REPORT
OF THE
DUNDEE UNIVERSITY SCORESBYLAND EXPEDITION 1970

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R. O'Brien, J. Lawrence, J. Peden, A. Walker

The hydrology party left the airstrip during the afternoon of 7th July, travelling by lorry 14 km. to Blyklippen. Assisted by Smart, Cannon and Brown the party crossed into Fundal with heavy loads of food and equipment and arrived at Sorte Hjorne, some 18 km. distant, in the early hours of the morning of the 8th. The hut was already occupied by Heywood, Hollins, Morrison and Pratt who were en route for Schuchert Dal and the Stauning Alps.

After a brief rest at Sorte Hjorne the hydrologists crossed the swollen channels of the Delta River to establish residence by the pingos which lie on the eastern edge of the flood plain. Smart, Cannon and Brown returned to Mestersvig via Expeditions Hus and Hestespas.

Two days were spent in East Delta Dal, surveying the pingos and making collections of water from the pingos, Oksedal and Delta Dal. On the 11th July the party returned to Sorte Hjorne to establish a gauging station on the Pings Elv, one of the twin rivers draining Fundal. Ten days were spent at Sorte Hjorne, surveying the gauging site, making discharge measurements and collecting water samples from surrounding areas.

HYDROLOGICAL INVESTIGATIONS IN DELTA DAL

R. O'Brien

Very little information has been gathered to date on the hydrology of permafrost regions; the available literature is scanty and refers almost entirely to areas of American and Soviet interest in Alaska and Siberia. No comprehensive hydrological investigations have yet been made in North-east Greenland. Permafrost terrains are distinctive hydrological environments in which there is a limited, seasonal flow of surface waters derived largely from glacier or snow melt. Ground water occurs in small quantities within or beneath impermeable permafrost layers. Such sub or intra-permafrost aquifers are characterised by low rates of transmission and recharge, and associated waters often have distinctive chemical characteristics.

During the summer of 1968 a geomorphological examination of the pingos of Schuchert Dal was made. Pingos are striking, isolated 'earth mounds', cored with massive ice bodies. They may rise to over 50 m. above the surrounding terrain and are related genetically to the ascent of sub-permafrost waters, under hydrostatic pressure, which causes doming in valley-bottom zones of degraded permafrost. Waters associated with the Schuchert Dal pingos were characterised by low concentrations of carbonate and calcium ions and high concentrations of chloride and sodium ions. Also they appeared to exhibit enrichment in heavy isotopes relative to 'natural abundance'. It is tentatively suggested that the above characteristics are consistent with a source in deep aquifers. (O'Brien, 1971). Observations made in other permafrost areas lend support to this conclusion. (Anisimova, 1964; Lamar, 1966).

The main objective of the 1970 programme was to explore further this water 'quality'/source relationship, by making a systematic and comprehensive collection of a wide variety of both ground and surface waters for later laboratory analysis.

Field work, based on Sorte Hjørne, was carried out mainly in Delta Dal and its major tributary valleys of Fundal and Oksedal. Delta Dal was felt to be entirely suitable as a study area for a number of reasons. A full range of natural waters is represented there. There are a large number of surface streams, some of which are nourished by glacial meltwater, and ground water reaches the surface in several spring localities. Ground work is also associated with a group of pingos which lie at the foot of the eastern slope of the valley. Because of the proximity of the government station at Mestersvig climatological data from the weather station there could validly be related to concurrent hydrological observations in Delta Dal.

During the months of July and August water samples were collected periodically at a number of selected sites in the area, including the pingos, where water temperature measurements and discharge measurements at spring orifices and pingo lake outfalls were performed at the time of sampling. Additional water samples were obtained from springs and pingos on Trail Island and in

Schuchert Dal, and also from the Malmbjerg mine.

It was also necessary to obtain information about rates of flow of surface waters. To this end a gauging station was established on the Pings Elv, one of the twin glacial rivers draining Fundal. Physical and hydraulic conditions conformed to requirements at a site about 1 km. above Sorte Hjorne (map 1). Because the water was too turbid to permit the use of a current meter, velocity determinations had to be made using floats. Observations at the gauging station yielded fairly detailed information about the diurnal and longer term flow regime of the river. Water samples, for chemical analysis and turbidity determinations were taken whenever observations were made at the site.

Most of the field work was carried out with the assistance of J. Lawrence, J. Peden, and A. Walker, Peden and Walker being responsible for the survey tasks connected with the project. Other expedition members assisted on occasions: I. H. M. Smart and R. O'Grady made flow measurements and collected water samples during August, and P. Brown and J. Cannon collected water samples from Schuchert Dal. The samples from Trail Island were obtained by Christian Hjort, Lund University, Sweden.

The water samples obtained in 1970 are currently being subjected to detailed analysis by Dr. C. R. Allen, Department of Chemistry, Dundee University. (Dr. Allen was a member of the 1968 expedition). Isotopic analysis is being carried out at the Scottish Research Reactor Centre, East Kilbride. The end result should be a worthwhile addition to the literature concerning the chemical character of natural waters in a High Arctic environment and its possible relationship to the origin and history of the water. The river flow study has been a valuable exercise in itself, yielding information about the regime of a typical East Greenland river in relation to observed meteorological conditions. As runoff in the river must represent a considerable proportion of the summer ablation loss from the glacier which feeds it, the results will also be of interest in a glaciological context.

At the present time some of the analytical work remains unfinished and as the available results are incomplete and of a technical nature they will not be discussed here. However, a brief statement about the practical significance of the river flow observations may be of interest.

Glacial rivers are one of the greatest objective dangers confronting travellers in Greenland. The fording of such streams when, water levels are high can be an extremely hazardous undertaking as members of the 1968 expedition discovered while forcing a crossing of the Schuchert River. Such rivers are highly turbulent and swift running; velocities of 7 kts. were measured in the Pings Elv. These factors combined with the buoyancy imparted by the water and the unstable footing provided by the shifting gravel of the river bed make it prudent to cross major channels only when water levels are relatively low. Water levels fluctuate widely with marked seasonal and diurnal rhythm. In ScoresbyLand river discharge reaches a maximum level in early July when mean air temperatures are highest and large quantities of snow remain both on the glaciers and in unglacierised valley heads. Thereafter water levels decline gradually until the autumn freeze-up occurs, generally by mid-September.

Superimposed on these broad seasonal trends are the marked daily fluctuations in runoff. Lowest water levels occur in the early morning, usually at about 0700 hrs. Discharge then increases rapidly, at first, and then more slowly to reach a maximum at about 20.00 hrs., after which time water levels decline steadily through the night. The magnitude of these daily variations is largely weather dependent. During calm, sunny conditions the volume of water in a channel may more than double, from the early morning minimum, in the space of a few hours. In contrast fluctuations are small and water levels remain relatively low during periods of cloudy weather, even when there has been considerable precipitation during the preceeding period.

A more detailed, quantitative statement concerning the flow regime of the Pings Elv together with other field observations and analytical results will be the subject of a paper, produced jointly with C. R. Allen. It is hoped that this will be published, in an appropriate journal, in due course.

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SURVEYING REPORT

A. Walker

Equipment

1 x Wild Constant Reduction Tacheometer with Tripod
1 x 5 metre Collapsible alloy staff
3 Ranging rods
2 x 30 m. steel tapes.

The above equipment was loaned by the Department of Civil Engineering.

Object

To produce a contour map of Pingo 4 and of the Pingo Elv gauging site. It was also necessary to produce surveyed profiles of Pingos 1, 2, 3, 5 and bed profiles at the points along the measuring reach of the Pingo Elv.

Method

A traverse survey of Pingo 4 and the relevant area of the Pingo Elv site was made using three stations for each, the distances and angles between the stations being surveyed tacheometrically. Distances and levels relative to the stations were tacheometrically surveyed for radial lines at intervals of about 15°.

Bathymetric surveys of pingo lakes were made using two methods. In some cases it was possible to use ice rafts from which a sounding line could be dropped: no drownings were reported. Alternatively, where the ice was thin or non-existant, a float method was used. This consisted of a graduated line (a) stretched across the water with a float (an empty polythene water bottle) attached. Another graduated line (b) with weight attached was passed through the handle of the bottle. Thus the depth could be found at any distance by subtracting the length on tape (a) from the length on tape (b) (fig. 1). This method proved quite accurate and was certainly less taxing on the nerves than 'ice-raft' method.

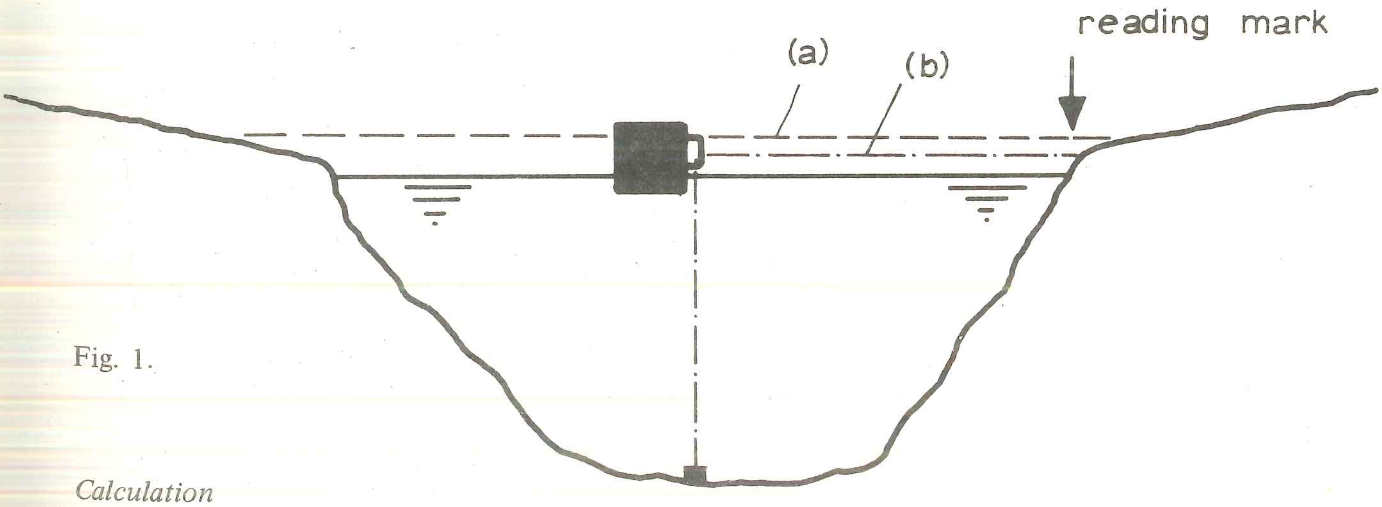
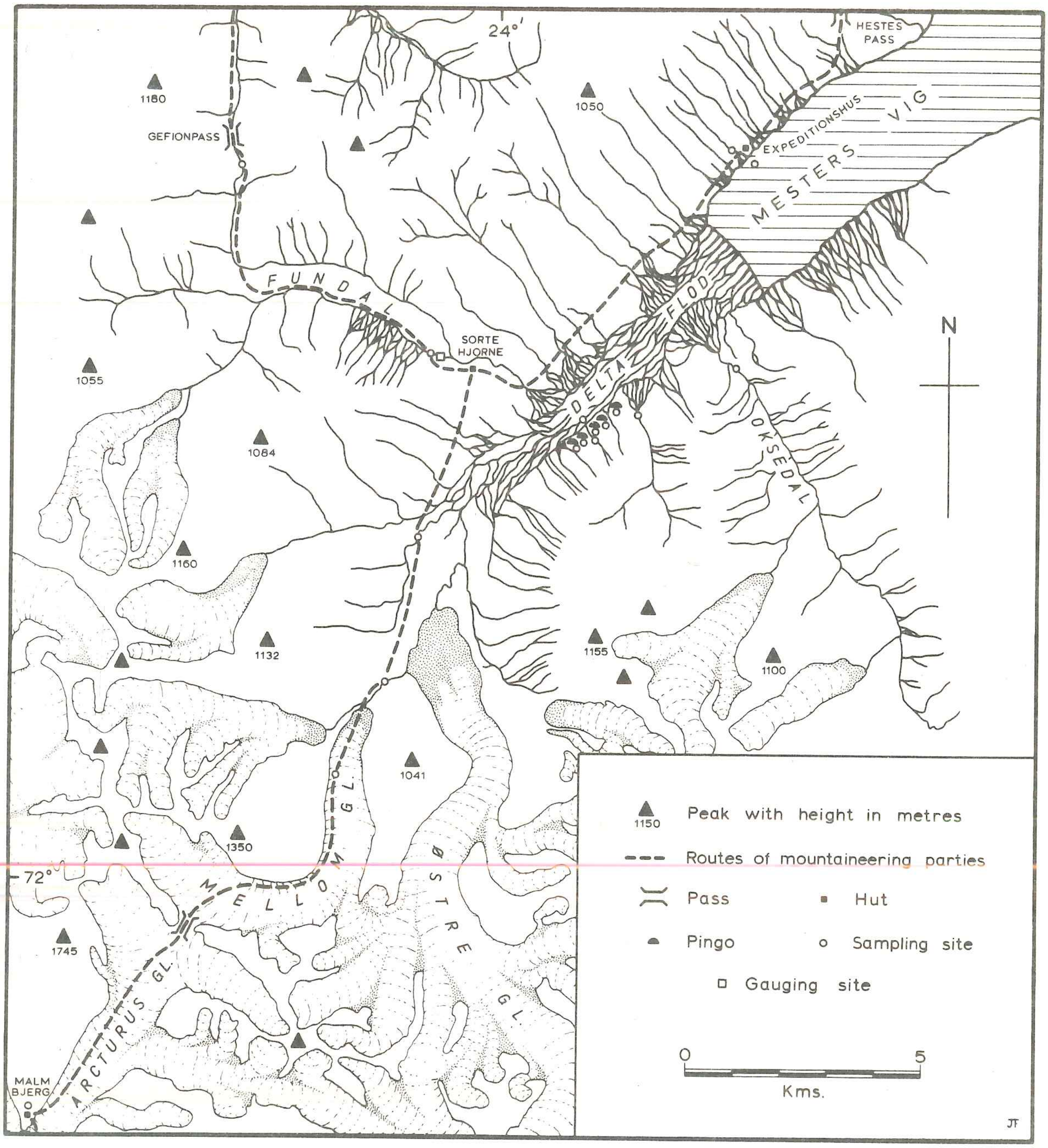


Fig. 1.

Calculation

The use of a constant reduction tacheometer enable the horizontal distances and vertical heights to be read directly off the staff, saving a vast amount of calculation and enabling results to be checked immediately. The results were reduced to a constant datum and plotted; contour lines were then drawn by interpolation.



24°
HESTES PASS
1180
GEFIONPASS
1050
EXPEDITIONSHUS
MESTERS VIG
FUNDAL
SORTE HJORNE
DELTA FLOD
N
1055
1084
OKSEDAL
1160
1132
1155
1100
1041
1350
72°
MELLOM GL.
ØSTRE GL.
1745
ARCTURUS GL.
MALM BJERG
Peak with height in metres
1150
Routes of mountaineering parties
Pass
Hut
Pingo
Sampling site
Gauging site
0
5
Kms.
JT

HYDROLOGICAL SAMPLES: CHEMICAL ANALYSES

C. R. Allen

The samples werw 1-3 months old at the time of analysis and had been stored in tightly stoppered polythene bottles. All analyses were conducted with reference to 'blank' and standard solutions, and the reliability of each method was so established. Each sample was centrifuged free from visible sediment, if any, before analyses were begun. The methods used were as follows:–

pH Measurement: 'Herris' pH Meter at 20°C, with glass combination electrode.

Total CO_2 and HCO_3^-: 'total CO_2' by displacement with HC1 and measurement of the volume of gas evalued at 25°C in a Warburg apparatus; HCO_3^- by calculation from 'total CO_2', measured pH, and known dissociation constants for carbonic acid; no activity corrections.

Cl^-: by Ag/AgC1 electrodes in the form of a concentration cell; with correction for the Cl^- ion from dissolved AgC1.

SO_4^{2-}: by spectrophotometry of the $FeSO_4^+$ complex in the presence of excess Fe^{2+} in aqueous $HClO_4$.

Na^+ and K^+: by flame emission photometry.

Ca^{2+} and Mg^{2+}: by EDTA titrations (Ca^{2+} with Murexide at pH 12; Ca^{2+} + Mg^+ with Erio T at pH 10).

The established reliabilities of the various analyses are tabulated below. *Concentrations throughout the tables are in milliomoles per litre*; conversion factors, wherewith the tabulated value may be multiplied to obtain concentrations in parts per million, are also listed below.

Ion	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}
General Reliability, ± %	1	4	2	2	1	1	1
Minimum Uncertainty, ± M mol lit $^{-1}$	0.02	–	0.03	0.01	0.005	0.005	0.01
Conversion Factor to ppm	61.0	35.5	96.0	23.0	39.1	40.1	24.3

HYDROCHEMICAL STUDIES: DISCUSSION AND CONCLUSIONS

In what follows, unless the context implies otherwise, the term 'concentration'–of a water sample as a whole–refers to the total ionic concentration; the term 'composition' refers to the mutual proportions in which the detected ions are present in the sample.

