (1965). *Handbook of Wildfowl Behaviour.* New York.

* Johnsgard, P.A. (1979). *Waterfowl of North America.* Indiana University Press.

Jolicoeur, P. (1963). The multivariate generalisation of the allometry equation. *Biometrics* 19: 497-499.

Joy, J.A. & Clark, D.L. (1977). The distribution, ecology and systematics of the benthonic Ostracoda of the central Arctic Ocean. *Micropalaeontology* 23 (2): 129-154, pls. 1-3.

Kagarise, C.M. (1978). A simple trap for capturing nestling Wilson's phalaropes. *Bird-banding* 49, 281-282.

Kampp, K. & Wille, F. (1979). Føderanser hos den grønlandske Havørn *(Haliaeetus albicilla groenlandicus* Brehm.). *Dansk Ornith. Forens. Tidsskr.* 73: 157-164.

Karplus, M. (1952). Bird activity in the continuous daylight of arctic summer. *Ibis* 96: 31-46.

* Kear, J. (1963). The agricultural importance of wild goose droppings. *Wildfowl Trust Ann. Rep.* 14: 72-77.

* Kear, J. (1966). The food of geese. *International Zoo Yearbook* 6: 96-102.

* Kear, J. (1970). Adaptive radiation of parental care in waterfowl. In: Crook, J.H. (Ed.). *Social Behaviour in Birds and Mammals.* London; Academic Press: 357-392.

* Kennedy, P.G., Ruttledge, R.F. & Scroope, C.F. (1954). *Birds of Ireland.* Edinburgh.

Kidson, C., Gilbertson, D.D., Haynes, J.R., Heyworth, A., Hughes, C.E. & Whatley, R.C. (1978). Interglacial deposits of the Somerset Levels, South West England. *Boreas* 15(4): 215-228.

Kidwell, J.K. & Chase, H.B. (1967). Fitting the allometric equation - a comparison of ten methods by computer simulation. *Growth* 31: 165-179.

King, J.G. (1970). The swans and geese of Alaska's arctic slope. *Wildfowl* 21: 11-17.

Kinnear, P.K. (1978). Note on the diving times of Great Northern Divers on the sea. *British Birds* 71: 126-127.

* Kist, J. (1959). De Groenlandse Kolgans, *Anser albifrons flavirostris* Dalgety and Scott, nieuw voor Nederland. *Limosa* 32: 188-191.

Klie, W. (1929a). Beitrag zur Kenntnis der Ostracoden der südlichen und westlichen Ostsee, der festländischen Nordsee Küste und der Insel Helgoland. *z. Wiss. Zool.* 134: 270-306.

Klie, W. (1929b). Ostracoda. *Tierwelt der Nord-und Ostsee* 16: 16.1-16.56.

Klie, W. (1942). Die von Römer und Schaudinn 1898 bei Spitzbergen gesammelten Ostracoden. *Zool. Anz.* 137: 1-10, 7 figs.

* Koldewey, K. (1874). *The German Arctic Expedition of 1869-1870.* London. 541pp.

* Kolthoff, G. (1903). Bidrag till kännedom om Norra Polartrakternas Däggdjur och Faglar. *Kongl. Svenska Vetensk Akad. Handl. Ny Foljd* 36 (9): 54.

Krebs, J.R. (1974). Colonial nesting and social behaviour as strategies for exploiting food resources in the Great Blue Heron (*Ardea herodias*). *Behaviour* 51: 99-134.

Krebs, J.R. & Davies, N.B. (1978). *Behavioural Ecology: an evolutionary approach.* Oxford; Blackwell. 494pp.

Kretchmar, A.V. & Leonovitch, V.V. (1967). (Distribution and biology of the Red-breasted Goose during the nesting period). *Probl. Severa* 11: 245-253.

Krüll, F. (1976a). Zeitgebers for animals in the continuous daylight of high arctic summer. *Oecologia* 24: 149-157.

Krüll, F. (1976b). The position of the sun as a possible zeitgeber for arctic animals. *Oecologia* 24: 141-148.

Lambert, J.M. & Williams, W.T. (1966). Multivariate methods in plant ecology VI: Comparison of Information Analysis and Association Analysis. *J. Ecol.* 54: 635-664.

Lampio, T. (1974). Protection of wildfowl in Furope. *Finn. Game Res.* 34: 16-33.

Landsborough-Thomson, A. (1966). An analysis of recoveries of Great Skuas ringed in Shetland. *British Birds* 59: 1-15.

Lange, M. (1948). Macromycetes Part I. The Gasteromycetes of Greenland. *Medd. om Grøn.* 147 (4): 1-32.

Lange, M. (1955). Macromycetes Part II. The Greenland Agaricales *Medd. om Grøn.* 147 (11): 1-69.

Lange, M. (1957). Macromycetes Part III. Greenland Agaricales II. Ecological and plant geographical studies. *Medd. om Grøn.* 148 (2): 1-125.

Larson, S. (1960). On the influence of the Arctic Fox (*Alopex lagopus*) on the distribution of Arctic birds. *Oikos* 11: 276-305.

Lazarus, J. & Inglis, I.R. (1978). The breeding behaviour of the Pink-footed Goose: parental care and vigilant behaviour during the fledging period. *Behaviour* 65: 62-88.

Lebret, T. (1968). Veel eerstejaars Kolganzen *(Anser alibifrons)* Krijgens winters al een witte kol. (Many White-fronted Geese get their white-front patch during their first winter). *Limosa* 41: 85-89.

Lensink, C.J. (1968). Neckbands as an inhibitor of reproduction in Black Brant. *J. Wildl. Managmt* 32: 418-420.

Linke, O. (1934). Beitrage zur Sexualbiologie der Littorinen. *Zeitschrift fur Morphologie und Okologie der Tiere* 28:170-177.

Leung, Y. (1972). Ostracodesof the Central Arctic. In: Kobayash, H. (Ed.). Taxonomic guides to Arctic zooplankton. (VI). *Univ. Southern California, Dept. Biol. Sci., Tech. Rept.,* No.2: 29-40.

Lev, O.M. (1969). Analiz i Sopostavlenie Komplexov Ostrakod iz Pozdnekainozoiskikh Otlozhenii Nizovez Rek Eniseya, Obi, Pechory, Mezeni i Severnoi Duiny. *Uchen. Zap. Paleont. Biostrat., nauch-issled. Inst. geol. Arktiki, Vyp.,* 28: 25-34, 5 pls.