1. *General Classification by Concentration Ratios*

From a purely physical point of view the water samples may be classified under five headings:

(i) ice and meltwater samples ("glacial")
(ii) stream and river samples ("surface")
(iii) mine-tail and spring samples ("springs")
(iv) static waters associated with pingos ("pingo static")
(v) pingo effluents ("pingo effluent")

In view of the general effects of evaporation and of dilution by surface runoff, classification by overall concentration is not very discriminating; one may note that spring and pingo waters are about five to twenty times more concentrated than glacial and surface waters, but this is all that can be said. Classification by composition is potentially far more informative and proves to

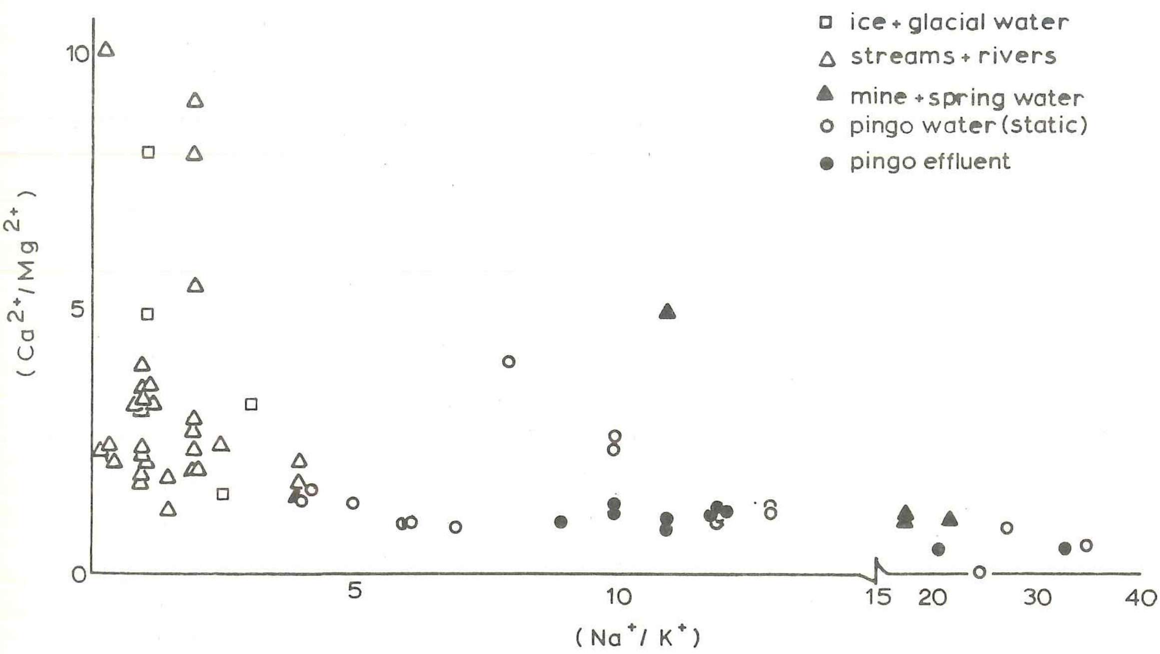


Fig. 1
ice + glacial water
streams + rivers
mine + spring water
pingo water (static)
pingo effluent
(Ca^{2+}/Mg^{2+})
(Na^{+}/K^{+})
0
5
10
15
20
30
40

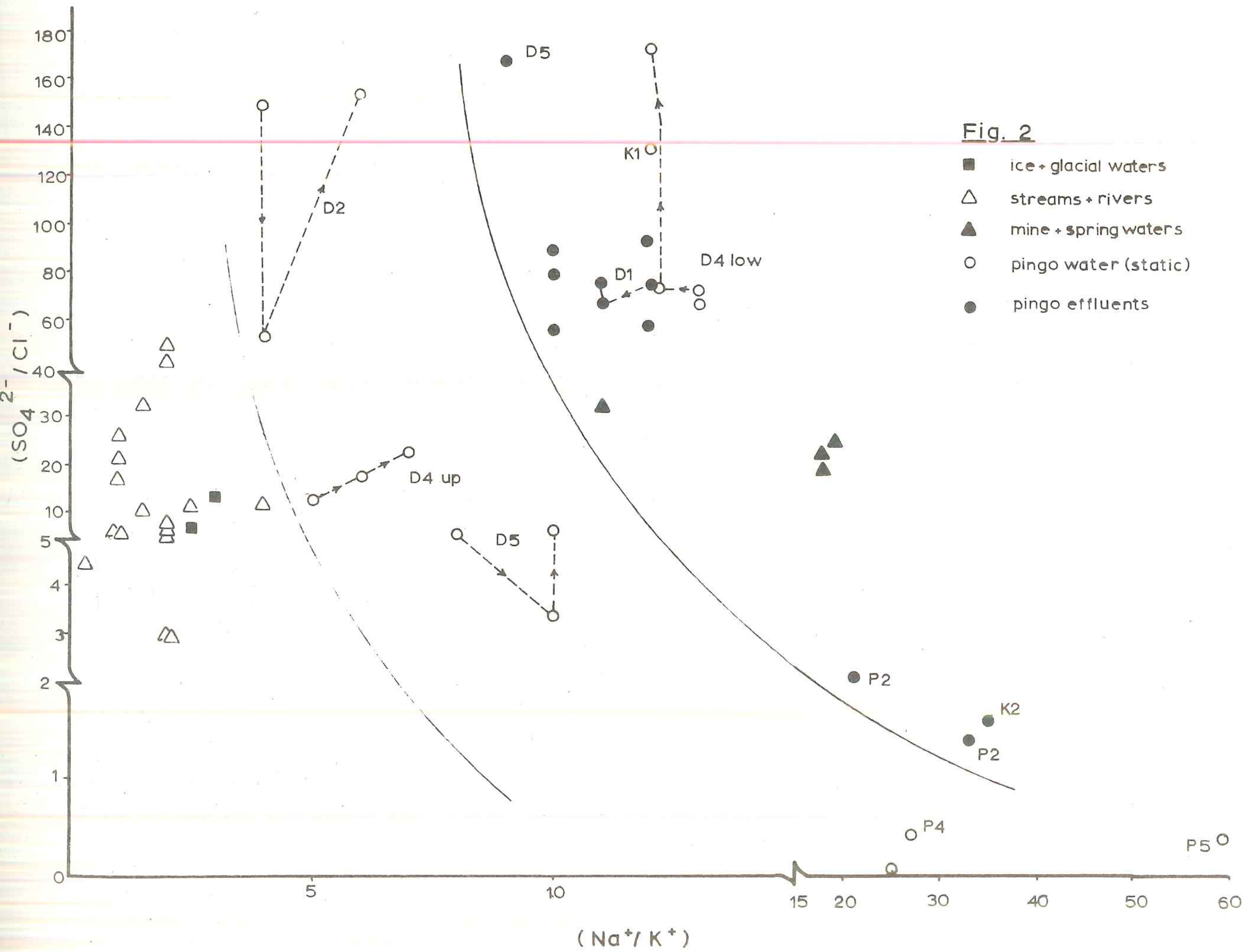


Fig. 2
ice + glacial waters
streams + rivers
mine + spring waters
pingo water (static)
pingo effluents
(SO_4^{2-}/Cl^{-})
(Na^{+}/K^{+})
D5
D2
K1
D4 low
D1
D4 up
D5
P2
K2
P2
P4
P5
0
1
2
3
4
5
10
20
30
40
60
80
100
120
140
160
180
5
10
15
20
30
40
50
60

be so, in fact, in these studies.

Cursory inspection suggested that the ionic concentration ratios (Na^+/K^+), (Ca^{2+}/Mg^{2+}) and (SO_4^{2-}/Cl^-) might be interesting. It was at once clear that the Ca/Mg ratio was not very useful, since it lay between 0 and 4 for the great majority of samples, though the pingo and spring samples tended on the whole to have lower values than surface and glacial waters. The correlation plot for (Na^+/K^+) and (Ca^{2+}/Mg^+), however, showed at once that the NA^+/K^+ ratio was far more discriminating. This plot (Fig. 1) suggested a classification "X" into four classes:

A	*B*	*C*	*D*
$(Na^+/K^+) < 3$	$0 < (Na^+/K^+) < 5$	$5 < (Na^+/K^+)$ 15	$(Na^+/K^+) > 15$
$(Ca^{2+}/Mg^{2+}) > 6$	$(Ca^{2+}/Mg^{2+}) < 5$		

This, however, accomplished only rough separation between the physical classes (i) to (v). However, the correlation plot between ($SO_4{}^{2-}/Cl^-$) and (Na^+/K^+), shown as Fig. 2, contained the physical classes clearly divided into three zones. Pingo effluents and springs are associated with higher values for both ratios; glacial and surface waters with lower values for both; and the intermediate zone is occupied by static waters. The only exception is the lower pond of pingo D4, and it is suspected that this receives effluent from D4 by permeation.

2. *Saturation of the Solutions*

The only relevant possibilities here are saturation of the solutions with respect to gypsum, $CaSO_4$; calcite, $CaCO_3$; and solids containing magnesium and carbonate. For gypsum the relevant equilibria are–

(1) $CaSO_4$ (s) $=$ $Ca^{2+} + SO_4{}^{2-}$, $K = 2.4 \times 10^{-5}\,M^2$

(2) $Ca^{2+} + CO_4{}^{2-}$ $=$ $CaSO_4$ (aqueous), $K = 2 \times 10^3\,M^{-1}$

It emerges that none of the samples is saturated with respect to gypsum. For calcite we consider

(3) $CaCO_3$ (s) $=$ $Ca^{2+} + CO_3{}^{2-}$, $K = 5.4 \times 10^{-9}\,M^2$

(4) $HCO_3{}^-$ $=$ $H^+ + CO_3^{2-}$, $K = 5.6 \times 10^{-11}\,M$

It then appears that first sight that a number of samples are supersaturated by a factor listed under "Sc" in the Tables. However, when account is taken of the depletion of free Ca^{2+} by the sulphate ion-pair formation (2), the supersaturation is fairly exactly removed in the cases marked '*'; cases marked '+' are then seen not even to be saturated. It emerges, then, that the cases marked '*' under 'Sc' may be saturated with respect to calcite at 25°C.

Magnesium carbonate species seem to be at least twice as soluble as calcite, and hence it appears that no samples are saturated with magnesium salts.

According to the measured pH values and total CO_2 contents, all the samples contained CO_2 in excess of the saturated value for contact with normal atmosphere at 20°C. Since the sampling temperatures were lower than this, and some had freshly emerged from regions of higher hydrostatic pressure, the fact is not surprising.

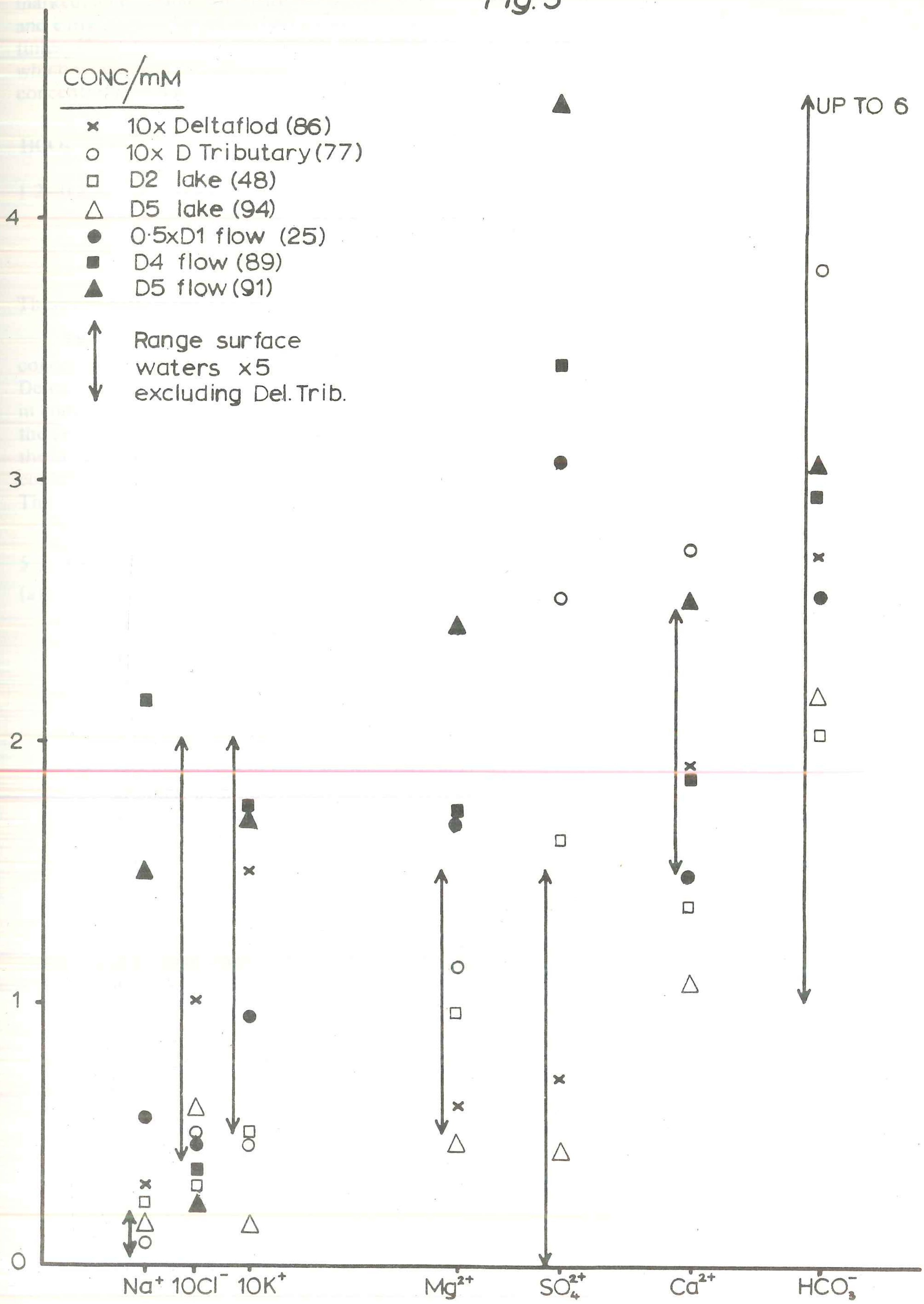
3. *Glacial Waters*

The analyses for the Arcturus ice sample and Mellom Glacier melt stream are best regarded as a check on the analytical procedures, which are seen to give credible results. The other melt-water samples were in contact with the ground and exhibit concentrations in the surface water range, except for the higher Ca^{2+}, SO_4^{2-} content of the Deltadal melt pond. The stream tributary in Deltadal shows a similar characteristic, presumably due to local occurrence of gypsum.

4. *Surface Waters*

The Ping Elv measurements are the most extensive and systematic: the variations are nowhere

Fig. 3


CONC/mM
× 10x Deltaflod (86)
○ 10x D Tributary (77)
□ D2 lake (48)
△ D5 lake (94)
● 0·5xD1 flow (25)
■ D4 flow (89)
▲ D5 flow (91)
Range surface waters x5 excluding Del. Trib.
UP TO 6
0
1
2
3
4
Na+ 10Cl− 10K+
Mg2+
SO42−
Ca2+
HCO3−

marked, and all that can clearly be discerned is a tendency to higher concentrations in mid-July and early August for all entities except HCO_3^-, which by contrast shows minimum values at these times. These tendencies may reflect the higher mean surface temperature at the times concerned, which would lead to higher rates of dissolution of solids and of "evaporation" of CO_2. Typical concentration ranges are as follows (mM)–

HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+
1.2–0.2	0.005–0.040	0.00–0.30	0.01–0.04	0.01–0.04

Ca^{2+}	Mg^{2+}
0.3 0.5	0.1–0.3

These are also shown in Fig. 3.

The other surface water analyses lie within these limits, except for the high Ca^{2+} and SO_4^{2-} concentrations of the Deltadal tributary. During July the concentrations at Expeditionshus, Deltaflod, Delta tributary and Gefionpass showed systematic increases without any clear change in composition, except for relatively increased $MgSO_4$ content of the Deltaflod. During August the Deltaflod and Oxseflod became systematically dilute, except for increased $MgSO_4$ content in the latter. This characteristic oddity with respect to Mg^{2+} and SO_4^{2-} is emphasis by the low content for these ions of the Gefion, Hestespass, Expeditionshus, Myggesø and Puig Elv samples. The Blyklippen sample is even more concentrated with respect to Ca^{2+}, Mg^{2+} and SO_4^{2-} ions.

5. *Pingo Waters, Static and Effluent*

(a) *Deltadal Pingos*

The late-season compositions of waters associated with the Deltadal pingo system are plotted in Fig. 3 together with those of local surface waters and the 'normal' ranges for Ping Elv samples. It can be seen that systematic correlations exist among these data. Static, and especially effluent, waters are on the whole 5–20 times as concentrated as surface samples, and the effluent waters show relatively high contents of Na^+, Mg^{2+} and SO_4^{2-} ions. All the samples had low Cl^- concentrations.

D2: The pingo lake in this case increased in concentration systematically through the summer, with no evident shift in composition, and retaining good correlation with local surface water throughout; there is no evidence of any waters of subpermafrost origin. The lake was at all times apparently saturated with respect to calcite.

D5: This lake also exhibited general concentration increase without change of composition– due, presumably, to simple evaporation–and showed good correlation with surface waters. In August, however, a discharge developed, showing generally higher concentrations and a dramatic relative increase in Na^+, Ca^{2+}, Mg^{2+} and SO_4^{2-} contents. The static lake was apparently at or near saturation with respect to calcite, but the discharge was not. It seems clear that discharge occurred by the breakthrough of water of sub-permafrost origin.

D1: The surface ice of this pingo was evidently cleansed of outlying impurities by melting during July. The Ca^{2+}, Mg^{2+} analyses for the first outflow sample are quite 'out of line' with the rest and highly suspect; only a small sample was available and they cannot be rechecked. Apart from this, however, the outflow was continuous, saturated with calcite, and of very high Mg^{2+} and SO_4^{2-} content relative to surface waters. Again, sub-permafrost origin is strongly indicated.

D4: This pingo had two subsidiary ponds beside the water of the main core. The ice core contained a cistern which collapsed later in the summer, and from which effluent emerged at all times. The early July samples show dilution of the effluent by melting of the ice; later the effluent was more concentrated, with increases in Na^+, Ca^{2+} and SO_4^{2-} relative to K^+ and Cl^-. It appears that an early melting phase released increasing quantities of sub-permafrost water. The ponds associated with D4, an upper and a lower, each had early-season compositions resembling surface water, and showed what appeared to be simple evaporative concentration through the season. The lower pond, however, was at any given time the more concentrated with respect to Na^+, Ca^{2+}, Mg^{2+}

and SO_4^{2-} but the more dilute with respect to K^+ and Cl^-. Taken in conjunction with the outflow analyses these results suggest that the lower pond either has its own small sub-permafrost source, or receives water from the outflow by permeation.

The general resemblance between the outflow compositions for D1, D4 and D5 strongly suggests common or very similar origins for these waters.

(b) *Schuchertdal Pingos*

These pingo waters were originally sampled and analysed in 1968; only P2 was re-sampled in 1970 owing to errors by field operatives. The correlation between the 1968 and 1970 results is very good, the latter being in general close to 1.25 times the former. This agreement has survived several changes in analytical methods!

Although the analyses were discussed in the Report of 1968, additional comparative comments can now be made. The most obvious features of the analyses are the remarkably high and mutually correlated Na^+ and Cl^- contents, the high Na^+/K^+ and low Ca^{2+}/Mg^{2+}, SO_4^{2-}/Cl^- ratios, which approach those of seawater (Fig. 2). In contrast to seawater, however, these waters show $Na^+ > Cl^-$ and $Mg^{2+} < SO_4^{2-}$; this discrepancy is most marked for the effluent water, P2 and least for P5.

The obvious explanation, compativle with these facts, is that all three pingo lakes receive sub-permafrost waters which are exposed to seawater permeation through deep aquifers. Perhaps the clinching observation is that the order 2, 4, 5 is that of increasing nearness to the sea. Moreover, the isotopic ratios tend towards seawater values in the same order.

P2 and, for a brief period, P5 showed actual discharges: but only the analytical work has revealed sub-permafrost activity for P4.

(c) *Traill Island Pingos*

The three pingos sampled on Traill Island provide a fascinating comparison with the 'mainland' samples.

Karupelv 1 has a retained ice core whose outflow was sampled. The analysis bears a striking general resemblance to those of the Deltadal effluents, with particularly high concentrations of the ions SO_4^{2-}, Na^+, Ca^{2+}; on Fig. 2 its representative point appears close to those for Deltadal samples, and we would characterise it as receiving 'uncontaminated' sub-permafrost water.

Karupelv 2, a collapse crater pond, resembles the Schuchert dal compositions, in particular that of P2, and is of the same intermediate kind. Finally the Gudenelv specimen, another collapse crater, has a composition which—alone of all those determined—correlates well with that of seawater; the only 'imperfection' is a two-fold relative excess of Ca^{2+}. Otherwise, the Gudenelv crater contains virtually a one-hundredth dilution of ocean water, and contamination of its source therewith is strongly indicated.

6. *Comparisons with other Analytical Work*

The analytical work in the Cape Thompson region of Alaska, reported by Lamar, affords some interesting comparisons; four of his analyses, providing relevant comparisons for the detection of seawater permeation, have been converted to the units of the present tables and annexed to them.

7. *General Conclusions*

It is evident that systematic, accurate chemical analyses of samples from well-designed collections are capable of affording reliable information about the following:

(i) Dilution of natural waters by thaw runoff,
(ii) Concentration of static waters by evaporation,
(iii) Incursion of waters of deep origin into surface lakes or effluents, and the seasonal variation of such incursions,

(iv) Contamination of waters derived from deep aquifers, by their permeation by seawater.
(v) In combination with geological and isotopic data—the origin and history of surface effluents.

8. *Analytical Work Pending*

Dr. W. Band, of the University of Lancaster, kindly collected further samples from the Schuchertdal pingos and seawater samples from Gurreholm and Mestersvig, in the late summer of 1971. Chemical analyses on these samples are in hand. Dr. S. Shepperd, of East Kilbride, is at present validating a mass spectrograph of advanced design for the determination of isotopic ratios. He has accepted the following samples for oxygen and, later, hydrogen isotopic analysis: 2, 8, 10–18, 21, 23, 43–45, 50–52, 62, 74, 76, 79, 87, 90–93, 95–98. These include examples of each type of water and of each pingo source.

9. *References*

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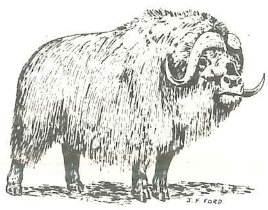

Ref. No.	Time Hr.	Time Dy	Time M	Time Yr	Origin	pH	Tot CO_2	Anions HCO_3^-	Anions Cl^-	Anions SO_4^{2-}	Cations Na^+	Cations K^+	Cations Ca^{2+}	Cations Mg^{2+}	$\frac{Na}{K}$	$\frac{Ca}{Mg}$	X	$\frac{SO_4}{Cl}$	S_c
0					Standard Mean Ocean Water			2.33	536	27.9	457	9.80	10.1	56.7	47	0.2	D	0.05	
					TRAILL ISLAND PINGOS														
95			8	70	Karupelv 1 ice core outflow	7.34	3.88	3.48	0.119	15.6	1.88	0.15	9.99	7.58	12	1.3	C	131	8*
97			8	70	Karupelv 2 crater pond	8.33	5.49	5.41	1.00	1.60	8.80	0.25	0.23	0.58	35	0.4	D	1.6	2*
96			8	70	Gudenelv crater pond	7.73	2.00	1.91	5.19	0.30	4.90	0.195	0.58	0.75	25	0.8	D	0.06	
					SCHUCHERTDAL PINGOS														
p5			7	68	P5 lake	8.05			13.0	4.83	17.7	0.30	0.00	3.47	59	?	D	0.37	?
					lake	7.18			2.82	1.23	6.00	0.22	0.27	0.30	27	0.9	D	0.44	?
P2			7	68	P2 outflow	8.00			1.16	1.62	5.90	0.18	0.64	1.30	33	0.5	D	1.40	?
62	1945	12	8	70	P2	7.65	7.38	7.00	1.27	2.68	7.20	0.35	0.90	1.93	21	0.5	D	2.11	3*
					DELTADAL PINGOS														
17	1100	10	7	70	D1 surface ice	6.76	1.60	1.12	0.117	0.93	0.19	0.075	0.58	0.38	2.5	1.5	B	7.9	
16	1100	10	7	70	D1 outflow	7.50	4.06	3.78	0.078	5.80	1.19	0.090	0.04	0.00	12	?	?	74	?
25	0100	12	7	70	D1 outflow	7.52	5.24	5.11	0.092	6.15	1.14	0.095	2.97	3.33	11	0.9	C	67	5*
76	1000	21	7	70	D1 surface ice	6.71	0.94	0.64	0.020	0.33	0.02	0.00	0.40	0.08	?	5	?	17	
91	1900	22	8	70	D1 outflow	7.50	4.61	4.28	0.077	5.85	1.11	0.090	3.41	3.55	11	1.0	C	76	5*
2	1900	8	7	70	D2 main lake	7.70	2.84	2.71	0.010	1.50	0.17	0.04	1.30	0.84	4.2	1.6	B	1.50	2*
48	0930	21	7	70	D2 main lake	7.83	2.10	2.02	0.030	1.62	0.22	0.05	1.36	0.96	4.0	1.4	B	54	2*
90	2015	22	8	70	D2 main lake	7.79	3.34	3.21	0.023	3.52	0.51	0.09	2.25	2.25	6.0	1.0	B	153	5*
8	1800	9	7	70	D5 crater lake	7.69	2.18	2.08	0.059	0.30	0.12	0.015	1.01	0.26	8	4.0	?	5.1	1
46	1000	21	7	70	D5 crater lake	7.33	2.04	1.83	0.119	0.41	0.21	0.020	0.92	0.36	10	2.6	C	3.4	
94	1500	22	8	70	D5 crater lake	7.84	2.24	2.16	0.061	0.42	0.15	0.015	1.07	0.45	10	2.4	C	6.9	2*
92	2015	22	8	70	D5 crater lake flow	7.50	3.30	3.06	0.025	4.44	1.50	0.17	2.54	2.43	9	1.0	C	178	2+
12	2400	9	7	70	D4 upper pond	7.42	1.44	1.32	0.030	0.38	0.70	0.14	0.38	0.26	5	1.4	B	13	
75	1000	21	7	70	D4 upper pond	7.08	2.88	2.39	0.045	0.82	1.31	0.22	1.08	1.10	6	1.0	B	18	
87	2015	22	8	70	D4 upper pond	8.03	3.34	3.26	0.060	1.35	2.50	0.38	0.64	0.71	7	0.9	B	23	2+
9	1900	9	7	70	D4 lower pond	7.47	1.46	1.35	0.018	1.20	0.83	0.065	0.78	0.62	13	1.2	C	67	
13	2400	9	7	70	D4 lower pond	7.20	1.74	1.51	0.020	1.45	0.92	0.070	0.84	0.65	13	1.3	C	73	
47	1000	21	7	70	D4 lower pond	7.80	2.50	2.41	0.035	2.57	1.72	0.14	1.48	1.35	12	1.1	C	73	2+
88	2015	22	8	70	D4 lower pond	7.81	2.89	2.78	0.020	3.46	2.08	0.17	1.73	1.75	12	1.0	C	173	3+

Ref. No.	Time Hr.	Dy	M	Yr	Origin	pH	Tot CO_2	Anions HCO_3^-	Cl^-	SO_4^{2-}	Cations Na^+	K^+	Ca^{2+}	Mg^{2+}	$\frac{Na}{K}$	$\frac{Ca}{Mg}$	X	$\frac{SO_4}{Cl}$	S_c
					DELTADAL PINGO														
11	1900	9	7	70	D4 cistern content	7.50	2.61	2.42	0.042	2.32	1.50	0.150	1.46	1.07	10	1.4	C	55	1+
10	1900	9	7	70	D4 cistern outflow	7.55	2.54	2.38	0.026	2.05	1.58	0.155	1.38	1.05	10	1.3	C	79	1+
24	0330	11	7	70	D4 cistern outflow	7.08	1.26	1.05	0.021	1.21	0.75	0.060	0.67	0.56	12	1.2	C	58	
74	1000	21	7	70	D4 cistern, collapsed	7.39	3.34	3.04	0.032	2.84	1.77	0.165	1.65	1.36	10	1.2	C	89	2+
89	2015	22	8	70	D4 cistern, collapsed	7.66	3.10	2.94	0.037	3.42	2.16	0.175	1.88	1.71	12	1.1	C	92	2+
					MINE WATER														
50				70	Malmbjerg mine	6.78	1.93	1.37	0.030	0.56	0.55	0.030	0.78	0.66	18	1.2	D	19	
51				70	Malmbjerg Mine	6.52	1.90	1.09	0.030	0.73	0.56	0.030	0.79	0.76	18	1.0	D	24	
52				70	Malmbjerg mine	6.79	1.90	1.36	0.027	0.68	0.55	0.025	0.82	0.72	22	1.1	D	25	
					GLACIAL WATERS														
14				70	Arcturus Gl. ice	6.29	0.42	0.19	0.007	0.03	0.00	0.00	0.03	0.00	?	?	?	4.3	
45				70	Mellom Gl. melt stream	5.10	0.00	0.00	0.015	0.00	0.01	0.00	0.11	0.02	1	5	B	0	
4	1900	8	7	70	Melt pond, Deltadal	7.78	1.77	1.70	0.054	0.76	0.12	0.040	1.18	0.36	3	3.3	B	14	
19	2300	10	7	70	Melt stream, Sorte Hjorne	7.19	1.11	0.96	0.013	0.10	0.01	0.010	0.41	0.05	1	8	B	7.7	
					STREAMS AND RIVERS														
43	2000	20	7	70	Blyklippen mine tail	7.30	1.62	1.44	0.032	1.06	0.56	0.050	1.27	0.24	11	5	C	33	
22	2200	11	7	70	Gefion elv	7.02	0.52	0.42	0.011	0.00	0.00	0.00	0.26	0.04	?	6	?	0	
23	2300	11	7	70	Gefionpass, stream	6.74	0.65	0.45	0.010	0.02	0.00	0.00	0.28	0.03	?	9	?	2.0	
44	2200	20	7	70	Gefionpass, stream	7.41	0.85	0.78	0.015	0.10	0.01	0.010	0.36	0.10	1	3.6	B	7	
21	1730	11	7	70	Hestespass, pond outflow	6.50	0.40	0.22	0.020	0.00	0.00	0.00	0.16	0.06	?	2.7	?	0	
20	1600	10	7	70	Expeditionshus, stream	7.31	0.73	0.65	0.013	0.04	0.00	0.00	0.41	0.00	?	?	?	3.2	
40	2230	18	7	70	Expeditionshus, stream	7.47	0.70	0.65	0.019	0.11	0.00	0.00	0.56	0.02	?	28	?	6.0	
5	1900	8	7	70		7.48	1.80	1.66	0.025	0.08	0.04	0.020	0.85	0.11	2	8	A	3.1	
41	0100	19	7	70	Myggesø	6.60	0.55	0.34	0.038	0.17	0.01	0.030	0.20	0.02	0.03	10	A	4.5	
98			7	70	Myggesø	7.09	0.26	0.22	0.028	0.08	0.02	0.00	0.20	0.08	?	2.5	?	3.2	
3	1900	9	7	70	Delta flod	7.37	0.63	0.57	0.007	0.04	0.04	0.020	0.28	0.03	2	9	A	57	
49	0930	21	7	70	Delta flod	7.46	1.09	1.00	1.011	0.13	0.05	0.020	0.30	0.13	2.5	2.5	B	12	
86	2015	22	8	70	Delta flod	7.02	0.33	0.27	0.010	0.07	0.03	0.015	0.19	0.06	2	3	B	7.0	
7	1300	9	7	70	Tributary, Deltadal	7.20	0.87	0.75	0.010	0.43	0.02	0.010	0.66	0.12	2	5.5	B	43	
77	1000	21	7	70	Tributary, Deltadal	7.12	1.51	1.27	0.017	0.85	0.03	0.015	0.91	0.38	2	2.4	B	50	
6	1500	9	7	70	Okse flod	7.32	1.00	0.90	0.013	0.08	0.01	0.010	0.44	0.11	1	4	B	6.1	
85	1930	22	8	70	Okse flod	7.51	0.61	0.57	0.007	0.19	0.01	0.010	0.30	0.16	1	1.8	B	27	
1	1900	8	7	70	to D2	7.31	1.58	1.41	0.023	0.41	0.02	0.020	0.77	0.00	1	?	?	18	

Ref. No.	Time				Origin	pH	Tot CO_2	Anions			Cations				$\frac{Na}{K}$	$\frac{Ca}{Mg}$	X	$\frac{SO_4}{Cl}$	S_c
	Hr.	Dy	M	Yr				HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}					
18	2200	10	7	70	Ping elv	7.50	0.98	0.94	0.008	0.00	0.02	0.015	0.35	0.10	1.3	3.5	B	0	
26	0100	13	7	70	"	7.10	0,89	0.75	0.013		0.04	0.010	0.36	0.20	4	1.8	B	?	
27	1900	12	7	70	"	7.81	0.96	0.92	0.011		0.04	0.010	0.36	0.17	4	2.2	B	?	
28	1600	13	7	70	"	7.28	0.96	0.85	0.020		0.02	0.010	0.38	0.14	2	2.7	B	?	
29	2000	13	7	70	"	7.31	0.94	0.84	0.013		0.01	0.010	0.38	0.11	1	3.4	B	?	
30	2400	13	7	70	"	7.12	0.81	0.68	0.015		0.01	0.010	0.34	0.00	1	?	?	?	
31	0400	14	7	70	"	7.10	1.43	1.20	0.013		0.01	0.010	0.29	0.12	1	2.3	B	?	
32	0800	14	7	70	"	6.82	0.80	0.58	0.224		0.03	0.175	0.33	0.14	0.2	2.4	B	?	
33	1200	14	7	70	"	7.12	0.94	0.79	0.055		0.02	0.050	0.36	0.14	0.4	2.5	B	?	
34	1215	15	7	70	"	7.50	0.92	0.85	0.042		0.02	0.040	0.38	0.18	0.5	2.1	B	?	
35	2000	15	7	70	"	7.43	0.39	0.36	0.018		0.01	0.010	0.37	0.12	1	3.1	B	?	
36	0930	16	7	70	"	7.57	0.44	0.41	0.013	0.04	0.02	0.010	0.33	0.16	2	2.0	B	3.2	
37	2140	16	7	70	"	7.38	0.46	0.42	0.011	0.00	0.01	0.010	0.31	0.13	1	2.3	B	0	
38	2100	17	7	70	"	7.49	0.63	0.58	0.023		0.01	0.010	0.43	0.19	1	2.2	B	?	
39	1900	18	7	70	"	7.61	1.04	0.98	0.011		0.01	0.010	0.49	0.13	1	3.7	B	?	
78	2000	21	7	70	"	7.21	0.87	0.75	0.010	0.00	0.02	0.015	0.36	0.15	1	2.4	B	0	
79	0800	30	7	70	"	7.58	1.09	1.02	0.007	0.16	0.03	0.025	0.47	0.26	1	1.8	B	23	
80	2000	30	7	70	"	7.59	1.10	1.03	0.007	0.06	0.04	0.020	0.38	0.19	2	2.0	B	8	
81	0800	6	8	70	"	7.37	1.20	1.09	0.017	0.22	0.08	0.020	0.46	0.31	4	1.5	B	13	
82	2000	6	8	70	"	7.21	0.86	0.75	0.010	0.33	0.03	0.020	0.31	0.17	1.5	1.8	B	33	
93	1500	22	8	70	Ping elv, ex sediment	7.97	0.76	0.74	0.008	0.09	0.03	0.020	0.28	0.24	1.5	1.2	B	11	
					WORK OF LAMAR, CAPE THOMPSON, ALASKA														
10		12	7	64	Drainage pond			0.20	0.113	0.01	0.23	0.010	0.04	0.01	23	4	D	0.009	
16		6	8	64	Freshwater creek			0.26	0.085	0.17	0.20	0.010	0.16	0.08	20	2.0	D	2.0	
2		30	7	64	Well near sea			1.64	1.75	0.28	1.52	0.046	0.82	0.40	33	2.0	D	0.16	?
14		8	9	64	Spring in marine plain			2.26	86.0	1.98	66.1	2.38	3.59	7.20	28	0.5	D	0.23	?
					Standard Mean Ocean Water			2.33	536	27.9	457	9.80	10.1	56.7	47	0.2	D	0.05	

THE MOUNTAINEERING PARTIES

R. HEYWOOD
P. HOLLINS
J. MORRISON
A. PRATT

J. LAWRENCE
J. PEDEN
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REPORT OF THE IVAAR BAARDSON (ROSLIN) GLACIER PARTY

R. Heywood (leader), A. Pratt, J. Morrison, P. Hollins.

The object of this party was to travel on foot as quickly as possible to the junction of the Ivaar Baardson and Dalmore Glaciers to arrive in time to receive an airdrop from the R.A.F. This was due to be made on July 12th, the distance to be covered was about 60 miles and involved crossing a glacier pass and at least one major river. Once the food drop had been received attention was to be directed to climbing in the upper reaches of the Dalmore Glacier. Finally a traverse was to be made from the Ivaar Baardson Glacier into the Bjørnbo system where the party would link up with the Delta Dal party at a food dump laid by helicopter at a pre-arranged place. The 'Ivaar Baardson' is the new name given by the Danish Geodetic Institute to this big glacier which for some years was known as the Roslin Glacier.