Longstaff T.G. (1932). An ecological reconnaisance in west Greenland. *J. Anim. Ecol.* 1: 119-142.

* Løppenthin, B. (1932). Die vogel Nordost Grønlands zwischen 73°00' und 75°30'N br. samt Beobachtungsergebrissen von der Dänischen Godthaab-Expedition 1930. *Medd. om Grøn.* 91 (6): 1-127.

Lucas, V.Z. (1931). Some Ostracoda of the Vancouver Island Region. *Contr. Can. Biol. & Fish.* 6: 399-416.

Maclean, S.F. Jnr. & Pitelka, F.A. (1971). Seasonal patterns of abundance of tundra invertebrates near Barrow, *Arctic* 24: 19-40.

Madsen, H. (1940). A study of the Littoral fauna of north Greenland. *Medd. om Grøn.* 124 (3): 1-24.

* Makatsch, W. (1974). *Die Eier der Vogel Europas, Band 1.* Neumann Verlag, Leipzig.

Manniche, A.L.V. (1910). The terrestrial mammals and birds of North East Greenland. *Medd. om Grøn.* 45: 1-200.

* Markgren, G. (1963). Studies on wild Geese in southernmost Sweden. *Acta Vert.* 2 (3): 297-418.

Marshall, A.J. (1936). Bird and animal activity in the arctic. *J. Anim. Ecol.* 7: 248-250.

Mason, R. (1977). *Petrology of the Metamorphic Rocks.* George Allen and Unwin. 245pp.

Maton, W.G. (1797). *Observations relative chiefly to the natural history, picturesque scenery and antiquities of the western counties of England, made in the years 1794 and 1796.* Salisbury; Easton.

* Matthews, G.V.T. (1966). Threat to *Anser albifrons* in Ireland. *Proc. 2nd European meeting on wildfowl conservation. Noordwijk Aaan Zee 9-14 May:* 157-162.

Mattocks, J.G. (1971). Goose feeding and cellulose digestion. *Wildfowl* 22: 107-113.

* Mattoxs, W.G. (1970). Bird banding in Greenland. *Arctic* 23: 217-228.

Mattox, W.G., Graham, R.A., Burnham, W.A., Clement, D.M. & Harris, J.T. (1972). Peregrine Falcon Study, West Greenland 1972. *Arctic* 25: 308-311.

Mayr, E. (1963). *Animal Species and Evolution.* Belknap Press, Harvard, Cambridge, Mass.

McGinitie, G.E. (1955). Distribution and ecology of the marine invertebrates of Point Barrow, Alaska. *Smithsonian Inst., Smithsonian Misc. Coll.* 128 (9): 1-201.

McKenzie, K.G. (1964). An ostracode fauna from Lago di Fasaro near Napoli. *Ann. Inst. Mus. Zool. Univ. Napoli* 16 (6): 1-23, pls. 1-6.

McKenzie, K.G. (1972). New data on the ostracode genera *Laocoonella* de Vos Stock, *Redekea* de Vos, and *Aspidoconcha* de Vos; with a key to the family Xestoleberididae and a resume of symbiosis in Ostracoda. *Beaufortia* 19, 254: 151-162.

McVean, A. & Haddlesey, P. (1980). Vigilance schedules amongst House Sparrows *(Passer domesticus). Ibis* 122: 533-536.

* Meinertzhagen, R. (1934). The relation between plumage and environment with special reference to the Outer Hebrides. *Ibis* 1934: 55.

Meinertzhagen, R. (1959). *Pirates and Predators.* London; Oliver and Boyd.

Meltofte, H., Elander, M. & Hjort, C. (1980). Ornithological observations in north-east Greenland between 74°30' & 76°00'n, 1976. *Greenland Bioscience* 3: 3-53.

* Merne, O.J. (1970a). Irish Bird Report 1969: 12-17.

* Merne, O.J. (1970b). (Ed.). Wexford Bird Report. IWC 1 (1): 1-28.

* Merne, O.J. (1971). (Ed.). Wexford Bird Report. IWC 1 (2): 1-29.

* Merne, O.J. (1972). Greenland White-fronted Geese in Ireland. *Ibis* 114: 584.

* Merne, O.J. (1975). White-fronted Geese on Wexford Slobs. *Ibis* 117: 425-426.

* Merne, O.J. (1975). *The Birds of Wexford.* Wexford.

Merrie, T.D.H. (1978). Relationship between spatial distribution of breeding divers and the availability of fishing waters. *Bird Study* 25: 119-123.

Mickelson, P.G. (1975). Breeding biology of Cackling Geese and associated species on the Yukon-Kuskokwim Delta. *Wildlife Monographs* 45: 1-35.

Mineau, P. & Cooke, F. (1979a). Rape in lesser Snow Geese. *Behaviour* 70: 280-291.

Mineau, P. & Cooke, F. (1979b). Territoriality in Snow Goose or the protection of parenthood - Ryder's and Inglis' hypotheses reassessed. *Wildfowl* 30: 16-19.

Møhl, J. (1979). Description and analysis of the bone material from Nugarsuk: an Eskimo settlement representative of the Thule culture in west Greenland. In: McCartney, A.P. (Ed.). *Thule Eskimo Culture: An Anthropological Retrospective.* Nat. Museum of Man Mercury Series: Archeological Survey of Canada. Paper No. 88: 380-389.

Morris, P.H. (1977). MS. Palaeoecology and eco-stratigraphy of Late-Glacial microfaunas from the '100 foot beach' clays, West benderloch, Argyll. *Unpublished Magister Thesis, University of Wales.*

* Morzer Bruyns, M.F., Phillipona, J. & Timmerman, A. (1973). Survey of the winter distribution of Palaearctic geese in Europe, Western Asia and North Africa. *Rev. Rep. of Goose Group of IWRB.*

Moss, R. (1973). Digestion and intake of winter foods by wild Ptarmigan in Alaska. *Condor* 75: 293-300.

Müller, G.W. (1931). Die Ostracoden des arktischen Gebietes. *Fauna Arctica* VI: 23-32.

Münzing, J. (1963). The evolution of variation and distributional patterns of European populations of the Three-spined Stickleback *Gasterosteus aculeatus. Evolution* 17: 320-332.

Murton, R.K. & Kear, J. (1973). The nature and evolution of the photoperiod control of reproduction in certain waterfowl (Anatidae). *J. Reprod. Fert. Suppl.* 19: 67-84.