Heywood reports:

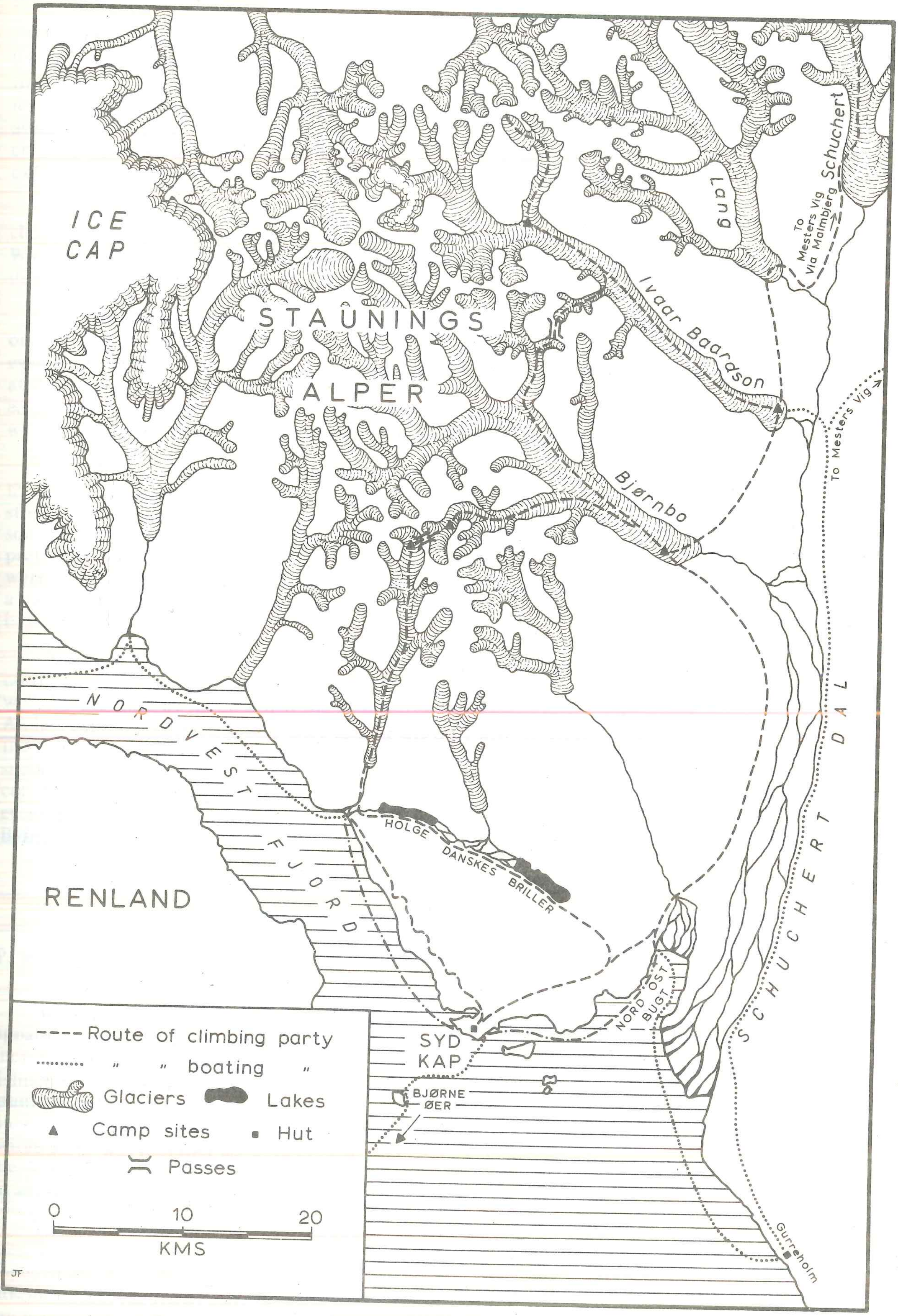
We were only two days out from Mestersvig, Noj was feeling sick, Phil had a sore hip, Al had a breeches rash and I, wearing new, unbroken boots, had foot trouble. We had reached the mining camp at Malmbjerg after a hard twelve hour slog from Sorte Hjorne and were looking forward to a long sleep on a mattress, an experience we would not have again for seven weeks, and a rapid overnight recovery from our various complaints.

We were in high spirits the following day, mainly due to the enormous breakfast of Frankfurters, potatoes and Sauerkraut, rye bread, honey and coffee that the hospitable Danes had provided. In addition, I had pointed out the snout of the Ivaar Baardson glacier, our destination two days hence. My three friends had not been to Greenland before, but, during the past months they had listened to my enthusiastic descriptions of a climbers' paradise; sound rock, long periods of sunshine and front point cramponing up firm, frozen snow slopes. I was to eat my words before very long.

We were all aware of the long distances to be travelled, but the others could not accept that distances, in the clear, dry Greenland air, are very deceptive. We found ourselves at the end of our first day out from Malmbjerg still a considerable distance from our objective. After a long hard grind over the ice of the Schuchert Glacier and its vast terminal moraines, we found our route barred by the deep boulder-strewn torrent which emerges from the snout of the Lang Glacier. Tired and dispirited, we camped for the night on the wrong side of the impassable river, which we by-passed the following day by crossing over the snout of the Lang Glacier. Easy terrain brought us to the Baardson snout, where we waited for the helicopter to arrive with supplies.

Another three days found us twenty miles up glacier, two to a tent, shouting abuse to each other above the noise of wind and rain. The English contingent (Phil and I) had been labelled as incompetent by the Scots. A section of a tent pole had been lost somewhere en route, but two skis held together with a perfect Boy Scout square lashing silenced their derision. This was the day when the Royal Air Force were to have dropped supplies, but the weather was obviously too bad. I had been trying to pacify the rebellious Scots by insisting that the strong winds were most unusual for the area and that the bad weather seldom lasted for more than two to three days. On the third day with no improvement and a switch to half rations, morale was decidedly low, but during a temporary clearance we were snapped out of our despondency by the drone of aero engines. We rushed out of our tents and caught a glimpse of the aircraft high above us in the clouds. The pilot circled and brought his big four-engined Hercules down through the swirling vapours to about 500 ft. above the glacier, well below the tops of the encircling peaks. At this height he made five runs down the glacier in gradually thickening weather, the aircraft, after each run, turning tightly within the confines of the trough. After this spectacular display, the aircraft climbed quickly out of sight, leaving twenty eight parachute leads sitting within 200 yds. of each other. Unfortunately, one chute had failed to open and its load of food was now littered across the glacier like manna from heaven. We gathered up chocolate and other goodies and retired to the tents.

The next two days were exceptionally fine and I was feeling very smug about my prediction that the bad weather would be short lived. I foolishly forecast that we could now expect a long stable spell, and so I was not too disappointed when we failed to climb our first mountain objective, a rock peak on the north side of the Dalmore Glacier. We had been repulsed less than


ICE CAP
STAÛNINGS
ALPER
Lang
Ivaar Baardson
Bjørnbo
To Mesters Vig Via Malmbjerg Schuchert
To Mesters Vig
NORDVEST FJORD
HOLGE DANSKES BRILLER
RENLAND
SCHUCHERT DAL
NORD OST BUGT
SYD KAP
BJØRNE ØER
Gurreholm
Route of climbing party
" " boating "
Glaciers
Lakes
Camp sites
Hut
Passes
0
10
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KMS
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half way to the summit after fifteen hours on very loose rock by an impassable gendarme.

Four days of mixed but generally poor weather followed, with overcast skies and strong winds, heavy snowfall and dense mist. During this period we did attempt the highest peak at the head of the Dalmore. The Magnificent Al had led and cut steps continuously up 1500 ft. of a snow and ice couloir, but on the final pitches I became apprehensive. I considered the snow to be in slab avalanche condition, the ice pitches being the scars of previous slides. When the snow began to creak and groan, each time, Al kicked a step, we became worried and decided to bail out. We were extremely disappointed for we had seen a possible line to the summit.

My prophecies of sound rock and snow and fine weather had been wrong and I had to change tack and fall back on the words of our leader, a veteran of six Greenland expeditions. When things were not going well that gentleman would remark "Don't ask me about Greenland, I don't know anything about it, I'm only here for the glory."

We had one day left before leaving to find a route from the Ivaar Baardson to our food dump on the Bjørnbo Glacier. Our spirits rose each hour of that day as the sky gradually cleared. The evening brought a keen frost and we looked forward to climbing our first peak. Midnight saw us at the summit of a snow peak to the south of the Dalmore. It did not matter that the ascent was easy; what did matter was that conditions were perfect and the climbing was enjoyable, and that we were rewarded with magnificent views of the Stauning Alps illuminated by the midnight sun.

Now began our traverse through to the Bjørnbo system. Our way led us some distance down the Baardson Glacier and past the camp of a recently arrived Cambridge Expedition where we stopped for a meal. One of them remarked that it was the first time he had ever breakfasted with someone who was eating dinner. In order to take advantage of the better snow conditions we preferred to travel at night and sleep during the day. We did not sleep well that day however, as we were, incredible as it may seem, too hot. For the first time in ten days we were off the ice and had a moraine camp site. The day was hot and windless and we were forced to occupy our sleeping bags to evade the mosquitos.

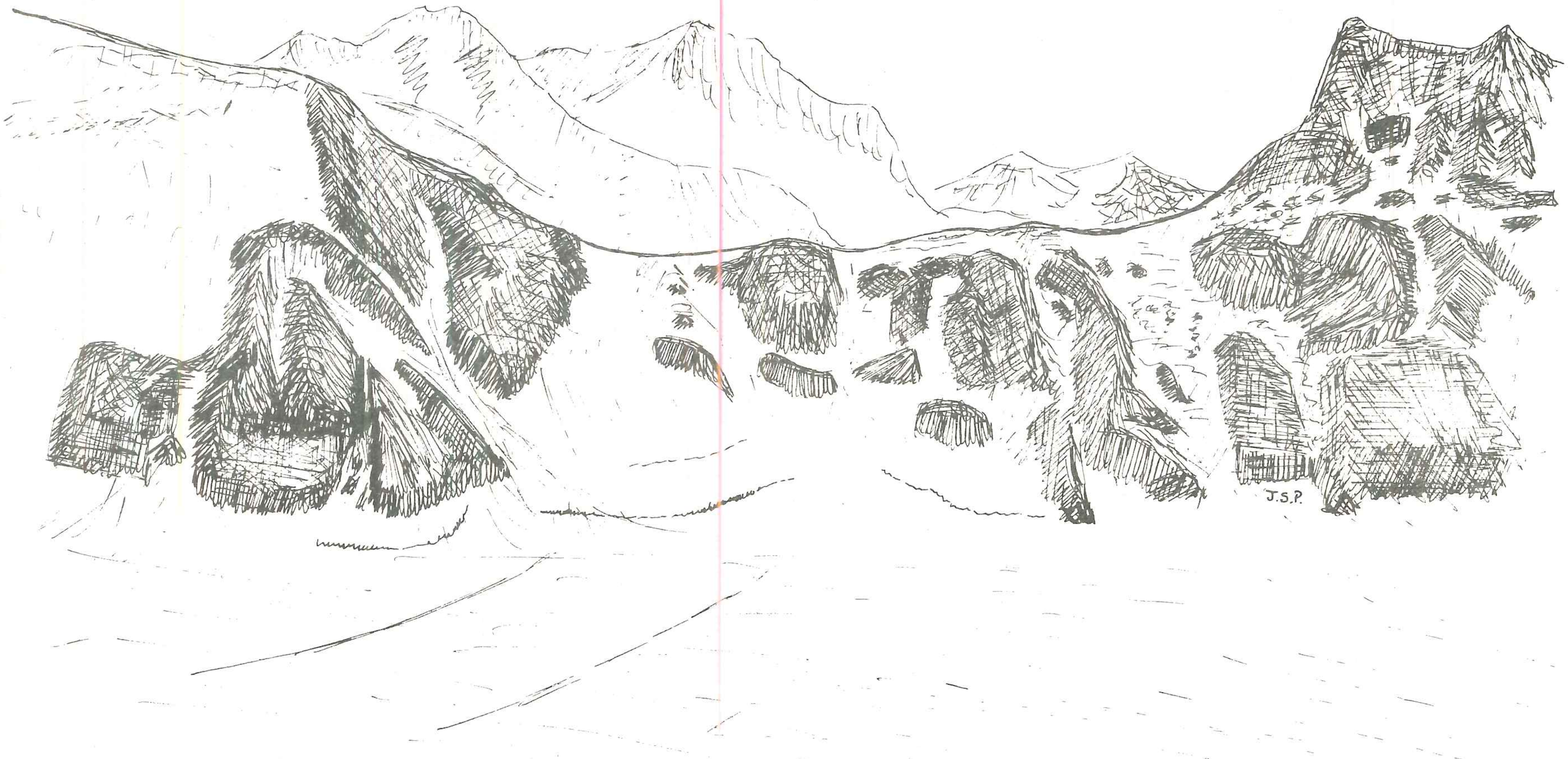
We were glad to be off once more but the going was not good. There was a breakable crust on the snow of the tributary glacier we were following and on ski the climbing wax did not hold well. By the time we had reached the foot of the steep slope to the col we had selected Noj and Al, less experienced skiers, who were almost weeping with frustration and quite ready to break their skis in half. Patience was further tried as we climbed steeply on foot through deep soft snow, zig-zagging to avoid seracs and numerous half-hidden crevasses. We eventually reached the col. After half a day sunbathing on a ledge we snatched a rock peak to the west in the cool of the evening and then skied down the Mars Glacier for several miles to our main food cache at the Bjørnbo Snout.

BJØRNBO GLACIER TO SYD KAP

P. Hollins

We had no difficulty in locating the Bjørnbo food dump, but the Delta Dal party had apparently navigated less well. A chance meeting with a 'Nordmine' prospector established that they had arrived two days previously after their long haul across the Werner Bjerge and down Schuchert Dal. After searching in vain across the nether regions of the Bjørnbo they retired disgruntled and emaciated to the Baardson cache. Morrison and Pratt were dispatched to collect them while Heywood and myself climbed a minor peak above the Leo Glacier. By the time the whole party was reunited we were already three days behind schedule and late for our R.V. with the boating party at Nord-Ost Bugt, some 25 miles distant. Leaving the new arrivals to recuperate an advance party, Heywood and myself, headed south.

The trek to Nord-Ost Bugt was made memorable by fine weather, aromatic tundra camp fires, weird mist formation on the Karstryggen Scarp and the multi-coloured rock strata of the slopes of east Schuchert Dal. We bivouaced en route in a cave which provided respite from both mosquitos and the harsh light of the night sun. Climbing out of Schuchert Dal on the following day we gained our first glimpse of the incredible Nord-West Fjord, with jagged Alpine peaks and snaking glaciers mirrored in its blue-green, ice-berg infested waters. We descended quickly to



MERCURY PASSET FROM LOWER SLOPES OF BOULDERBJERG.

Nord-Ost Bugt and made contact with the intrepid navigators, Cannon and Brown.

There followed an epic boat trip. On passage to Syd Kap we weaved among huge, fantastically shaped icebergs which were cracking and shedding large chunks of ice as they slowly drifted seaward. Our inspection of one particularly well pinnacled berg was perhaps too close. Within a few seconds of our passing the monster turned turtle across our wake. Later we rode more minature tidal waves as another two bergs rolled.

The hunting cabin at Syd Kap proved to be a haven of peace, indolence and gluttony. We gorged ourselves on ample rations and an abundance of fresh salmon, the vital part of gutting having been mastered: victims were netted with ease from the shore. By this time the sun was beginning to set and its waning light on the scenic splendours of the berg filled fjord provided the most photogenic scenes of the whole expedition. During our residence at Syd Kap we received a number of visitors. A lone Dane, of extraordinary character, reported having seen a polar bear in the near vicinity, feasting on a freshly killed seal. Subsequently Greenlanders, who seemed to be overwhelmingly pleased by our presence, dropped in at the cabin. Communication was achieved in broken German and Danish and by a rather ambiguous sign language.

The surprisingly hot weather at this time moved one of our number to take a swim, which lasted all of ten seconds, in the icy fjord waters. After several days of idyllic existence, apprehension grew concerning the remainder of our party. The boat men were due to leave Syd Kap after ferrying the mountaineering party up Nord-West Fjord but, unable to wait any longer, they agreed to transport the food and equipment to a pre-arranged place. Heywood and I went along for the ride and, having established the dump, the boatmen continued up-fjord while we made our way slowly back. It was a further anxious two days before the others arrived. They were fit and well but insisted on the same privileges as the advance party and settled down to sample life at Syd Kap.

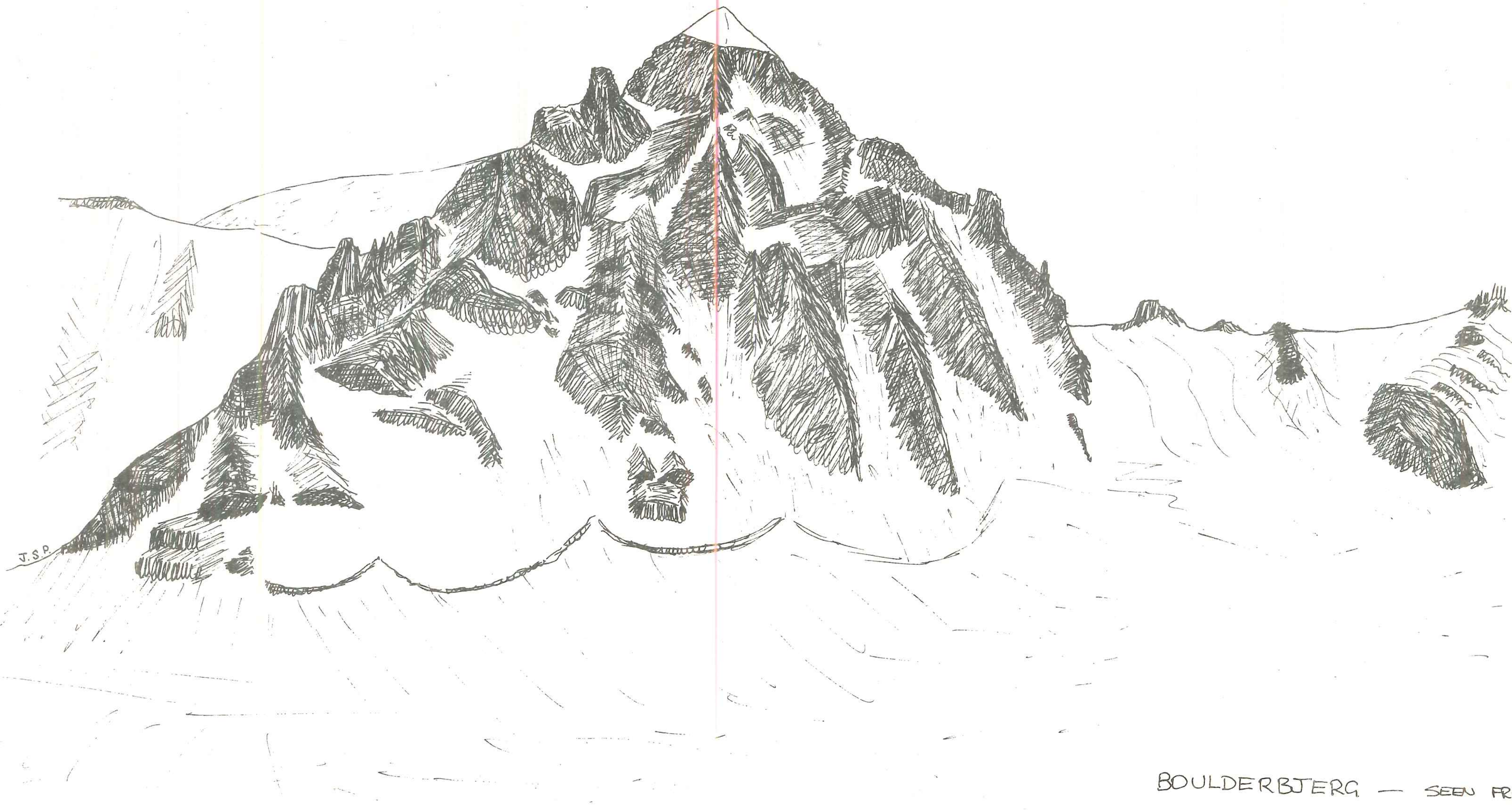
THE TRAVERSE FROM N.W. FJORD TO BJØRNBO

J. S. Peden

Almost unwillingly we put our feet to work again, for we had enjoyed our rest at Syd Kap, but there were deeds to be done. On the 4th of August the seven of us crossed the ten miles of pleasant tundra, back to Nord-Ost Bugt, whence our route lay through the Holger Danskes trough which is slightly reminiscent of the Lairig Ghru, although it is wider, deeper and more level and contains two lakes, each about four miles long. We reached the inner end of the first after about five hours of easy going and camped on the alluvial flats at its head. Fine ultra-Scottish-type scenery and brilliant weather made for high spirits and certain stalwarts carried this to the ridiculous extreme of swimming in the ice-cold lake.

The following day brought gradually deteriorating weather and 3½ hours and 10 miles later the scene at our food dump on the shores of N.W. Fjord was made even more Scottish by dense drizzle. A fairly tricky crossing of the silt-laden river flowing out of the second lake brought us to the terminal moraine of the glacier running almost due north to Wedge Peak. This was separated at its head by a low col from Mercury Glacier over which we intended to cross back into the Bjørnbo system. We picked our way through the fairly stable outwash debris up the true left bank of the river for two to three miles and gained access to the snout of the glacier by means of an excitingly narrow and somewhat precarious comb of ice. It was now raining heavily and very cold so, having established ourselves on the glacier, we camped about a mile from the snout on a well-gardened patch of moraine which was found to be warmer and no less comfortable than the ice itself.

The morrow brought if anything a thickening of the weather so we opted to stay put for 24 hours. The glacier at this point is narrow and fairly dissected by deep meltwater gorges and carries considerable amounts of surface debris. As is normal the bad weather did not last long and we moved off up the glacier in bright sunshine the following day. High drama ensued after only a mile or so of relatively mild going when Al's sledge carrying both tents took charge, and slid down a steep ice-slope into a raging meltwater stream. All was immediately supposed lost by everyone except Al who succeeded in stopping it temporarily by throwing huge boulders at it and, before its tow-rope either broke or slid off the rock that was holding it, a cramponned Bob, belayed by Al, plunged in to the rescue.



BOULDERBJERG — SEEN FROM MERCURY PASSET.

Once everyone had safely crossed the torrent rapid progress was made up the glacier which widens out dramatically after four or five miles, the bare ice surface becoming pretty smooth and unbroken. We travelled at our own speeds, more or less in the middle of the glacier and were duly impressed by the several tributary glaciers which tumbled in icy confusion on either side. A slight bend revealed the head of the glacier about seven miles distant with what looked in the clear air like a largish boulder sitting on the ice ahead of us. Several hours later our "boulder" turned out to be a small nanatak about 150 feet high at the downstream end, 12 miles from the head. At the upstream end the ice piled like a huge bow-wave to within 10 feet of the top. The last mile or so to the Boulder was fairly crevassed, with a thin snow cover thickening as the glacier rose in a step around the Boulder. We followed the east side of the Boulder and easily established a splendid and extremely comfortable camp atop it. It had taken eight hours to cover the 12 or 13 miles from the snout and although tired we could not fail to appreciate the view of impressive peaks appearing and then disappearing again in the thickening cloud. A few hours later it began to snow and those sleeping out hastily moved into the tents.

The next day it continued to snow and again we stayed where we were. About 3-4 inches of snow fell during the day and the mist was right down which did not really surprise us since we were camped at close on 4000′. It was still snowing the following day but it cleared slightly later on and we caught a vague glimpse of the col leading over to the Mercury. The col looked fairly easy as we had suspected from aerial photographs. It was therefore decided to cross it without further ado and after thawing out our boots and striking camp the whole party in two ropes moved through deep snow up to the col.

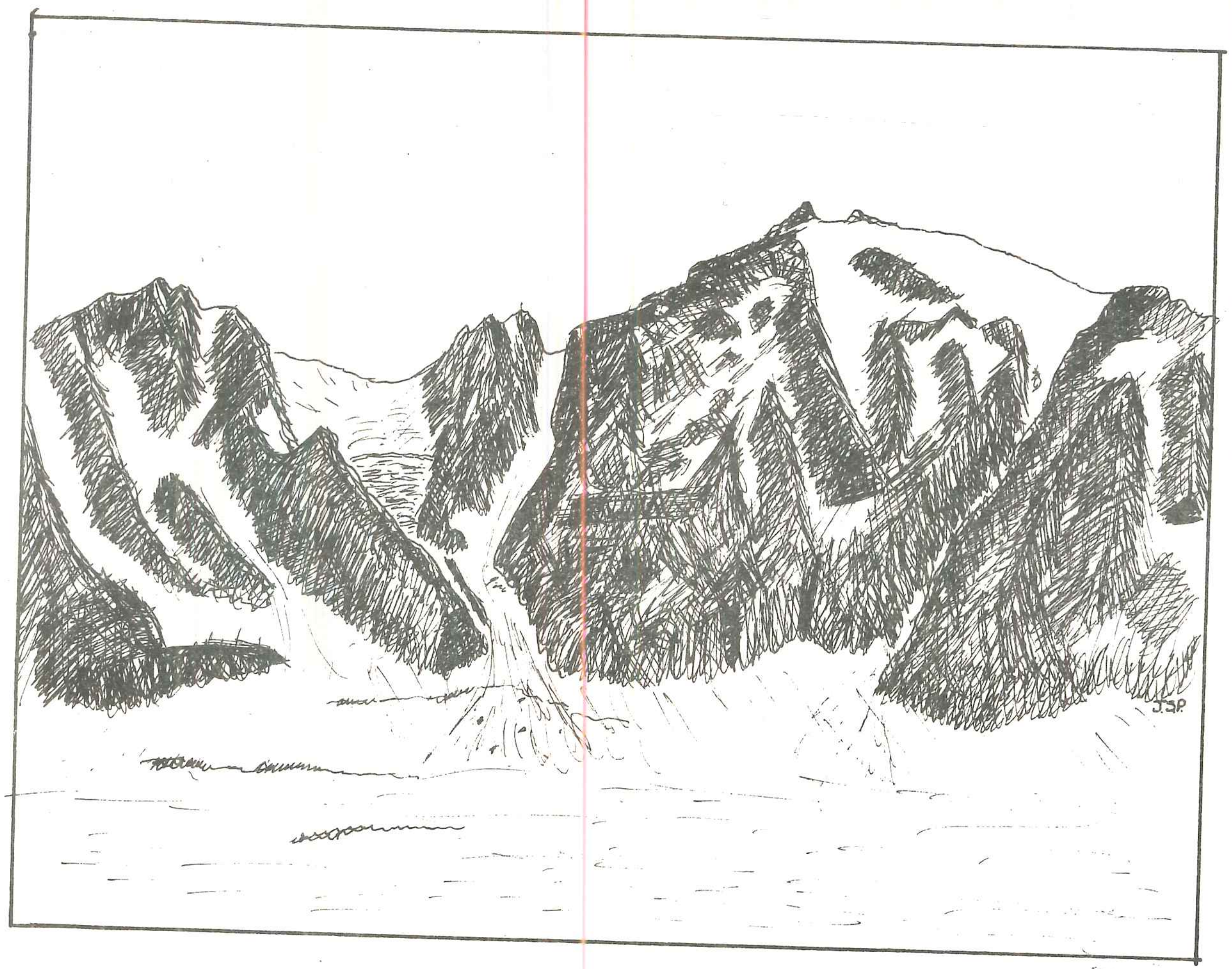
The col itself standing about 300′ above the level of the Boulder Glacier proved almost disappointingly easy with only a small well-bridged bergschrund at either side. We followed the firm neve up the lefthand side to where it ran out into loose rock and experienced little difficulty even in the mist. The party stopped a mile or so down the Mercury as soon as we dropped below the cloud and after sorting out food and equipment Joe, Anthony and John pitched camp, while the others carried on to the main food dump on the Bjørnbo. Noj who should also have stayed had unfortunately sustained a broken crampon during the vanishing tents episode. The crossing of the col had taken us three hours in bad weather, camp to camp; the date was now the 10th of August.

THE MERCURY PARTY

Lawrence, Peden and Walker

The weather did not look promising as we pitched our tent at the head of the Mercury Glacier. However, by early morning on the 12th of August the cloud was lifting and it was decided to attempt the prominent peak beside the boulder campsite which we had already named "Boulderbjerg". 10.30 a.m. saw us taking photos from the top of the pass in brilliant sunshine and an hour later we were cramponing solo up a short gully leading to the N.E. ridge. The gully soon ran out, and after one hour easy scrambling over loose rock, we arrived at a succession of steep rock pitches interspersed with more loose rocky slopes. Again the weather was deteriorating and soon the leaden skies appeared to be enveloping us, but our spirits returned when we reached a snowy col from which the summit could just be made out in the swirling mist. What had looked like an easy hours climb turned out to be a gruelling five hour battle against the weather, which involved climbing the rocky ridge until the tottering pinnacles forced us down into the gullies on our left more often than not swinging on the rope from expensive pitons. Time and again this procedure had to be adopted, but just as we were feeling more like chunks of ice and less like humans, the slope eased off, we crossed another col, and there we were on the top. The ascent had taken 11½ hours.

A quick reconnaissance revealed precipitous snow and ice slopes to the north and west and sheer cliffs to the south; so there was nothing for it but to retrace our steps. After a bite of frozen honey and soggy biscuits in no particular order, we set off and were delighted when a steep snow gully appeared leading down to the south. Several pitches of this were followed by a 150 foot abseil over a couple of rock and ice steps from which two shallow gullies and a couloir led us to the foot of "Boulderbjerg". Twenty hours after leaving camp we were snuggling down into our sleeping bags again, with the homely sound of primus roaring fiercely.



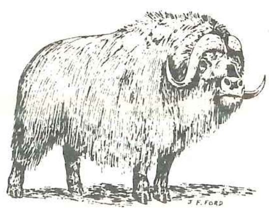
TAUROBJERG AS SEEN FROM LOWER LEO GLETCHER.

More bad weather and a shortage of food forced us to strike camp on the 14th of August. A pleasant 4½ hour walk down the glacier on a hard snow surface took us to the foot of the Mercury and thence on to our rendezvous with the main party on the Bjφrnbos.

While the Mercury party was sleeping the sleep of the just, Bob and Phil took advantage of good weather and bagged a minor peak from the Leo Glacier, a tributary of the Bjφrnbo about four miles up from base camp and adjacent to the Mercury. Their peak lay a mile or so up the Leo on the true left flank and was an easy rock summit of around 1800 metres.

Shortly after their return a peak-hungry Noj and Al roused the sleepers and conned Joe and John into going with them without delay to the Leo. Half-way up the glacier where it bends lay an interesting virgin peak of about 1900 metres, looking straight down to the Bjφrnbo. A Grade II ice-gully filled with powder snow, about 1500 feet long and overlooked by a small, but very precarious-looking hanging glacier, led to a saddle from which a superb early morning view was to be had over the mouth of the Schuchert Flod and N.W. Fjord. From there a pretty easy but thoroughly enjoyable ridge of sound granite led to the top. The four of us sat on the summit block for a considerable time, basking in the now strong sun and photographing the panorama of shining peaks. We then abseiled onto the snow ridge leading west which degenerated into a large convex showfield. From this a basalt dyle led us straight down to the glacier. Thence back to camp. The ascent took seven or eight hours, the descent three and the mountain was named Taurobjerg (since Noj and Joe who reached the top first both had Taurus for their Zodiac sign, and the name fitted in with the existing nomenclature of the Bjφrnbo system).

The following day, August 17th saw the dismantling of basecamp on the Bjφrnbo and all seven of us started our return journey up Schuchert Dal, once again in fine weather. Although we had completed the traverse thus establishing the Boulder-Mercury col as an easy through-route, we were plagued by the weather, which had the habit of turning sour whenever we were within striking distance of a mountain, and we were therefore unable to take anything like full advantage of our visit to the area.



MOUNTAINEERING NOTES

The following is a list of climbs, successful and unsuccessful, made by members of the expedition. Grading follows the accepted Alpine system giving some snow and rock pitches in British grades. Summit heights are those shown on the Danish Geodetic Institutes' 1:200000 provisional map of the area. Mountains are numbered in the order climbed or attempted. Most are not yet named.

The ascents are described in the following form:–

(a) Name, altitude and location of mountain
(b) Date climbed or attempted
(c) Names of party in alphabetical order
(d) Grading
(e) Time taken from camp back to camp
(f) Route notes.

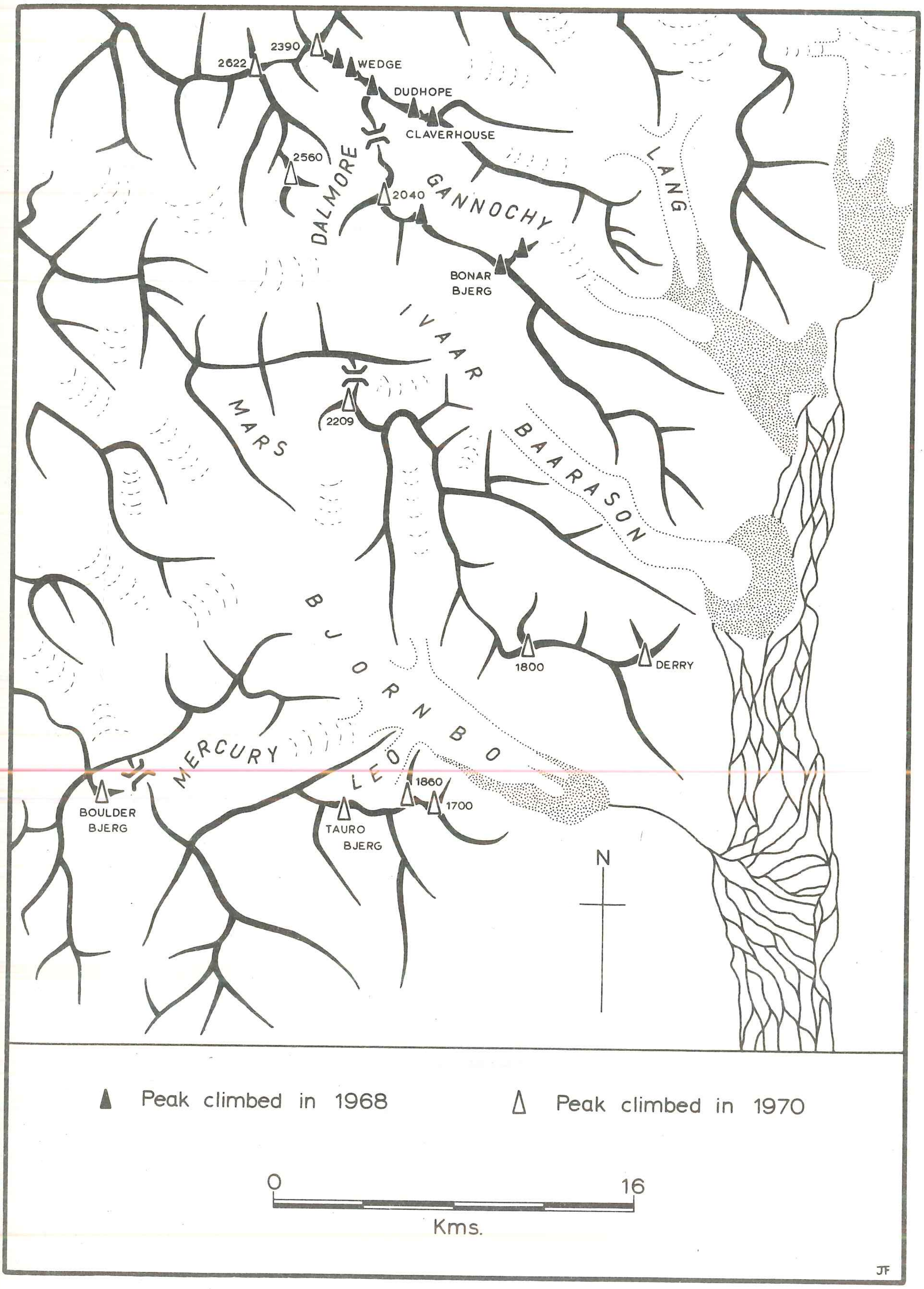
1. (a) A rock peak situated by the true right hand of the Dalmore Glacier, near its junction with the Ivaar Baardson Glacier. (2140 m)
(b) 14th July
(c) Heywood, Hollins, Pratt and Morrison
(d) A.D. (?)
(e) 15 hours
(f) From the Dalmore Glacier, the route was via a small subsidiary glacier and a snow couloir to reach the west ridge. The rock was extremely loose and progress was eventually halted at an impassable gendarme.

2. (a) Highest pyramidal peak at the head of the Dalmore basin. (2622 m)
(b) 18th July
(c) Heywood, Hollins, Pratt and Morrison
(d) P.D. (?)
(e) 8 hours
(f) Route via large couloir, leading to the west ridge. Climb abandoned after 1500 ft, (10 snow and ice pitches) because of snow conditions.

3. (a) Snow peak lying between the Dalmore and upper Gannochy Glacier. (2210 m)
(b) 20th July
(c) Heywood, Hollins, Morrison and Pratt
(d) F
(e) 6½ hours from camp on Dalmore Glacier
(f) Climbed from Courier Passet via north-east ridge

4. (a) Rock peak (2209 m) immediately south-west of the col, used by the expedition, between the Baardson and Mars Glaciers.
(b) 22nd July
(c) Heywood, Hollins, Morrison and Pratt
(d) P.D. (from the Baardson Glacier)
(e) 5½ hours from the col
(f) Route by east ridge to the summit mainly easy rock with some Diff. pitches. Climb to the col involved negotiating seracs and crevasses.

5. (a) Peak (1800 m) situated west of Derry (1480 m), the conspicuous ice capped peak north-east of the Bjørnbo snout.
(b) 25th July
(c) Morrison and Pratt
(d) P.D.


2390
2622
WEDGE
DUDHOPE
CLAVERHOUSE
2560
DALMORE
2040
GANNOCHY
LANG
BONAR BJERG
IVAAR
MARS
2209
BAARASON
BJORNBO
1800
DERRY
MERCURY
LEO
1860
1700
BOULDER BJERG
TAURO BJERG
N
Peak climbed in 1968
Peak climbed in 1970
0
16
Kms.
JF

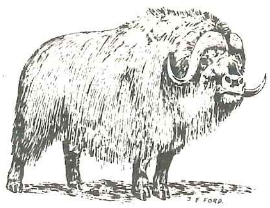
(e) 12 hours from Bjørnbo Camp
(f) Route–south ridge direct to summit. Then traversed along the connecting ridge to summit of Derry. Scrambling, difficult climbing and grade 1 snow pitches.