Murton, R.K., Isaacson, A.J. & Westwood, N.J. (1971). The significance of gregarious feeding behaviour and adrenal stress in a population of wood pigeons *Columba palumbus. J. Zool. London* 165: 53-84.

Muus, B. (1967). The fauna of Danish Estuaries and lagoons. *Medd. Danm. Fisk. -og Havunders* 5: 1-316.

* Nansen, F. (1890). *The First Crossing of Greenland.* London; Longmans.

Nansen, F. (1897). *Furthest North.* London; Constable.

Neale, J.W. (1959) *Normanicythere* gen. nov. (Pleistocene and Recent) and the division of the ostracod family Trachyleberididae. *Palaeontology* 2 (1): 72-93, pls. 13, 14, 5 text-figs.

Neale, J.W. (1974). Species of the boreal and arctic genus *Finmarchinella* Swain 1963, (Crustacea, Ostracoda). *Bull. Brit. Mus. (Nat. Hist.)* 27: 183-193, 2 pls.

Neale, J.W. (1978). A re-investigation of Scott's *Pontocypris ? hypoborea* (Ostracoda from Franz Joseph Land). *Crustaceana* 34 (1): 69-75.

Neale, J.W. & Howe, H.V. (1975). The marine Ostracoda of Russian Harbour, Novaya Zemlya and other high latitude faunas. *Bull. Amer. Paleont.* 65, No. 282. *Biology and Palaeobiology of Ostracoda:* 394-441, 10 figs, 7 pls.

Neale, J.W. & Schmidt, R.A.M. (1967). On *Normanicythere leioderma* (Norman) and *Normanicythere concinella* Swain. *Micropaleontology* 13 (3): 345-350, 6 figs.

Nelson, E.W. (1887). *Report on the natural history collections made in Alaska between the years 1877 and 1881.* Arctic series of publications issued in connection with the signal Service of the US Army. Washington D.C. 337pp.

* Nethersole-Thompson, D. (1971). *Highland Birds.* Highlands and Islands Development Board. 112pp.

* Newton, A. (1875). Notes on birds which have been found in Greenland. In: Jones, J.T. (1875). (Ed.). *Manual of the Natural History, Geology, and Physics of Greenland.* London; HMSO: 94-115.

Newton, I. (1977). Timing and success of breeding in tundra nesting geese. In: Stonehouse, B. & Perrins, C.M. (Eds.). *Evolutionary Ecology*. London; Macmillan: 113-126.

* Newton, I. & Campbell, C.R.G. (1970). Goose studies at Loch Leven in 1967/68. *Scottish Birds* 6: 5-18.

* Nielsen, B.P. (1979). Finn Salomonsens arbejde med ringmaerkning og fuglefredning i Grønland. *Dansk Ornith. Forens. Tidsskr.* 73: 13-24.

* Nielsen, J.C. (1907). The Insects of East Greenland. *Medd. om Grøn.* 29: 363-414.

Nordquist, P. & Wille, F. (1976). Stortur til Grønland 1976. *Dansk Ornith. Forening*. 19pp.

Norman, A.M. (1862). Contributions to British Carcinology. II. On species of Ostracoda new to Great Britain. *Ann. Mag. Nat. Hist.* 9 (3): 43-52, pls.2,3.

Norman, A.M. (1863). On species of Ostracoda found in Northumberland and Durham, new to Great Britain. *Trans. Tyneside nat. Fld. Club* 5: 143-151, 1 pl.

Norman, A.M. (1869). Shetland Final Dredging Report. Part II. On the Crustacea, Tunicata, Polyzoa, Echinodermata, Actinozoa, Hydrozoa and Porifera. *Rep. Br. Assoc. Advmt. Sci. Norwich* 38: 247-336.

Norman, A.M. (1877). Crustacea, Tunicata, Polyzoa, Echinodermata, Actinozoa, Foraminifera, Polycystina and Spongida. In: Jeffreys, J.G. *Preliminary report of the biological results of a cruise in H.M.S 'Valorous' to Davis Strait in 1875. Royal Soc., Proc.* 25: 202-215.

Norman, A.M. (1891). Notes on the marine Crustacea of Norway. *Ann. Mag. Nat. Hist.* ser. 6,7: 108-121.

Norman, A.M. (1902). Notes on the Natural History of East Finmark. *Ann. Mag. Nat. Hist.* ser. 7, 10: 341-361, 472-486.

Nyholm, E.S. (1965). Ecological observations on the geese of Spitzbergen. *Ann. Zool. Fenn.* 2: 197-207.

O'Brien, R.M.G. & Greenwood, J.J.D. (1972). Report of the University of Dundee North-east Greenland Expedition, 1972. Dundee. 98pp

Odhner, N.H.J. (1915). Die Molluskenfauna des Eisfjorde. Ergonisse d. Schwed. Expedition 1908 ii, 1.K. *Svenska Vetensk-Akad. Handl.* 54 (1): 1-274.

Ogilvie, M.A. (1964). *Wildfowl Trust Ann. Rep.* 15: 84-88.

* Ogilvie, M.A. (1968). Notes on the species of geese wintering in Britain. *Proc. Int. Regional Mtg. Conservation of Wildlife Resources, Leningrad:* 108-9.

* Ogilvie, M.A. (1970). The status of wild geese in Britain and Ireland. In: Sedgewick, N.M., Whitaker, P. & Harrison, J. (Eds.). *The New Wildfowler in the 1970's*. London; Barrie and Jenkins: 249-257.

* Ogilvie, M.A. (1974). Wildfowl Censuses and counts in Britain and Ireland, 1973 1. *Wildfowl* 25: 163-164

* Ogilvie, M.A. (1976). *The Winter Birds*. London; Michael Joseph. 224pp.

* Ogilvie, M.A. (1978). *Wild Geese*. Berkampstead; T. & A.D.Poyser. 350pp.

* Ogilvie, M.A. (1979) *The Birdwatchers Guide to the Wetlands of Britain*. London; Batsford. 189pp.

* Ogilvie, M.A. & Wallace, D.I.M. (1975). Field identification of Grey Geese. *British Birds* 68: 57-67.

* O'Leary, P.J. (1967). Statement on the Irish policy concerning the conservation of wetlands. In: *Proc. 2nd European meeting on wildfowl conservation. Noordwijk Aan Zee 9-14 May:* 83-84.

Owen, M. (1972a). Movements and feeding ecology of the White-fronted Geese at the New Grounds, Slimbridge. *J. Appl. Ecol.* 9: 385-398.