6. (a) Rock peak immediately south-west of Bjørnbo Camp (1880 m)
(b) 26th July
(c) Heywood and Hollins
(d) P.D.
(e) 7 hours
(f) East ridge, scrambling and diff. pitches.

7. (a) Boulderbjerg (2230 m)
(b) 14th August
(c) Lawrence, Peden and Walker
(d) A.D.
(e) 21 hours from Mercury camp
(f) Ascent by east ridge involved severe rock pitches. Descent by way of ice couloir on south face (grade II).

8. (a) Peak at right hand side of the Leo Glacier near its junction with the Bjørnbo. (1700 m)
(b) 16th August
(c) Heywood and Hollins
(d) F
(e) 10 hours
(f) Route by way of a couloir and steep snow field (grade 1) to the north ridge. Scramble to the summit.

9. (a) Taurobjerg (1860 m) situated at the head of the Leo Glacier
(b) 17th August
(c) Lawrence, Morrison, Pratt and Peden
(d) P.D.
(e) 14 hours
(f) Grade II snow couloir to the east ridge. V. Diff. climbing to the summit.



GURREHOLM BOAT PARTY

I. H. M. SMART

J. D. CANNON

P. F. BROWN

REPORT OF THE GURREHOLM BOAT PARTY

I. H. M. Smart, J. D. Cannon and P. F. Brown

Brown and Cannon left Mestersvig by helicopter on July 11th with 200 kg. of food for the Ivaar Baardson Glacier Party. The supplies were dropped off at the glacier snout where Heywood and his merry men were waiting–tired and not a little envious of the two who, in 20 minutes, had followed the arduous route that had taken them 3 days on foot. Remarks were exchanged by the two parties drawing each other's attention to the relative comfort of the two methods of travel. The atmosphere also sparkled a little because less food than expected had been brought. The alleged payload of the helicopter was found to be more than the pilot was prepared to carry. Fortunately Cannon and Brown were quickly whisked across the Schuchert River and dropped on its east side. They then started marching south to Gurreholm.

The helicopter then returned to Mestersvig, picked up Smart and 300 kg. of food and equipment. The latter was dropped at an agreed place on the snout of the Bjørnbo Glacier, the next glacier south of the Baardson. Smart was then taken to the east side of the Schuchert where in an hour or so he was joined by the southward-marching Brown and Cannon. The united party then proceeded southwards in deteriorating weather. The party was tentless and the 24 hour walk to Gurreholm turned into an uncomfortable endurance march through steady rain and dense clouds of midges.

THE JOURNEY TO THE BEAR ISLANDS

John D. Cannon

By early morning of Monday, 13th July, 1970, the three members of the boat party–Dr. Iain Smart, Peter Finlay-Brown and myself–had reached Gurreholm in various states of demoralisation. The weather had been very wet and miserable and mosquitoes extremely annoying during the 50-mile walk which we had made, with very little rest, down Schuchert Dal from our helicopter disembarkation point.

So, after 12 hours' sleep in our tent at Gurreholm, we loaded our supplies and equipment aboard the "Scottodan" and set off for Syd Kap. The "Scottodan" is a fine 16-foot clinker-built dinghy which had been left at Gurreholm after a previous expedition in 1969 and, fitted with a small outboard motor of 5½ h.p., she was to prove her worth on many occasions in Scoresby Sund.

Apart from grounding a couple of times near Gurreholm (for the sea is shallow at this point due to mud deposited at the debouchment of the Schuchert), our 2-hour passage across the 12 miles or so th Syd Kap was easy as we wound our way between huge icebergs, quite unrestricted by any pack-ice.

July 14th was a day of rest and recuperation. The weather was calm and very sunny and our exercise was limited to exploring the two huts at Syd Kap, netting salmon and cooking them, and admiring the scenery. To the south and east the sea was glassy and blue, studded with great white masses of ice taking on the most bizarre shapes and standing out in marked contrast to the blue hills of the Bjorne Øer, or Bear Islands, which lie directly south of Syd Kap, about 18 miles distant. These were the islands which we intended to visit next day.

We arose much refreshed about noon on Wednesday, 15th July and breakfasted well on boiled salmon. The afternoon was spent preparing food-boxes and packing our tent and sufficient petrol for the 4 days which we intended to spend in the Bjorne Øer. When, by about 19.00 hours, we were quite ready, we set sail south from Syd Kap for the largest and most northerly of the Bjorne Øer–an island measuring about 5 miles in its east–west dimension and about 3 miles from north to south. The sun was hidden by cloud and, though the sea was calm and smooth, the coldness of the air and a slight breeze contrived to chill us to the marrow.

As we neared this island, pack-ice began to provide us with a considerable problem. At first it was possible to find "leads" of clear water through the ice, but eventually, as we approached the east side of the island after 2½ hours at sea, we were forced on more than one occasion to climb from the boat on to the restricting ice-floes and force them apart by the use of our oars in order to continue our progress.

Once we rounded the eastern extremity of the island, the ice proved less troublesome, and we soon found a small bay with a gravelly shore up which the Scottodan could easily be dragged and secured for the night. A small level patch of tundra beside a small stream provided a perfect campsite and we felt much better after a meal of curry stew. A short walk up the rocks above our camp gave us a wonderful view of the surrounding country: to the south lay the rest of the Bjorne Øer, some almost as large as the one on which we stood, others mere rocks jutting out of a sea congested with pack-ice; to the southeast huge icebergs littered the sea as far as the orange mountains on the south side of Scoresby Sund, lit up by the evening sun and perhaps 60 miles distant; but most impressive of all was the sight to the west where the fantastic spires of the mountains of Renland were silhouetted in black against the bright sky, their reflections reproduced perfectly in the calm water of a large bay.

On our return to the camp, Smart pointed out, at a distance of about 50 yards from our tent, the ill-defined ruins of 2 eskimo houses; from the arrangement of the rocks lying about they appeared to have been rough stone-built dwellings somewhat igloo-shaped. Near these ruins was a pile of stones, probably a meat-safe, where freshly-killed seals or bear would have been stored before eating, and, farther up the hill, a human grave was to be seen, a similar pile of stones in which we found part of a human parietal bone. It was about 150 years since the last Eskimos were sighted in these parts.

The following morning, we arose and set off in the Scottodan to sail south and deeper into the Bjorne Øer. After a short while, relatively unimpeded by ice, we reached a small island, possibly 200 by 400 yards, which appeared to be a tern colony. On this island, Smart spent some time making accurate measurements of eggs of the Arctic tern for research purposes; these birds appeared to build their nests in the rocks and gravel of the exposed tops of such islands, while the eider ducks, which were also very common in this area, tended to opt for the steeper sides of the islands where they and their large blue eggs might gain some shelter amongst the dwarf birch and willow which grew thickest there.

Gradually the weather became colder and more cloudy, and by the time we had explored several of the channels of the island group and found a suitable gravelly inlet by which to spend the night, a heavy drizzle had developed and made the only suitable piece of tundra for a campsite rather boggy.

On Friday, 17th July, it rained all day without a break. We awoke to the patter of rain on the sagging tent above us, and as we peered out the sky looked uniformly dull and full of rain. The sea had lost its reflections to the splashing of the rain and the rocks and tundra about us were dark and lifeless. But the atmosphere in the tent had become so clammy and uncomfortable that we decided to explore the area on foot and retain the same campsite for the following night.

I donned a pair of rubber boots, one of which had collected a considerable amount of rainwater during the night, and, suitably attired, I wandered up the hillside behind our camp. The rain soon soaked through my hair and trickled down my neck, but the walk was surprisingly pleasant; the view across the other islands was still most impressive on this dull day. On my way I collected a few botanical specimens for the expedition, and as I passed behind a large rock, I came upon a small eider duckling which was madly struggling over slippery stones, as though not in full control of his big feet, in an effort to get away from me. Falling behind a clump of tundra, most of his body still exposed to my view, he stopped, obviously content that he had successfully hidden himself from his dangerous intruder.

I returned to the camp and we sat in the tent for a time contemplating the continuing rain. Just before we bedded down, we saw a little patch of brightness in the sky to the southwest.

Next day we rose early to find that the rain had abated and the sun was shining through a much clearer sky. After breakfast, we launched the Scottodan, baled out most of the rainwater, packed our gear and set sail again. Going deeper amongst the islands, we spotted a flock of eider ducks and steered towards them. Peter loaded our shotgun and took aim at a drake; one shot brought him down and another finished him off; he would make a good supper.

The brilliant watery sun which typically follows clearing rain flashed and sparkled on the sea

The Bjorne Oer or Bear Islands from North East.

and ice about us as we passed between some small islands. One such island, which proved to be a tern colony and provided eggs for measurement, was also a site for the most fantastic echoes. The calling voice was repeated four times from the great rocks and fjords about, a phenomenon made even more wonderful by the fact that the fourth, and last, echo was louder than the rest.

Though now quite sunny and calm, the weather still felt quite cold in the boat, but as this was to be our last full day in the Bjorne Øer, we decided to make the most of it. We sailed on into the evening, the low sun glinting in the foam of our wake, and when we eventually reached a suitable campsite, it was on the largest of the islands, at a point not far west of Wednesday's site. I skinned and gutted the duck and Iain stewed it in some rice as the Greenlanders do. "Muma-gayo," we pronounced in union in Greenlander fashion, for the meat was delicious. We retired well fed.

On Sunday, 19th July, we awoke at 10.00 hours on a fine but mosquito-troubled morning. We breakfasted and then set sail for Syd Kap by 11.00 hours. The ice appeared too solid around the east side of the island and so we deemed it prudent to extend our journey round the west side in order to avoid trouble. Rounding the western extremity of the island, we passed within a few miles of the ragged high peaks of Renland, then turned due north towards Syd Kap. We stopped at a couple of small islands where a good number of tern eggs were measured, and we reached Syd Kap by 15.10 hours. It was good to be back "home", though the Bear Islands had given us our first taste of exploration in the Scottodan, a taste which we hoped to satisfy later to the full in Nordvest Fjord.

THE JOURNEY INTO NORDVEST FJORD

P. F. Brown

Nordvest Fjord, the deepest ramification of Scoresby Sund, is still relatively unexplored. It is an impressive winding stretch of water about 2 kms across on average, and flanked by a couple of thousand metres of steep rock on each side, broken every now and then by steep-sided valleys. The fjord has a large population of icebergs derived from the glaciers of the inland ice which discharge into the remote inner branches and on this account has an evil reputation as the calving glaciers can set up tidal waves which sweep down the fjord.

Our object, apart from general exploration, was to search for specimens of reindeer skulls and antlers. Cranial material of the recently extinct East Greenland reindeer is relatively scarce. The broader valleys on the north side of the fjord seemed to offer a good chance of providing some specimens. Collection of flowers and insects was also to be attempted whenever the opportunity presented and the Danish Arktisk Institut had requested colour slides of the areas explored.

The boat party was now reduced to John D. Cannon and myself—Iain Smart, aware of the fjord's reputation, had walked back to Mestersvig having convinced us of his great need to measure birds eggs around the Kong Oscar's Fjord region. It had been agreed that John and I should set up a food dump for the mountaineering party who were proposing to traverse across from Nordvest fjord to the Bjørnbo glacier. Thus on the 26th of July, the heavily laden "Scottodan" putted away from Syd Kap. The mountaineering advance party, comprising Bob Heywood and Phil Hollins were to accompany us as far as the selected site of the food dump.

Keeping close to the shore we entered the mouth of the fjord and made good, care-free progress for the first hour or so. This was soon slowed as we began to encounter rows of impressively big icebergs strung across the now narrowing neck of the fjord. Already the dis-wuieting lack of any suitable landing points was apparent, caused mainly by the rapidity with which the very narrow shore arises to become very steep mountain-side. The decision to press on past a suitable site was always a difficult one, the thought that the weather might worsen at any time, tempering any desire to be committed to a long journey across a large expanse of water.

Another two hours putting in fairly open water put us at the site for the food dump. The small bay selected lies on the north side of the fjord just opposite Storm Point, an aptly named promentary, about 25 km up the southern side of the fjord. A sizeable melt water river ran into the bay carving a path amongst tons of rubble which formed the shore. Beaching the boat would have been possible but was not attempted as John and I wished to take advantage of the calm water and push on. There were, however, a few suitable camp sites on a stretch of tundra, one hundred or so yards back from the shoreline with an adequate water supply. Bob and Phil said their tearful goodbyes to the "vulgar boatmen" and it was with a certain amount of trepidation that we left the shelter of the bay, cries of "bold bulgars" wringing in our ears.

An uneventful 1½ hours had us approaching the next bay along the coast. This was to be our first camp site. Our initial impression of the surrounding region was one of total desolation, a complete wilderness. For the first time we realised the extent of our dependence on the "Scottodan" since the possibility of leaving Nordvest fjord by any other route was now becoming less and less feasible.

Glacial moraine covered the valley floor leading into this bay, the only flat ground being afforded by a sandy shore ringing the bay. The moraine extended a considerable distance up the sides of the valley, only a small strip of vegetation being left on each side. Flowers and grasses were collected from these fertile areas. The glacier that not so long ago resided in this valley now lurks several kilometres inland waiting for a kindly cold spell to revive it. An attempt was made to reach the top of the valley to inspect the sleeping giant was frustrated by the necessarily slow progress along the valley floor and worsening weather conditions. Any hope of discovering undisturbed reindeer remains was fast feceeding as the nature of the terrain made covering any large area nearly impossible, even supposing that reindeer had once inhabited such a barren region.

Mid-morning of 28th of July we broke camp and headed for Nord Bugt, 15–20 kms deeper into the fjord. Two hours later we approached a small unnamed island and took advantage of a natural harbour located on the east side of the island. Thoughts of being the first men to set foot on the island flashed through our minds as we ceremoniously secured the anchor. The island is perhaps 2 kms long by about 1 km wide. A climb of 150 m or so took us to the top which was an excellent vantage point enabling us to see clearly the entrance to Nord Bugt, a major bay on the north side of the main fjord. The water west of the island seemed rougher compared with the calm water conditions we had encountered so far. Nord Bugt appeared within easy reach and we regretfully left this little island, having first collected as many botanical specimens as possible. As soon as we rounded the island our confidence rapidly dissipated as the boat began to roll and pitch ominously in response to the apparently moderate swell running. For the first time on the trip the sturdy 5½ h.p. motor of the Scottodan had to be shut back. When waves began to break over the bows we decided that it would be wiser to return to the safety of the island and wait for more favourable conditions. We beached the boat this time on the west side of the island and ascertained that there was sufficient water should we have to stay for any length of time. Come late afternoon, the prospects brightened as the fjord returned to its previously peaceful state, but we were now fully aware of how quickly conditions in Nordvest fjord could change.

Seeking the false security of the shore we again edged towards Nord Bugt, again noting the lack of suitable landing places. The skies were darkening as we tentatively started to thread our way through the many massive icebergs blocking much of the bay. The frequency with which these icebergs shed large chunks of themselves was evidenced by the many pieces of shattered ice floating around their parent berg. We fould an adequate camp site on the flood plain at the head of Nord Bugt the land being such that we could just pull the boat a safe distance up the shore. This rather onerous task had been performed daily throughout the expedition apparently serving no other purpose but the removal of useful paint from the bottom of the boat and useful skin from the palms of our hands. However, as Iain Smart had often emphasised, MacPherson's Law of Maximum Inconvenicne *is* inconvenient and we were later to be thankful that we had indeed been such dedicated paint removers.

The surrounding area was again extremely barren, piles of moraine looking remarkably like coal bings at the foot of the imposing mountains which completely walled us in–the only way of leaving Nord Bugt was the way we had come. The virtually unexplored flood plain which stretched endlessly back from the bay seemed the most promising place, so far encountered, for finding reindeer skulls and antlers. The plain proved to be more fertile than was at first apparent but only the occasional half antler pointed to any previous presence of the once ubiquitous reindeer. Flowers and grasses were routinely collected as were several specimens of fungi.

The   of August was such a fine day, sunbathing being possible due to the warm sun and surprising lack of mosquitoes, that John and I decided to relax and regain some of the well-being that is such a feature of any stay in Greenland. The temperature rose such that many of the icebergs in the bay began to melt at an almost visible rate. The melting process enhances the natural tendency of the bergs to split and the quiet of the bay was periodically shattered as yet another few thousand tons of ice plunged into the fjord. Our camp site had become ringed by several impressive examples of these ice mountains, all being well over 100 m high and it was with mild indifference that John and I watched a slightly larger than normal chunk break off one of the nearer icebergs. Nothing much seemed to happen at first but then we both had the impression that the iceberg was beginning to topple–and topple our way. As if hypnotised we watched as millions of tons of ice, with ever increasing speed, crashed towards us.

The impact as the whole berg turned over was deafening, but what really terrified us was the 5 m wall of churning water that was now coming our way. Luckily as well as pulling the boat about 10 m up the shore we also had the bow and stern ropes firmly moored to rocks. Even though, the force of the wave easily lifted the Scottodan and sent her crashing down onto the surrounding rocks. The wave stopped short of our tent and equipment and soon the only sign that anything unusual had happened was the many fragments of ice which littered our camp site, the shore, and the bay.

The question now arose as to whether we should cross to the south side of the fjord and approach Flyver Fjord. We decided that if the water was sufficiently calm when we left the shelter of Nord Bugt we would attempt to cross the 5–6 miles of open water and then edge up the far coast. Flyver Fjord is approaching the limits of small boating in Nordvest fjord because of the increasing proximity of the major glaciers of the area. The carving of these glaciers into the fjord can initiate the occasional tidal wave which increases enormously around Flyver Fjord because of the funnelling process of the narrowed fjord there. However the situation didn't arise because it was obvious as soon as we left Nord Bugt that the weather was again worsening and any attempt to cross the fjord then, would have been extremely foolhardy. We decided to gain the nearest dry land and wait out the approaching storm. Thus it was that John and I found ourselves seeking refuge on our now familiar island. Stormy weather kept us there for two long days. Fine weather again returned on the afternoon of the   when we set off for the comparative luxury of our island camp.

The homeward journey down the fjord was relatively uneventful, little or no navigational problems presenting and so it was with a sense of relief and achievement that the Scottodan and its two "vulgar boatmen" sailed into Syd Kap.

Prospects of Gurreholm Party

1. Measurement of tern egg size. The investigation into the geographical variation of egg size on the Arctic Tern described in the report of the 1968 expedition was continued. Measurements made in the Bear Islands and Kong Oscar's Fjord in 1970 were less convincing than those obtained in 1968.

2. Reindeer Skull Measurements. Skulls and antlers of the East Greenland reindeer are still to be found scattered over the tundra. Many have been taken by visitors as souvenirs. Only very incomplete skulls were found by us and no measurements could be made to help characterise their population.

3. A botanical collection was made for Dr. S. Halliday at various sites. The most remarkable find was Limosella aquatica, discovered in a pool on some small islets off Syd Kap. This has previously only been recorded from the southern part of the east coast. (Böches and Jakobsen's Greenland Flora).

4. An attempt to repeat Scoresby's achievement of starting a fire by focusing the sun's rays with a lens of clear ice fouled because the only time we discovered clear ice was during a period of cloudy weather.

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MESTERSVIG BIOLOGY PARTY

M. J. COTTON
R. SUMMERS
R. O'GRADY

MESTERSVIG BIOLOGICAL PARTY

M. J. Cotton, R. Summers, R. O'Grady

INTRODUCTION

While it is true to say that many biologists have collected specimens from N.E. Greenland and that there are published lists for most major groups of plants and animals, it is also a fact that there have been few ecological studies in this region. Such studies have the advantage of not only providing a representative collection of the species present in an area but of knowing in addition something of their inter-relations, their role in the particular habitat and the effects upon them of their physical environment. The principal objective of the 1970 expedition was to make an extensive study of a sand dune system in the high arctic regions. Coastal dune systems have been much neglected habitats for ecological studies on their fauna, although this is not true for dune plant life. However, any ecological study on community inter-relations must consider both types of organisms in addition to the physical environment and in this sense sand dunes are poorly studied ecosystems. It is important for any expedition to have several lines of investigation open to them and we had prepared for several secondary surveys:

a) The status of the Greenland Lemming in the coastal area around Mestersvig, involving a collection of skulls and skins for incorporation in the National Collection of the British Museum (Natural History).

b) Collection of ectoparasites from birds and mammals–the former by collection of disused nests and the latter by trapping and examination of corpses.

c) An ecological study of a small tarn or loch by weekly net samples throughout the arctic summer.

d) Ornithological studies–notably on the arctic tern and snow bunting.

e) General collection of invertebrates from arctic tundra and other habitats in the entire area visited by expedition members.

It is often the case that one has by necessity to resort to studying one of the secondary lines of investigation and certainly to omit most of the intended areas of study. We fully expected to see no lemmings, after having transported fifty traps and equipment to deal with those we hoped to catch! However, we were indeed fortunate in that every anticipated study proved possible. The dune system at Noret, only a short walk from Mestersvig, was ideal for our main ecological work; lemmings were abundant in the same area, as indeed were arctic hares and arctic fox; snow buntings, long-tailed skua, barnacle geese, long-tailed duck and other birds were all found nesting; and a small tarn was close to hand near Lemming Bay.

It is also important that the scientific members of an expedition have good conditions in which to work, preferably equipped as a laboratory. Under such conditions their productivity is increased many times. We had hoped to find a small hut to serve this purpose, but were impressed by the accommodation provided for us by the Danish staff at Mestersvig. It was suggested that we should base ourselves in the disused settlement at Nyhavn, a group of huts around the small harbour where the 'ice-breaker' makes its annual visit. The base was ideal, overlooking the shore of Kong Oscar's Fjord and the dunes at Noret, and close to our freshwater tarn. We had equipped ourselves with our own transport and on any day a lone figure could be seen cycling across the sandy tundra. Both the huts and bicycle added enormously to the success of the expedition. However, but for our sponsors we should not have been there in the first place and the biologists were particularly indebted to the Royal Society for the award of a Scientific Investigations Grant–in–aid of £250 to facilitate the study of an arctic dune system and the Trustees of the Godman Exploration Fund who agreed to a grant of £150 for the collection of insects for the British Museum (Natural History). In addition the University of Dundee made a personal grant of £125 to Dr. M. J. Cotton to enable him to accompany the expedition.

M. J. Cotton.

THE STATUS OF THE GREENLAND LEMMING IN THE MESTERSVIG AREA

M. J. Cotton

The terrestrial mammal fauna of Greenland is restricted to five species all of which are present in ScoresbyLand. Three are herbivores, grazing the arctic tundra, the musk ox, arctic hare and lemming and two are carnivores, the arctic fox and stoat, preying on the smaller herbivores and birds. Notes on these mammals were given in the report of the University of Dundee ScoresbyLand Expedition 1968. Specimens were collected in 1970 of the arctic hare (*Lepus arcticus*) and arctic fox (*Alopex lagopus*) and skulls and skins presented to the British Museum (Natural History). Arctic hares were common in the Mestersvig area being conspicuous by their white coat which remains during the summer. Several were examined for ectoparasites and fleas (*Euhoplopsyllus g. glacialis*) were common on several individuals. All fleas were of the one species and one hare carried a single flea larva, presumably of this species. This is of great interest since fleas breed in the nests of their host and the larvae always remain there feeding in a non-parasitic manner on general nest detritus and on the excess blood which passes through the adult flea. Only once have flea larvae been recorded from the body of a mammal–both flea and host being of the same species as the Mestersvig specimens.

The arctic fox is well known to be bold and invade camp sites taking food and anything else available. There is a den in the immediate vicinity of Mestersvig and at least twice the huts at Nyhavn were visited by foxes. Following baiting with cheese close to the huts both individuals were caught and skulls and skins obtained for the British Museum. No ectoparasites were found present.

The Greenland Lemming (*Dicrostonyx groenlandicus*) is a species distinct from the other Varying Lemmings (*Dicrostonyx sp.*) which inhabit the arctic tundras of N. America and Siberia. These are all distinct from the only other genus of lemmings (*Lemmus*) which occur in Scandinavia, Siberia and N. America. Varying Lemmings turn white in winter and hence their name. In winter the middle claws of the forefeet are modified by the growth of a thick horny shield which is gradually worn down by burrowing until the tip of each modified claw becomes bifid in appearance. The pad of each foot is covered densely with fur providing insulation against heat loss, as does the thick, soft fur forming the pelt. The ears are almost concealed under its fur, again protecting a surface which normally tends to lose heat readily. The Greenland Lemming in summer is mostly grey with a tinge of rust especially around ears, flanks and the ventral thoracic region. Many *Dicrostonyx* bear a black stripe along the length of the back which is apparently rarely seen in the Greenland species. However, those collected all show an indistinct dark line mid-dorsally. *D. groenlandicus* is smaller than its relatives, its teeth apparently weaker and the skull weaker and narrower. It is distributed mainly in northern Greenland and appears absent from west and south Greenland. It is mainly confined to coastal districts and was found in sand dune and sandy tundra. Their presence on dune soils is probably linked with a preference for dry spots as summer dwellings, since melting ice and snow will often produce water-logged conditions in the tundra. They are reported as often moving to dry spots higher up the slopes in summer. Lemming signs are invariably present in the form of old faeces and nests, dug-out holes and burrow systems and runways through the tundra vegetation. However, these signs persist for many years in the cold arctic conditions under snow and ice and may prove misleading to the lemming population density. The earlier report indicates that lemmings were not noticable in ScoresbyLand in 1958, 1960 or 1968, but that lemming predators (long-tailed skua, and snowy owl) were apparently more numerous in the latter year. During 1970 lemmings were frequently seen, there were many signs of recent activity and avian predators were certainly present. The long-tailed skua feeds exclusively on lemmings when available and they were commonly seen in the Noret dune region. A pair of ravens also inhabited this area and hunted across the dunes. They too are recorded lemming predators. Snowy owls were however unseen, as were stoats. It is however usual to find mammalian predators of lemmings reaching their highest density in the year following a lemming year, while avian predators tend to arrive at the time of a peak and vacate the area at the crash. The Varying Lemming does not appear to show the catostrophic crashes and "mass suicide" traditionally associated with the Norwegian Lemming and other *Lemmus* species (Marsden, 1954).

During July and August 1970 traps were set at several sites in the Mestersvig area. Although there were lemming signs at Nyhavn none were caught in classical tundra vegetation. All animals trapped came from Noret and Mestersvig or from the sandy tundra separating these localities.

Since only break-back traps were available skulls were occasionally damaged and ectoparasites were able to leave the cold host prior to its collection. Fleas were found on four lemmings and were all *Megabothris groenlandicus*. In the laboratory each lemming was weighed, measured, sexed and the reproductive condition noted, prior to skinning and removal of the skull. The 16 males showed a full range of reproductive conditions, the position of the testes being scrotal, pelvic or abdominal, while of the 12 females only one was definitely pregnant and lactating and two others showed possible early pregnancy. Greenland Lemmings are thought to breed once or twice in summer but captive pairs have shown high litter rates (one each month over a 6 month period). Manning (1954) found captive females could produce 13 litters in about 10 months, with an average interval of 25 days between litters, and a mean litter size of about 4. Normal gestation period is 19-21 days, females maturing at about one month from birth, though males take 46 days to reach sexual maturity. Longevity in the laboratory was on average 10 months, though individuals did reach 2-3 years. It is unusual for lemmings to live more than a year in the field.

Since the Greenland Lemming is a distinct species the series collected from Mestersvig represents an important collection providing information on the morphological features of a single population. The collection of *Dicrostonyx* in the British Nuseum is very limited and *D. groenlandicus* was represented by only a few individual skins or skulls from scattered localities. Much of the material being in poor condition. The present series has been examined and some of the data is presented in Table 1. Examination of the skulls showed that most individuals possessed on the upper cranial surface a distinct diamond shaped open suture between the parietals (parietal aperture). Complete fusion of skull bones is often delayed during development but in the Greenland Lemming the situation even persists in adults. The small number of skulls of *Dicrostonyx* present in the British Museum indicated that this may be a feature associated with *D.groenlandicus*, since of the six skulls of this species four had open sutures, but those of other *Dicrostonyx* all showed no such open suture. In the present collection 18 skulls were undamaged and 14 had a parietal aperture. The 4 with closed sutures were all females and the nine largest apertures were all males (fig. 1). Since females are known to mature earlier it appears that the parietal aperture is correlated with the age and state of maturity of the individual and its presence in the species may result from the short period of active growth associated with high-arctic animals. This is further supported by the apparent absence of the feature from related species which do not venture so far north.

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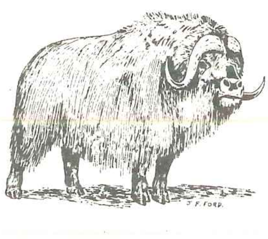


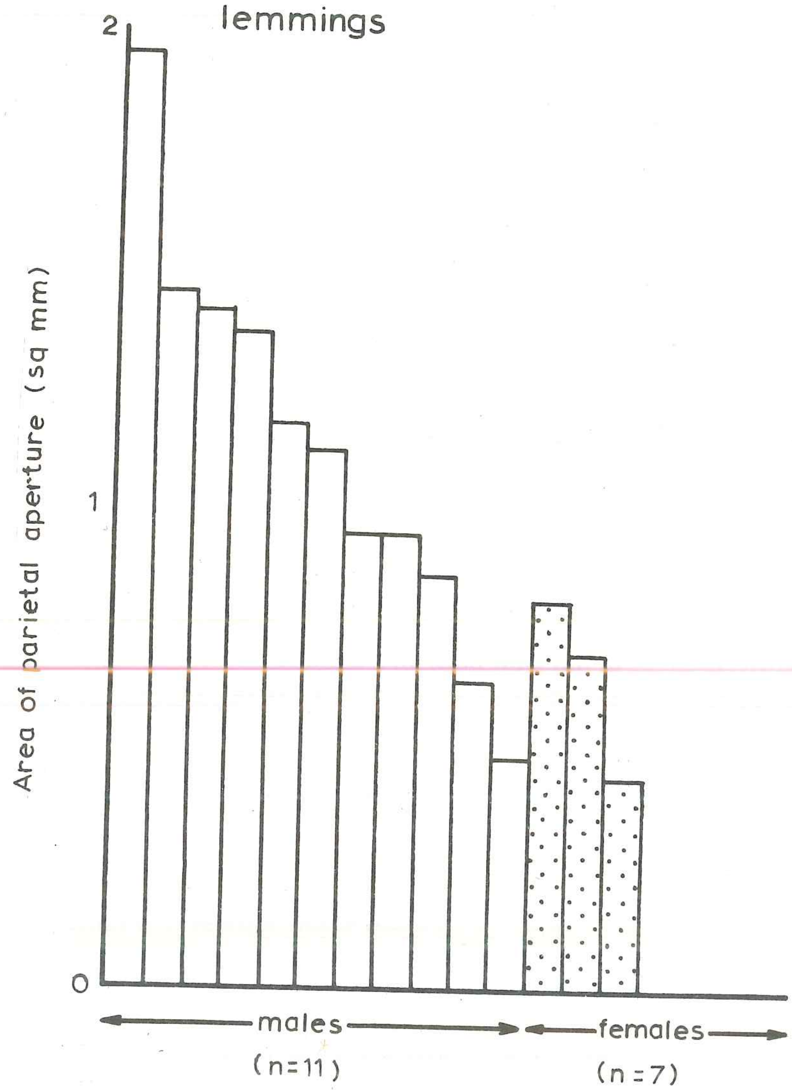
Table 1.

	males		females	
	mean	range	mean	range
Weight (gms.)	41	32-61.5	39	30-61
Length head and body (mm)[1]	119	105-140	120	101-157
Length tail (mm)	15.5	12-20	15.5	11-20
Length hind foot (mm)	14.3	13.2-15.5	14.7	13.3-16.8
Skull length (mm)[2]	2.8	2.6-3.0	2.8	2.6-3.0
Skull width (mm)	1.75	1.6-1.9	1.79	1.7-1.95

Notes:
1. All skin measurements refer to those made following card preparation
2. Skull length was taken as the condylo-basal length and width as the zygomatic width (after Southern, 1964)

Table 1. Measurements of the Greenland Lemming (*Dicrostonyx groenlandicus*) collected at Mestersvig, N. E. Greenland.

Fig 1 Variation in area of parietal aperture of male and female lemmings



ECOLOGICAL STUDIES ON AN ARCTIC SAND DUNE SYSTEM

M. J. Cotton

INTRODUCTION

Coastal dune systems require for their formation a good supply of mobile sand, the wind to move it and pioneer plant species to stabilise it once it has accumulated about an obstacle. Consequently in Britain dunes tent to establish around the coastal margins of river estuaries, forming systems parallel to the coastline. In Greenland, where mountains meet the sea, and there is little shore development it is not possible to find parallel dune systems and any sand accumulations are confined to the heads of fjords, such as the Hurry Fjord, or to coastal inlets and basins, such as Noret. Beach material is derived from sediments deposited by large river systems, often in a deltaic formation and the sand after wind-blow is able to accumulate at the foot of rock outcrops. Vegetation begins to colonise this mobile sand until it becomes stabilised by creeping root systems and allows for the establishment of other plant species. Ultimately the raw sand evolves into a soil, poor in mineral nutrients, especially nitrates and phosphates, but with the gradually decomposing dead plant remains. Competition for nutrients between plant species leads eventually to the pioneer species being excluded from the community until ultimately the system attains a balance with its climatic environment and the most stable community within the prevailing conditions is the climatic climax. Thus, the dune system is typified by a succession of different plant types, from its early pioneers to its later climax species. In temperate conditions the climax vegetation may be woodland or at least dune shrub, with birch, willow, alder, privet and other species. But in the arctic the climate intervenes in climax development and permits only the establishment of a prostrate tundra vegetation (sand tundra). One of the best and earliest accounts of dune conditions and vegetation in East Greenland is the study of Hartz and Kruuse (1911). They visited by ship a variety of localities in the Scoresbysund area and gave detailed descriptions of the plant communities. The most extensive systems were those at the head of the Hurry Fjord (Jameson Land of Fame Islands and Ryders Elv, Klitdalen) where deep sand deposits formed 'coffin-shaped' sand hills characterised by arctic willow (*Salix arctica*), *Dryas octopetala* and arctic willow herb (*Epilobium latifolium*). The sand hills ran in an E.-W. direction. Smaller dune systems are present further north at the entrance to Orsted Dal (Fleming Fjord).

The principal objectives of the present survey involved collection of the Arthropod fauna (insects, spiders) through the short arctic summer in relation to seasonal activity and vegetational succession. Since activity of 'cold-blooded' animals is very much influenced by temperature a study of the microclimatic conditions in various positions within vegetation stands and in bare sand was necessary. In 1970 the summer was late in its arrival and when the dunes at Noret were first visited (July 7th) there was still snow in deep drifts in shaded positions. The local Danes said that the snow on Noret had melted about three weeks earlier (i.e. last weeks of June) and that it was likely to return by late August or early September. Night frosts would be certain by mid-August. This gives an activity period for Arthropods of from 6-9 weeks during which time sampling was made for six weeks (July 7th–August 18th). During the first week Noret was covered with ice and since the prevailing summer wind was from the S.E. across the water air temperatures were low. The ice cleared by July 13th after which the dunes were warmer. It is likely therefore that our sampling period covered the major period of Arthropod activity although it would be of interest to observe the end of the season and see which species were capable of survival and activity during the onset of winter.

Samples were taken by a grid of 80 pitfall traps (white plastic cartons) placed in 5 parallel lines running approximately N.–S. from Noret towards Nyhavn. The distance between each line was 10 metres and there were 5m. between traps in each line. Each line thus represented approximately 100m. through various stages of dune succession. Because of the topography of the system, especially on the sand-covered rock outcrop, it was not possible to place the same number of traps in each line but this was insignificant in that all traps were collected according to vegetation-type rather than topographic position. Within the grid five vegetation types were recognised (Fig. 1):

Type 1.	Wet sand flats–South facing (Noret)	10 traps
Type 2.	Dune hummocks lying in N.–S. direction	23 traps
Type 3.	Dune slopes–mobile–on lower rock slopes	15 traps

Type 4. Rock plateau–open sandy upper slopes ... ... 20 traps
Type 5. Dry sand flats–North facing (Nyhavn) ... ... 12 traps

An additional 20 traps were sited in stable dune tundra vegetation slightly west of the main grid (type 6).

TOPOGRAPHY AND VEGETATION

Noret is an inlet on the southern shores of Kong Oscars Fjord with the exit to the fjord guarded by a narrow neck. It receives the drainage waters from Tunnelelv which have to traverse a wide region of flat tundra (about 5km.) before releasing their sedimentary materials into Noret. Because of the sheltering effects of the neck of Noret and the low rate of flow of the river these sediments form a beach on the northern shores. Prior to the construction of the runway at Mestersvig the main drainage channels were in a N.W. direction towards Nyhavn, where the river gave rise to a wide delta before entering the fjord directly. However, the river has now been entirely re-routed and the old delta is now a dry sand flat between Nyhavn and Noret (about 3km.) characterised by sand tundra plants. A road has also been constructed across the old delta from Mestersvig to Nyhavn. Thus, there is a supply of sand both to the south and north of the dune system at the head of Noret (fig. 1). Hartz and Kruuse were of the opinion that sand-drift must take place during the summer as the sand at other times will be frozen and covered by snow. Evidence for this they found by examination of the erosion of the young shoots of the arctic willow binding the sand. The direction of the dune hummocks at Noret indicates formation by winds from the south-east and this is further supported by the accumulation of sand at the foot of the rock outcrop. However, on the northern side of the outcrop there is also a smaller sand accumulation, although hummocks are not present. It is probable that this sand is derived by north-westerly winds blowing across the now dry old river delta. Certainly during the 1970 summer, winds of gale force blew from this direction bringing cold wet conditions and moving sand in their wake, but the prevailing winds were indeed from the south. To the north-west of Noret is a second dune system (fig. 1;A) nestling at the foot of the Labben hills. Hummocks are very well developed and face N.W.–S.E. providing further evidence of sand movement from the old delta region. If this is indeed the situation then one might expect this to be a relatively young dune system.