Owen, M. (1972b). Some factors affecting food intake and selection in White-fronted Geese. *J. Anim. Ecol.* 41: 79-92.

Owen, M. (1973). Management of grassland areas for wintering geese. *Wildfowl* 24: 123-130.

Owen, M. (1975). An assessment of fecal analysis technique for waterfowl feeding studies. *J. Wildl. Managmt.* 39: 271-279.

* Owen, M. (1976a). Factors affecting the distribution of geese in the British Isles. *Wildfowl* 27: 143-147.

Owen, M. (1976b). The selection of winter food by White-fronted Geese. *J. Appl. Ecol.* 13: 715-729.

* Owen, M. (1977). *Wildfowl of Europe*. London; Macmillan. 250pp.

* Owen, M. (1978). The Greenland White-fronted Goose - the case for protection. Unpublished mss. 3pp.

* Owen, M. (1980). *Wild Geese of the World*. London; Batsford. 216pp.

Owen, M. & Ogilvie, M.A. (1979). Wing moult and weights of Barnacle Geese in Spitzbergen. *Condor* 81: 42-52.

Owen, M. & Wells, R.H. (1979). Territorial behaviour in breeding geese - a re-examination of Ryder's hypothesis. *Wildfowl* 30: 20-26.

* Palmer, R.S. (1976). *Handbook of North American Birds. Vol.2: Waterfowl, Part 1*. Yale, Newhaven and London: 89-110.

* Parkes, K.C. (1960). Greenland White-fronted Goose on the St. Lawrence River. *Can. Fld. Nat.* 74: 162-163.

Pearce, G.J. (1977). The ecology and distribution of Recent Foraminifera and Ostracoda from North Uist and St. Kilda, Outer Hebrides. *Unpublished Magister Thesis, University of Wales.*

Pedersen, A. (1930). Fortgesetzte beitrage zur kenntnis der saugetier und vogel fauna der ostkuste Grønland. *Medd. om Grøn.* 77 (5): 343-561.

* Pedersen, B.B. (1980). Rapport fra Sjaeldenhedsudvalget for 1977 og 1978. *Dansk Ornith. Forens. Tidsskr.* 74: 127-140.

Peiponen, V.A. (1970). Animal activity under sub-arctic summer conditions. In: *Ecology of the Sub-Arctic Regions*. UNESCO: 281-287.

Perrins, C.M. (1965). Population fluctuations and clutch size in the Great tit, *Parus major*. *J. Anim. Ecol.* 34: 601-647.

Petersen, G.H. (1962). The distribution of *Balanus balanoides* (L.) and *Littorina saxatilis*, Olivi var. *groenlandica*, Mencke in northern west Greenland. *Medd. om Grøn.* 159 (9): 1-43.

Petersen, G.H. (1977). Biological effects of sea ice and icebergs in Greenland. In: Dunbar, M.J. (Ed.). *Polar Oceans*. Arctic Inst. N. America, Calgary, Alberta: 319-329.

Petersen, G.H. (1978). Life cycles and population dynamics of marine benthic bivalves from the Disko Bugt area of west Greenland. *Ophelia* 17: 95-120.

* Plantema, O. & Groesz, R. (1978). Vogelwaarnemingen op west-Greenland. *Het Vogeljaar* 26: 172-175.

* Ploeger, P.L. (1968). Geographical differentiation of Arctic Anatidae as a result of isolation during the last glacial. Leiden; E.J. Brill. 159pp.

* Pollard, D.F.W. & Davies, P.W. (1968). A preliminary study of feeding of the Greenland White-fronted Goose in Cardiganshire. *Wildfowl* 19: 108-116.

Polunin, N. (1959). *Circumpolar Arctic Flora*. Oxford; Claredon. 514pp.

Porsild, A.E. (1953). Edible plants of the Arctic. *Arctic* 6 (1): 15-34.

Posselt, H.J. & Jensen, J.A.D. (1898). Grønlands Brachipoder og Bloddyr. *Medd. om Grøn.* 23: 1-298.

Powell, G.V.N. (1974). Experimental analysis of the social value of flocking by Starlings *(Sturnus vulgaris)* in relation to predation and foraging. *Animal Behaviour* 22: 501-505.

* Preuss, N.O. (1966). Grønlandske gaes. *Feltornithologen (Køhenhavn)* 8: 130-138.

Prevett, J.P. (1972). Family behaviour and age dependant breeding biology of Blue Goose *Anser caerulescens*. Report of Canadian Wildlife Service. 192pp.

Prevett, J.P. & MacInnes, C.D. (1980). Family and other groups in Snow Geese. *Wildl. Monogr.* 44: 1-46.

Prop, J., Van Eerden, M.R., Daan, S., Drent, R.H., Tinbergen, J.M. & St. Joseph, A.M. (1978). Ecology of the Barnacle Goose *(Branta leucopsis)* during the breeding season: Preliminary results of expeditions to Spitsbergen in 1977 and 1978. In: *Spitzbergen Symposium*. Arctic Centre, Univ. Groningen, Netherlands: 51-112.

Pruitt, W.O.jnr. (1978). *Boreal Ecology*. London; Edward Arnold. Studies in Biology No. 91. 73pp.

Pullianen, E. (1975). Choice of prey by a pair of Gyrfalcons, *Falco rusticolus*, during the breeding period in Forest-Lapland. *Ornis Fennica* 52: 19-22.

Raffaelli, D.G. (1979). The taxonomy of the *Littorina saxatilis* species complex with particular regard to the systematic position of *L. patula* Jefferies. *Zool. J. Linn. Soc.* 65: 219-232.

Raffaelli, D.G. & Hughes, R.N. (1978). The effects of crevice size and availability on populations of *Littorina rudis* and *L. neritoides*. *J. Anim. Ecol.* 47: 71-83.

Rankin, N. (1947). *Haunts of British Divers*. London; Collins.

Ranwell, D.S. (1960). Newborough Warren, Angelsey II. Plant Associations and succession cycles of the sand dune and dune slack vegetation. *J. Ecol.* 48: 117-148.

Ranwell, D.S. (1972). *The Ecology of Salt-marshes and Sand-dunes*. London; Chapman and Hall.

Ranwell, D.S. & Downing, B.M. (1959). Brent Goose *(Branta bernicla)* winter feeding pattern and *Zostera* resources at Scolt Head Island. *Animal Behaviour* 7: 42-56.

Raveling, D.G. (1966). Factors affecting age ratios of samples of Canada geese caught with cannon nets. *J. Wildl. Managmt.* 30: 682-691.

Raveling, D.G. (1970). Dominance relationships and agonistic behaviour of Canada Geese in winter. *Behaviour* 37: 291-319.

Raveling, D.G. (1978). Timing of egg-laying by northern geese. *Auk* 95: 294-303.

Raveling, D.G. (1979a). The annual cycle of body composition of Canada Geese with special reference to control of reproduction. *Auk* 96: 234-252.

Raveling, D.G. (1979b). Traditional use of migration and winter roost sites by Canada Geese. *J. Wildl. Managmt.* 43: 229-235.

Rearden, J.D. (1951). Identification of waterfowl nest predators. *J. Wildl. Managmt.* 15: 386-395.

Reimchen, T.E. (1980). Spine deficiency and polymorphism in a population of *Gasterosteus aculeatus:* an adaptation to predators ? *Can. J. Zool.* 58: 1232-1244.

Reimers, E., Gaare, E. & Skjenneberg, S. (1980). (Eds.). *Proc. 2nd Int. Reindeer/Caribou Symp., Røros, Norway 1979*. Direktoratet for vilt og ferskvannsfisk, Trondheim. 2 vols.

Remmert, H. (1980). *Arctic Animal Ecology*. Berlin; Springer-Verlag. 250pp.

Rohwer, S. (1975). The social significance of avian winter plumage variability. *Evolution* 29: 593-610.

Rohwer, S. (1977). Status signalling in Harris' Sparrow: some experiments in deception. *Behaviour* 61: 107-129.

Rohwer, S. & Rohwer, F.C. (1978). Status signalling in sparrows: experimental deceptions achieved. *Animal Behaviour* 26: 1012-1022.

Rosenfeld, A. (1977). Die rezenten Ostracoden - Arten in der Ostsee. *Meyniana* V. 29: 11-49.

* Ross, A. (1913). Birds of Islay. *The Glasgow Naturalist* 6 (1): 7-32.

Rothchild, M. (1952). A collection of fleas from the bodies of British birds. *Bull. Brit. Mus. Nat. Hist. Entomology* 2(4): 186-232.

* Roux, F. & Spitz, F. (1963). Les stationnements d'anatides en France pendant la vague de foid de 1962-1963. *Oiseaux de France, IWRB Publication* 6.

Rowell, C.F. (1957). The Breeding of the Lapland Bunting in Swedish Lapland. *Bird Study* 4: 33-50.

* Ruttledge, R.F. (1929). The birds of Loughs Mask and Carra and surrounding district. *Ir. Nat. J.* 2(11): 223.

* Ruttledge, R.F. (1964). The Wildfowl situation in Ireland. *Proc. 1st European meeting on Wildfowl Conservation, St. Andrews, Scotland:* 31-34.

* Ruttledge, R.F. (1966). *Ireland's Birds. Their distribution and migration.* London; Witherby. 206pp.

* Ruttledge, R.F. (1968). Status of wildfowl occurring in Ireland. *Proc. Int. Regional Meeting on Conservation of Wildfowl Resources, Leningrad:* 25.

* Ruttledge, R.F. (1973a). National Report 1972/73. *IWRB Bull.* 36: 25.

* Ruttledge, R.F. (1973b). Estimate of wintering goose populations in Ireland. (Winter 1972/73). *IWRB Bull.* 36: 61-62.

* Ruttledge, R.F. (1973c). Decrease in Greenland White-fronted Geese wintering in Ireland. *Irish Bird Report* 21: 65.

* Ruttledge, R.F. (1975). Irish Goose Report 1974/75. *IWRB Bull.* 39/40: 64.

* Ruttledge, R.F. (1976). Irish Goose Report 1975/76. *IWRB Bull.* 41/42: 85.

* Ruttledge, R.F. (1977). Irish Goose Report 1976/77. *IWRB Bull.* 43/44: 86.

* Ruttledge, R.F. & Hall-Watt, R. (1958). The distribution and status of wild geese in Ireland. *Bird Study* 5: 22-33.

* Ruttledge, R.F. & Ogilvie, M.A. (1979). The past and present status of the Greenland White-fronted Goose in Ireland and Britain. *Irish Birds* 1: 293-363.

Ryder, J.P. (1969). Nesting colonies of Ross's goose. *Auk* 86 (2): 282-292.

Ryder, J.P. (1970). A possible factor in the evolution of clutch size in Ross's Goose. *Wilson Bull.* 82: 4-13.

Ryder, J.P. (1971). Distribution and breeding biology of the Lesser Snow Geese in the central Canadian Arctic. *Wildfowl* 22: 18-28.

Ryder, J.P. (1975a). The significance of territory size in colonially nesting geese: an hypothesis. *Wildfowl* 26: 114-116.

Ryder, J.P. (1975b). Nesting colonies of Ross' Goose. *Auk* 86: 282-292.

Rydzewski, W. (1973). Longevity records III. *Ring* 7: 63-70, 91-96.

* Saeijs, H.L.F. & Baptist, H.J.M. (1980). Coastal engineering and European wintering wetland birds. *Biol Conserv.* 17: 63-83.

Salomonsen, F. (1928). Bemerkungen über die verbreitung der *Carduelis linaria* Gruppe und ihre variationen. *Videnskab. Medd. fra Dansk Naturhist. Forening* 86: 123-202.

* Salomonsen, F. (1935). Some records on birds new or rare to Greenland. *Medd. om Grøn.* 93 (6): 1-16.

Salomonsen, F. (1939). Moults and sequence of plumages in the Rock Ptarmigan *(Lagopus mutus). Videnskab. Medd. fra Dansk Naturhist. Forening* 103: 1-491.

Salomonsen, F. (1941). *J. Orn.* 89: 282-337.

Salomonsen, F. (1943). The Natural History Expedition to North West Greenland, 1936. Report on the Expedition. *Medd. om Grøn.* 124 (1): 1-38.

* Salomonsen, F. (1948a). The distribution of birds and the recent climatic change in the North Atlantic area. *Dansk Ornith. Forens. Tidsskr.* 42: 85-99.

* Salomonsen, F. (1948b). Blisgaasen (*Anser albifrons* (Scop.)) og dens slaegtinge. *Dansk Ornith. Forens. Tidsskr.* 42: 102-108.

* Salomonsen, F. (1950a). *Grønlands Fugle. The Birds of Greenland.* København. 609pp.

* Salomonsen, F. (1951). The status of wildfowl in Greenland. (Report of an address given to the BOU). *Ibis* 93: 330-331.

* Salomonsen, F. (1956). The Greenland bird ringing system. *The Ring* 7: 130-133.

* Salomonsen, F. (1959a). The Greenland bird-banding system. *Arctic* 9: 258-264.

Salomonsen, F. (1965a). The geographical variation of the Fulmar and the zones of marine environment in the North Atlantic. *Auk* 82: 327-355.

* Salomonsen, F. (1967a). *Fuglene på Grønland.* København; Rhodos. 342pp.

* Salomonsen, F. (1968). The moult migration. *Wildfowl* 19: 5-24.

* Salomonsen, F. (1970). Birds useful to man in Greenland. In: Fuller, W.A. & Keran, P.G. (Eds.). *Productivity and Conservation in Northern Circumpolar Lands. Proc. Conf. IUCN.* Edmonton 1969.

* Salomonsen, F. (1974). *Fuglene i Menneskenes Lands.* Det Grønlandske Forlag. 127pp.

* Salomonsen, F. (1975). Blisgaasen. In: *Danmarks Natur.* 101: 425. Norrevang, A., Meyer, T.J. & Christensen, S. (Eds.). Politikens Forlag.

* Salomonsen, F. (1979a). Ornithological and ecological studies in S.W. Greenland (59°46' - 62°27'N Lat.). *Medd. om Grøn.* 204 (6): 1-214.

* Salomonsen, F. Preliminary lists of recoveries of birds ringed in Greenland. *Dansk Ornith. Forens. Tidsskr.* :
(1947). 41: 141-143.
(1948c). 42: 100-102.
(1949a). 43: 251-255.
(1950b). 44: 168-170.
(1952). 46: 110-117.
(1955a). 49: 130-135.
(1957). 51: 33- 39.
(1959b). 53: 31- 39.
(1961). 55: 197-208.
(1965b). 59: 92-103.
(1967b). 61: 151-164.
(1971). 65: 11- 19.
(1979b). 73: 191-206.

Beretninger vedrorende Grønlands Styrelse:
(1948d). 1: 58- 62.
(1949b). 2: 59- 61.
(1950c). 1: 81- 85.

Beretninger vedrorende Grønland:
(1955b). 1: 52- 54.
(1959c). 1: 55- 58.
(1966). 1: 56- 61.

Tidsskriftet Grønland:
(1972). 111-120.

Sars, G.O. (1866). Oversight of Norges Marine Ostracoder. *Norsk Vidensk. Akad. Forhandlingar* 1865: 1-130.

Sars, G.O. (1922-1928). *An account of the Crustacea of Norway, with short descriptions and figures of all the species.* 9: 1-277, pls. 1-119. Bergen Museum.

Saunders, S.A. (1978). The development and distribution of discontinuous variation in the human infracranial skeleton. Nat. Museum of Man, Mercury Series. Archeological Survey of Canada Paper No. 81: 1-549.

* Schaanning, H.T.L. (1933). Zoological results of the Norwegian Scientific expeditions to East Greenland; a contribution to the bird fauna of east Greenland. *Skrifter om Svalbard og Ishavet, Oslo.* 49: 16.

* Schalow, H. (1895). Ueber eine Vogelsammlung aus Westgrönland. *J. fur Ornithologie* 43: 468-469.

Schiller, E.L. (1952). Cestode parasites of the White-fronted Goose (*Anser albifrons*) with the description of *Hymenolepis barrowensis* n. sp.. *J. Parasitology* 38: 32-34.

* Schiøler, E.L. (1925). *Danmarks Fugle, med Henblik paa de i Grønland, paa Faerøne og i Kongiget Island forekommende Arter. Vol. 1: Indledning og Andefugle (Anseres).*

* Schönwetter, M. (1967). *Handbuch der Oologie. 1.* Berlin.

Schornikov, E.I. (1970). *Acetabulastoma* novii rod ostrakod ectoparasitov Amphipoda. *Zool. Zhur. Moskva* 49(8): 1132-1143.

* Scottish Bird Reports: Scottish Ornithologists Club, Edinburgh. Published annually.

* Scot-Skirving, R. (1878). Notes on the natural history of Islay. *Proc. Royal Phys. Soc. Edinburgh 1878:* 35-43.

* Scott, D.A. (1980). Biogeographical populations and numerical criteria for selected waterfowl species in the western Palaearctic. IWRB. 13pp.

* Scott, P. (1946). *A Monograph of the Wild Geese.* London; Prospect, Country Life.

* Scott, P. (1948). The migration of Wild Geese. *The New Naturalist:* 156-169. Collins.

* Scott, P. (1961). *The Eye of the Wind.* Cambridge: 570-574.

Scott, P. (1966). The Bewicks Swans at Slimbridge. *Wildfowl Trust Ann. Rep.* 17: 20-26.

* Scott, P. (1980). *Observations of Wildlife.* Oxford; Phaidon. 112pp.

* Scott, P. & Boyd, H. (1957). *Wildfowl of the British Isles.* London.

* Scott, P. & Fisher, J. (1953). *A Thousand Geese.* London; Collins.

Scott, P., Boyd, H. & Sladen, W.J.L. (1955). The Wildfowl Trust's sceond expedition to central Iceland, 1953. *Wildfowl Trust Ann. Rep.* 7: 63-98.

Scott, T. (1899). Report on the marine and freshwater Crustacea from Franz Joseph Land, collected by Mr. William S. Bruce, of the Jackson-Harmsworth Expedition. *J. Linn. Soc. London* 27: 60-126, pls. 3-9.

Seastedt, T.R. & Maclean, S.F.jnr. (1979). Territory size and composition in relation to resource abundance in Lapland Longspurs breeding in arctic Alaska. *Auk* 96: 131-142.

Siegel, S. (1956). *Non-parametric Statistics for the Behavioural Sciences.* McGraw-Hill. 312pp.

Sjölander, S. & Agren, G. (1973). Reproductive behaviour of the common loon. *Wilson Bull.* 84 (3): 296-308.

Skogland, T. (1975). Range and food selectivity by wild Reindeer in southern Norway. Biological Papers of Univ. Alaska, Spec. Rep. 1: 342-354. In: Luick, J., Lent, P.C., Klein, D.R. & White, R.G. (Eds.). *Proc. 1st International Reindeer/Caribou Symposium Fairbanks 1972.*

Skogland, T. (1980). The comparative summer feeding strategies of arctic and alpine *Rangifer. J. Anim. Ecol.* 49: 81-98.

Skutch, A.F. (1962). The constancy of incubation. *Wilson Bull.* 74: 115-152.

Smart, I.H.M. & O'Brien, R.M.G. (1971). (Eds.). Report of the Dundee University Scoresbyland Expedition, 1970. Dundee: Dundee University NE Greenland Expedition.

Smit. F.G.A.M. (1954). Lopper - Danmarks Fauna 60. København 125pp.

Smith, A.J.E. (1978). *The Moss Flora of Britain and Ireland.* Cambridge; CUP.

Smith, J.E. (1981). The natural history and taxonomy of shell variation in the Periwinkles *Littorina saxatilis* and *Littorina rudis. J. mar. Biol. Assoc.* 61: 215-241.

* Snyder, L.L. (1957). *The Arctic Birds of Canada.* Toronto.

Southwood, T.R.E. (1968). *Ecological Methods.* London; Methuen.

Staab, M.L. (1979). Analysis of faunal material recovered from a Thule Eskimo site on the island of Silumiut, N.W. Territories, Canada. In: McCartney, A.P. (Ed.). *Thule Eskimo Culture: An Anthropological Retrospective.* Nat. Museum of Man, Mercury Series: Archeological Survey of Canada Paper No. 88: 349-379.

Stephensen, K. (1913). Grønlands Krebsdyr of Pycnogonider (Conspectus Crustaceorum et Pyconogonidorum Groenlandiae). *Medd. om Grøn.* 22: 1-479.

Stephensen, K. (1936). The Godthaab Expedition 1928. Crustacea Varia. *Medd. om Grøn.* 80 (2): 1-38.

Stephenson, T.A. & Stephenson, A. (1972). *Life between the tide-marks on rocky shores.* San Francisco; Freeman.

Steven, D. (1938). The shore fauna of Amerdloq Fjord, west Greenland. *J. Anim. Ecol.* 7: 53-70.

Stewart, P.A. (1967). Diving schedules of a common loon (*Gavia immer*) and a group of oldsquaws (*Clangula hymenalis*). *Auk* 84: 122-123.

Strandgaard, H. (1979). Tugto, Vildrenen. Kaskelot, Biologforbundets blad. 39: 2-9.

* Stroud, D.A. (1980). The White-fronted Goose in Greenland. *WAGBI Magazine Winter 1980:* 20-22.

Sugden, D.E. & John, B.S. (1976). *Glaciers and Landscape.* London; Arnold.

Swain, F.M. (1963). Pleistocene Ostracoda from the Gubik Formation, Arctic Coastal Plain, Alaska. *J. Paleontol.* 37 (4): 798-834, pls. 95-99, 13 text figs.

Temple, J.H., Temple, S.A. & Swartz, L.G. (1972). Time-lapse photographic methods of nesting peregrines. In: *The Living Bird:* 113-128. Cornell Lab. Ornithology.

Temple, S.A. (1972). A portable time-lapse camera for recording wildlife activity. *J. Wildl. Managmt.* 36: 944-947.

Thing, H. (1980). Preliminary studies of habitat use and food selectivity of west Greenland Caribou. In: Reimers *et al.* (1980): 151-158.

Thomas, V.G. & Prevett, J.P. (1980). The nutritional value of Arrow-grasses to geese at James Bay. *J. Wildl. Managmt.* 44: 830-836.836.

* Thompson, W. (1885). *The Natural History of Ireland.* 3: 42-44. London; Reeve and Benham.

Thomson, W.A., Vertinsky, I. & Krebs, J.R. (1974). The survival value of flocking in birds: a simulation model. *J. Anim. Ecol.* 43: 785-820.

Thorson, G. (1940). Studies on the egg-masses and larval development of Gasteropoda of the Iranian Gulf. *Danish Scientific Investigations in Iran* 2: 159-238.

Thorson, G. (1944). Marine Gasteropoda Prosobranchiata. The Zoology of East Greenland. *Medd. om Grøn.* 121 (13): 1-181.

Thorson, G. (1946). Reproduction and larval development of Danish bottom invertebrates, with special reference to the planktonic larvae in the Sound (Oresund). *Medd. fra Kommisionen for Danmarks Fiskeri og Havundersogelser Serie: Plankton* 4 (1): 1-523.

Thorson, G. (1949). Reproductive and larval ecology of marine bottom invertebrates. *Biol. Rev.* 25: 1-45.

Timmerman, G. (1949). The Birds of Iceland. *Soc. Scient. Islandica.* 28: 241-524.

* Timmerman, A., Morzer Bruyns, M.F. & Phillipona, J. (1976). Survey of the winter distribution of Palearctic geese in Europe, Western Asia and North Africa. *Limosa* 49: 230-292.

Tinbergen, N. (1935). Field observations of east Greenland birds. I: The behaviour of the Red-necked Phalarope in spring. *Ardea* 24: 1-42.

* Todd, F.S. (1979). *Waterfowl: Ducks, Geese and Swans of the World.* California; Seaworld Press.

* Todd, W.E.C. (1950). Nomenclature of the White-fronted Goose. *Condor* 52: 63-68.

Trapnell, C.G. (1933). Vegetation types in Godthaab Fjord in relation to those in other parts of west Greenland, and with special reference to Iseriutilik. *J. Ecol.* 21: 294-334.

Trivers, R.L. (1972). Parental investment and sexual selection. In: Campbell, B. (Ed.). *Sexual Selection and the descent of man.* Chicago; Aldine.

Tuck, L.M. (1971). The occurrence of Greenland and European birds in Newfoundland. *Bird Banding* 42: 184-209.

Turner, E.R.A. (1965). Social feeding in birds. *Behaviour* 24: 1-45.

* Unger, U. (1971). (First records of Greenland White-fronted Goose *Anser albifrons flavirostris* in Sweden). *Var Fagelvarld* 30: 123.

* Ussher, R.J. & Warren, R. (1900). *The Birds of Ireland.* London.

Vibe, C. (1940). Preliminary investigations on shallow water animal communities in the Upernavik and Thule Districts (North-west Greenland). *Medd. om Grøn.* 124 (2): 1-42.

Vibe, C. (1950). The Marine animals and marine fauna of the Thule District (NW Greenland) with observations on the ice conditions in 1939-41. *Medd. om Grøn.* 150 (6): 1-115.

Vibe, C. (1967). Arctic animals in relation to climatic fluctuations. *Medd. om Grøn.* 170 (5): 1-227.

Voous, K.H. (1973). List of Recent Holarctic Bird Species: Non-Passerines. *Ibis* 115: 612-638.

Voous, K.H. (1977a). List of Recent Holarctic Bird Species: Passerines I. *Ibis* 119: 223-250.

Voous, K.H. (1977b). List of Recent Holarctic Bird Species: Passerines II. *Ibis* 119: 376-406.

Voous, K.H. & Wattel, J. (1963). Distribution and migration of the Greater Shearwater. *Ardea* 51: 143-157.

Wagner, C.W. (1957). *Sur les Ostracodes du Quaternaire Récent des Pays-Bas et leur utilisation dans l'étude géologique des depôts Holocenes.* 159pp., 50pls. Mouton & Co., The Hague.

* Walker, D. (1860). Notes on the zoology of the last arctic expedition of Captain Sir F.L. M'Clintock R.N.. *Royal Dublin Society 1860:* July p.6.

Washburn, A.L. (1979). *Geocryology - a survey of periglacial processes and environments.* London; Arnold. 404pp.

Watson, A. (1963). Bird numbers on tundra in Baffin Island. *Arctic* 16: 101-108.

Watling, R. (1977). Larger fungi from Greenland. *Astarte* 10: 61-71.

Weedon, R.B. (1968). Foods of Rock and Willow Ptarmigan in Central Alaska with comments on inter-specific competition. *Auk* 86: 271-281.

Weidick, A. (1968). Observations of some Holocene glacier fluctuations in west Greenland. *Medd. om Grøn.* 165 (6): 1-202.

Whatley, R.C. (1976). Association between podocopoid Ostracoda and some animal substrates. *Abh. Verh. Naturwiss. Ver. Hamburg.* (NF) 18/19 (suppl.): 191-200, 2 pl.

Whatley, R.C. & Kaye, P. (1971). The palaeoecology of Eemian (Last Interglacial) Ostracoda from Selsey, Sussex. In: Oertli, H.J. (Ed.). Paléoécologie Ostracodes, Pau, 1970. *Bull. Centre Rech. Pau - S.N.P.A.* 5 Suppl. : 311-330, 7 text-figs.

Whatley, R.C. & Masson, D.G. (1979). The ostracod genus *Cytheropteron* from the Quaternary and Recent of Great Britain. *Rev. Esp. Micropal.* 11 (2): 223-227, 8 pls.

Whatley, R.C. & Wall, D.R. (1969). A preliminary account of the ecology and distribution of Recent Ostracoda in the southern Irish Sea. In: Weale, J.W. (Ed.). *Taxonomy, Morphology and Ecology of Recent Ostracoda (2nd International Symposium, Hull. 1967* Edinburgh; Oliver and Boyd: 268-298, 16 text-figs.

Whatley, R.C. & Wall, D.R. (1975). The relationship between Ostracoda and Algae in littoral and sublittoral marine environments. *Bull. Amer. Paleont.*, 65, No. 282. *Biology and Palaeobiology of Ostracoda:* 173-203, 2 text-figs.

Whittaker, J.E. (1972). MS. Recent Ostracoda from Christchurch Harbour, the Fleet and Weymouth Bay. *Unpublished Doctoral Thesis, University of Wales.*

Whitten, K.R. & Cameron, R.D. (1980). Nutrient dynamics of Caribou forage on Alaska's Arctic Slope. In: Reimers *et al.* (1980): 159-166.

* Wille, F. (1975). Ekskursion til Grønland, 1975. Dansk Ornith. Forenings. 17pp.

Wille, F. (1978). A study of the food ecology of the White-tailed Eagle in Greenland: Preliminary Report for 1977. Unpublished mss. Dansk Ornith. Forenings.

Wille, F. (1979). A choice of food of the Greenland White-tailed Eagle. *Dansk Ornith. Forens. Tidsskr.* 73: 165-170.

Williams, G.C. (1966). *Adaptation and natural selection: a critique of some current evolutionary thought.* Princetown University Press.

Williamson, F.S.L. & Emison, W.B. (1971). Variation in the timing of breeding and molt of the Lapland Longspur (*Calcarius lapponicus*) in Alaska, with relation to differences in latitude. *Bioscience* 21: 701-707.

* Williamson, K. (1968). Goose emigration from Western Scotland. *Scottish Birds* 5: 71-89.

* Williamson, K. (1975). Birds and climatic change. *Bird Study* 22: 143-164.

* Williamson, K. & Ruttledge, R.F. (1951). Early arrival of Greenland White-fronted Geese in Ireland. *Irish Nat. J.* 10: 263.

* Wilson, J.R. (1981). The migration of high arctic shorebirds through Iceland. *Bird Study* 28 (1): 21-32.

Wilson, J.W. (1954). The influence of the 'midnight sun' conditions on certain diurnal rhythms in *Oxyria digyna*. *J. Ecol.* 42: 81-94.

* Winge, H. (1898) Grønlands Fugle. *Medd. om Grøn.* 21 (1): 116-118.

Wium-Andersen, G. (1970). Haemoglobin and protein variation in three species of *Littorina*. *Ophelia* 8: 267-273.

Witherby, H.F. *et al.* (1939). *The Handbook of British Birds. Vol. 3.*

Wootton, R.J. (1976). *The Biology of the Sticklebacks.* Academic Press.

* Wrigley, F. (1973). Bird-spotting kit for the Wild Goose Chase. *Western Mail* 17 November 1973.

* Wrigley, F. (1975). Conspectus of data which may be relevent to the decreasing numbers of the Greenland White-fronted Goose in Cardiganshire. Unpublished mss. 7pp.

* Wrigley, F. & Dolan, B. (undated mss.). Flight lines of the Greenland White-fronted Geese on the Dovey Estuary. 6pp.

Würdinger, I. (1975). Vergleichend morphologische Untersuchungen zur Jugendentwicklung von *Anser* und *Branta* -arten. *J. Ornith.* 116: 65-86.

Wypkema, R.C.P. & Ankney, C.D. (1979). Nutrient reserve dynamics of lesser snow geese staging at James Bay, Ontario. *Can. J. Zool.* 57(1): 213-219.

Yassini, I. (1969). Ecologie des Associations d'Ostracodes du Bassin d'Arcachon et du Littoral Atlantique: Application à l'interpretation de quelques population du Tertiare Aquitain. *Bull. Inst. geol. Aquitaine* 7. 288pp, 39pls.