The early stages of colonisation by plant species can be seen in type 1, the wet sand flats bordering the beach at Noret. Large expanses of bare sand are still evident and the area is scarcely above the water level. The surface is consequently wet and cold with a pale grey cover provided by the granular lichen *Stereocaulon (cfv. alpinum)*. The creeping roots of arctic willow (*Salix arctica*) bind the surface and deep pink climps of *Saxifraga oppositifolia* and moss campion (*Silene acaulis*) provide colour in a rather desolate wind-swept habitat. Other plants include two types of whitlow-grass (*Cruciferae*), *Draba alpina* (yellow) and *D.arctica* (white); mountain sorrel (*Oxyria digyna*); and a sedge, *Carex nardina*. As conditions become dryer the topography changes (type 2) in the appearance of sand hummocks, with valleys between adjacent hummocks (the 'coffins' of Hartz and Kruuse). They vary in size, some are several metres long and form a ridge about one metre high. They are formed entirely by the colonisation of *Salix*, together with avens (*Dryas octopetala*) forming a pale yellow creeping mat. Hummocks may be formed entirely by one species or by both. The bare sand shows the grey *Stereocaulon* and another lichen present is the yellow calciphil *Fulgeusia bracteata* (probably var. *alpina*). A frequent colonist of hummocks is the willow-herb (*Epilobium*) and *Silene, Oxyria, Draba* and *Carex* are all present. Additional stabilisation is provided by the shrub-like black bearberry (*Arctous alpina*), rich in berries turning from red to black. Bearberry however reaches its peak later in the succession. The deep sandy slopes leading up to the rock outcrops are very unstable (type 3) and have large erosion cracks produced by drainage from the rock plateau. The area is probably the most unstable of the entire succession but is rich in variety of plant life. Nothing dominates however and most species appear to be 'casuals'. All those found in type 1 are present here but in addition there is *Dryas, Epilobium,* arctic poppy (*Papaver radicatum*), hairy sandwort (*Arenaria ciliata*), arctic chickweed (*Cerastium arcticum*), a bistort (*Polygonum viviparum*) and another saxifrage (*S.nathorstii*). *Salix* manages to bind the sand in part but bearberry is absent. The rock outcrops, part of the chain of Labben hills, have sand deposited between crags on the top (type 4), although much of the terrain is bare rock. Stabilisation is mainly by lichens especially the grey species but variety increases. There is no moss and little *Salix*. The main flowering plants are *Dryas* and *Arctous*, although the rough 'grey' sedge (*C. nardina*) and a grass (*Poa pratensis*) are also important in binding sand. Colour is given by moss campion and saxifrage (*S. oppositifolia*). The northern slopes of the outcrop gradually fall to sealevel and dry sand flats (type 5). There are no hummocks and the topography resembles type 1. The vegetation is mainly *Silene, Salix, Dryas* and *S. oppositifolia*. Mosses are spasmodic in occurrence, as they are throughout the succession and are currently being examined by Dr. Halliday (Lancaster University). Once away from the effects of moving sand the area develops into a flat landscape resembling typical arctic tundra but built upon a soil of almost pure sand (dune tundra–type 6). Most of the species present in the former types are now absent although *Silene* and *Salix* are common, as are many lichens.

The presence of the lichen *Fulgeusia* indicates calcareous conditions and therefore an alkaline pH. Measurements taken from a number of sites showed a pH from 7.2–7.8, the highest result being from the Noret beach. There was a fall in pH with soil depth and on the dune ridges the pH fell from 7.7 (surface) to 7.2 (15cm. depth).

MICROCLIMATE

It is of obvious significance that temperature and humidity conditions differ greatly between those prevailing in the air (ambient) and those within particular niches. Thus, the temperature in a bird nest (Snow Bunting) under a brood of chicks may reach 30°C. while the air outside shows a mere 17°C. and this high temperature may last over most of the 24 hours of any day while the night air temperature falls to 1°C. only a metre from the nest (see Summers, present report). This higher temperature is of great importance to chick survival and also to the fleas (*Ceratophyllus v. vagabundus*) which breed in the nest. Similarly, temperatures within vegetation tussocks and clumps, between root systems, under leaves or above and below the ground surface all differ between themselves and ambient. Thus, on a dune hummock within bearberry at 1500 hours on a July day the air temperature at 30cm. height was 12°C., on the ground surface 22°C. and at 15cm. in the sand 17°C. A difference of 10°C. for a ground dwelling Arthropod very much increases its activity and rate of development.

Continuous temperature records were taken over the entire study period by means of a Grant Recorder and thermistors. Each thermistor was set in a given position and its temperature charted every hour over a 24 hour period. A number of recording sites were selected corresponding to the vegetation types.

Relative humidity varies inversely with temperature but is also of great importance to activity, development and rate of growth (especially plants). In field conditions it is not possible to record relative humidity on a continuous basis. The method used involved placing small strips of cobalt thiocyanate paper in each microhabitat and after four hours exposure placing it in liquid paraffin. The paper is pink when wet (i.e. high humidity) and blue when dry (i.e. low humidity) and a range of intermediate colours can be distinguished against reference colour discs. The method is more reliable above 60% R.H. when about 5% accuracy can be obtained. Since one seldom obtains very low humidities in the field, and not in vegetation stands, this is a reasonable method. The results given in table 1 show relative humidity readings for a day in July from six sites each having a position at ground level (G) and one 15cm. above the ground (A). Temperature recordings were also made at three of these sites and the relation between temperature and humidity can be seen in table 2.

Thus it can be seen (table 1) that ground conditions are usually the more humid by night but are less humid than air by mid-day, when the sand surface heats up and temperatures of >20°C. may result. The exception is the wet sand flats (type 1) where usually the ground humidity, as expected, is higher. The lowest humidity (40%) was recorded on the higher parts of the dunes (i.e. the slopes, type 3 and the hummocks, type 2).

The complete analysis of the temperature recordings will require use of a computer but some preliminary results are given in figs. 2, 3 and 4.

The difference in temperature between microhabitats is illustrated by comparison of the mean daily temperatures over 5 days from July 9th–13th. Ground temperatures for the hummocks (type 2) and the dune slopes colonised by bearberry (type 4) showed means of 7.9°C. and 7.4°C. respectively. The same sites had mean temperatures of 10.1°C. and 9.7°C. at 15cm. depth.

However, the comparable temperatures from the low-lying sand tundra (type 6) were 4.9°C. (surface) and 5.6°C. (15cm. depth). Mean temperatures however obscure the important diurnal pattern which can best be seen by the extensive series of temperatures recorded in the *Salix-Dryas* hummock (type 2) from July 9th–25th (fig. 2) and the fluctuations in a bearberry hummock from July 19th–25th (fig. 3). Both figures show ground surface temperatures contrasted against temperatures at 15cm. depth. In addition ambient conditions at 30cm. above the sand surface were taken from the bearberry hummock. The air is of a consistently lower temperature, about 10°C. in mid-afternoon and the rise in temperature of the sand surface at mid-day above that of the deeper sand layers is seen in fig. 3. The thermal capacity of sand in these conditions is demonstrated in fig. 2 where for most of the day the higher temperatures occur within the sand. This is somewhat unusual since the more normal pattern shows the lower strata holding their heat by night but the sand surface rising above the lower layers during the heat of the day (fig. 3). Further analysis will clearly indicate the more subtle temperature differences between micro-habitats, although it is clear that conditions are much more severe in the mobile sand tundra south of the hummocks and adjacent to the wet sand flats (fig. 4). Here the cooling effects of winds across Noret are most felt and the atmosphere is often highly humid giving a "haar effect". Temperatures are seldom above 10°C. on the sand surface and for most of the day it is considerably warmer in the lower sand layers.

FAUNA

The Dundee University ScoresbyLand Report (1968) gives a brief introduction to the Arctic environment and in particular discusses the trophodynamic aspects of animal and plant inter-relationships. A model energy pyramid is given for both summer and winter conditions but most attention, as might be expected, is given to the role of birds and mammals within the ecosystem. Terrestrial invertebrates, principally Arthropods, are grouped within a single level above the vegetation. They too however can be arranged into their own energy pyramid since many, like the Collembola are scavengers feeding on dead plant remains and occasionally on fungi, others such as caterpillars, adult Lepidoptera and aphids, may feed on the living plant, and many prey upon these lower strata and upon themselves (spiders, ichneumonid wasps, predatory flies).

Previous studies have concentrated on collecting particular groups of animals, rather than on relating the fauna with the nature and complexity of an arctic community. Since most samples were taken by pitfall traps they favour the capture of active predatory species (e.g. spiders) rather than groups such as springtails, mites and insect larvae. However, hand collections were made and the samples are thought representative of dune invertebrates present through the summer. Since the collection is with the staff of the British Museum (Natural History) and there are numerous problems in the taxonomy and identification of some of the groups present a complete species list is not possible at this stage but preliminary observations are given.

The main groups present in the dunes were springtails (Collembola), flies (Diptera), mites (Acarina), spiders (Araneida) and parasitic groups of Hymenoptera (Ichneumonids, Braconids, Proctotrupoids, Chalcids). On the sand flats (type 1) an interesting small beetle (Staphylinidae; Aleocharinae) was common in the early season becoming less frequent in August. It never occurred in the central dunes (types 3 and 4) and specimens in other parts of the dunes probably were derived from the mudflats. Larvae, probably of this species, were found in late July in types 1 and 2. This species, only about 3mm. long, was the only terrestrial beetle found in any habitat throughout much of ScoresbyLand. Another prominent group of the sand flats were the spring-tails, although numerous individuals were collected from the rest of the dunes. Six species have been identified viz:– *Onychiurus sibiricus, Hypogastrura denticulata, H. viatica, Folsomia fimetaria, Archisotoma besselsi,* and *Pseudisotoma sensibilis*. Mites were more common on the sand flats than elsewhere, seldom found in the central dunes or the dry flats (type 5). They were however common in the sand tundra (type 6).

Insects are adapted to feed on a wide variety of plant diets and have mouth parts modified accordingly. Many suck plant juices (aphids) or have a long probing proboscis to reach the flower nectaries (bees, butterflies and moths). Aphids live close to their plant host and are often specific in their food plants. Three species were recorded–the most common being *Myzus* (*? polaris*), most often found in type 6 but also in types 2 and 3, *Acyrthosiphon auctus* most frequent in type 2 and in the same habitat *Thuleaphis acuadata*. The only other Hemiptera found was a Mirid bug (*Cheamydatus pulicarius f. pseudopulla*) in the flower of *Dryas* although not from the Noret dune system. Bumble bees (*Bombus arcticus*) were common, moving between the dune flowers alongside the yellow butterflies (*Colias hecla*) and fritillaries (*Clossiana chariclea* and *C. polaris*), while the caterpillars of butterflies and moths chew at the leaves of many plants.

There is no doubt that once all groups are identified the collection will provide an insight into the diversity and pattern of invertebrate life in an arctic sand dune system.

ACKNOWLEDGMENTS

The project would not have been possible but for the assistance of R. O'Grady who gave his help throughout and ran the entire study during August. Identification of plants was by Dr. G. Halliday (University of Lancaster) and lichens by Miss P. Topham, who collected lichens in the Mestersvig area during the 1968 expedition (see Report, 1968). The staff of the British Museum (Natural History) who identified insects and other groups are acknowledged separately.

Fig. 1

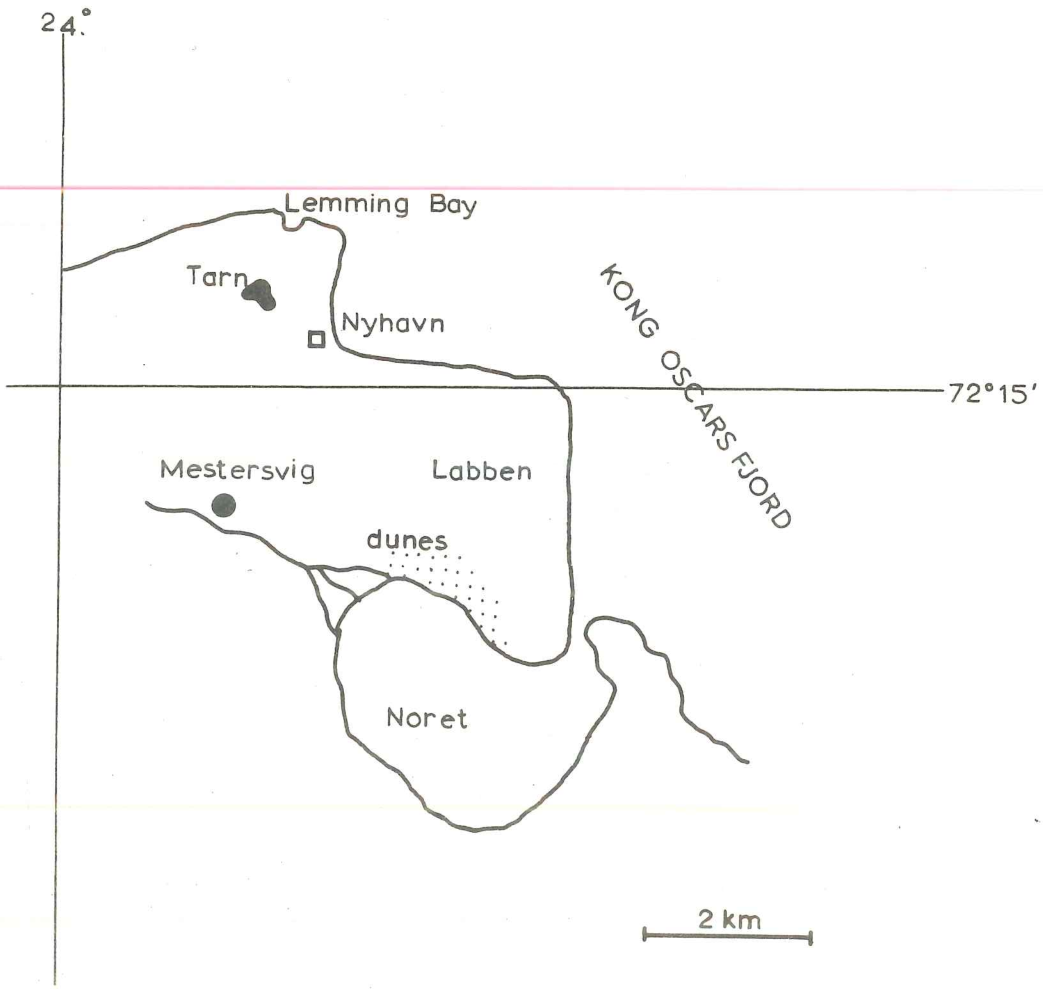


Table 1. **Fluctuations in relative humidity (%) recorded from an arctic dune system**

		2300	0300	0700	1100	1500	1900
Sand flats– type 1	A	78	95	82	78	65	74
	G	87	97	82	73	73	80
Mobile dune tundra– type 1-2	A	85	93	83	72	70	77
	G	90	97	87	75	55	77
Bearberry hummock– type 2	A	87	95	83	85	60	80
	G	88	92	82	72	40	70
Salix-Dryas hummock– type 2	A	87	92	80	65	50	80
	G	85	95	80	50	40	77
Dune hill-bearberry– type 4	A	85	93	85	63	50	77
	G	92	97	97	65	40	60
Fixed dune tundra– type 6	A	87	95	80	67	60	80
	G	87	97	95	60	50	77

Notes: Recordings made on July 14th–15th 1970 using cobalt thiocyanate papers

A denotes ambient (15cm. above the ground)

G denotes the sand surface

Table 2. The relation between diurnal temperature and relative humidity at ground level in three vegetation stands in a sand dune system.

		Mobile sand tundra	Bearberry ridge on hummock	Salix-Dryas hummock
23.00 hrs.	R.H.	90	88	85
	T°C.	3	5	7
03.00 hrs.	R.H.	97	92	95
	T°C.	0	2	3
07.00 hrs.	R.H.	87	82	80
	T°C.	6	5	5
11.00 hrs.	R.H.	75	72	50
	T°C.	14	14	15
15.00 hrs.	R.H.	55	40	40
	T°C.	11	22	18
19.00 hrs.	R.H.	77	70	77
	T°C.	12	11	13

Fig 2. Diurnal temperature fluctuations in a dune hummock (Salix-Dryas)

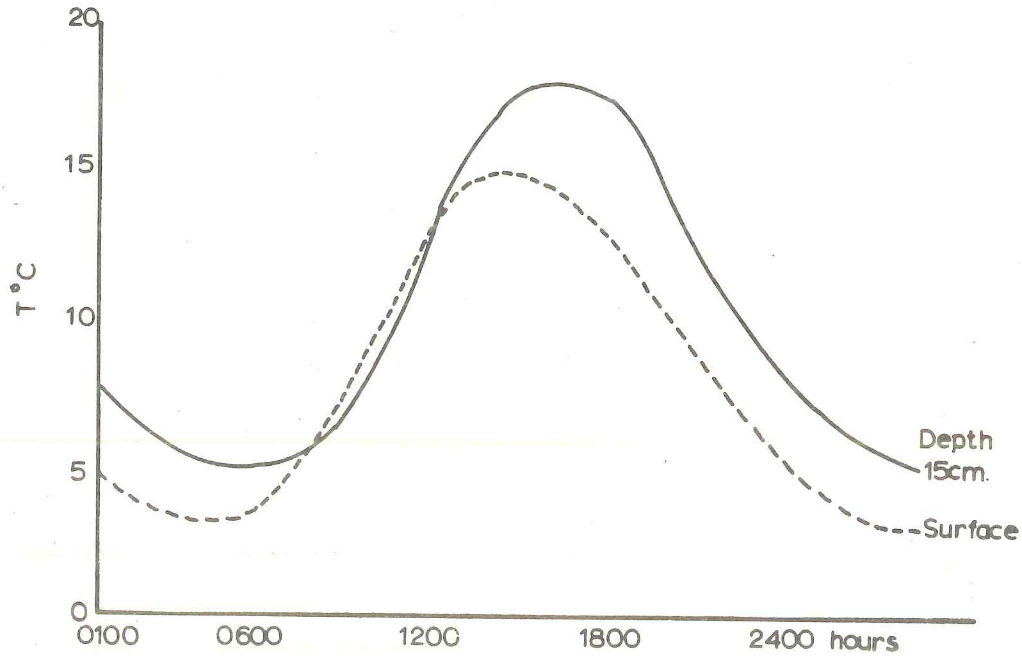


Fig. 3 Diurnal temperature fluctuations in a dune hummock (ARCTOUS)

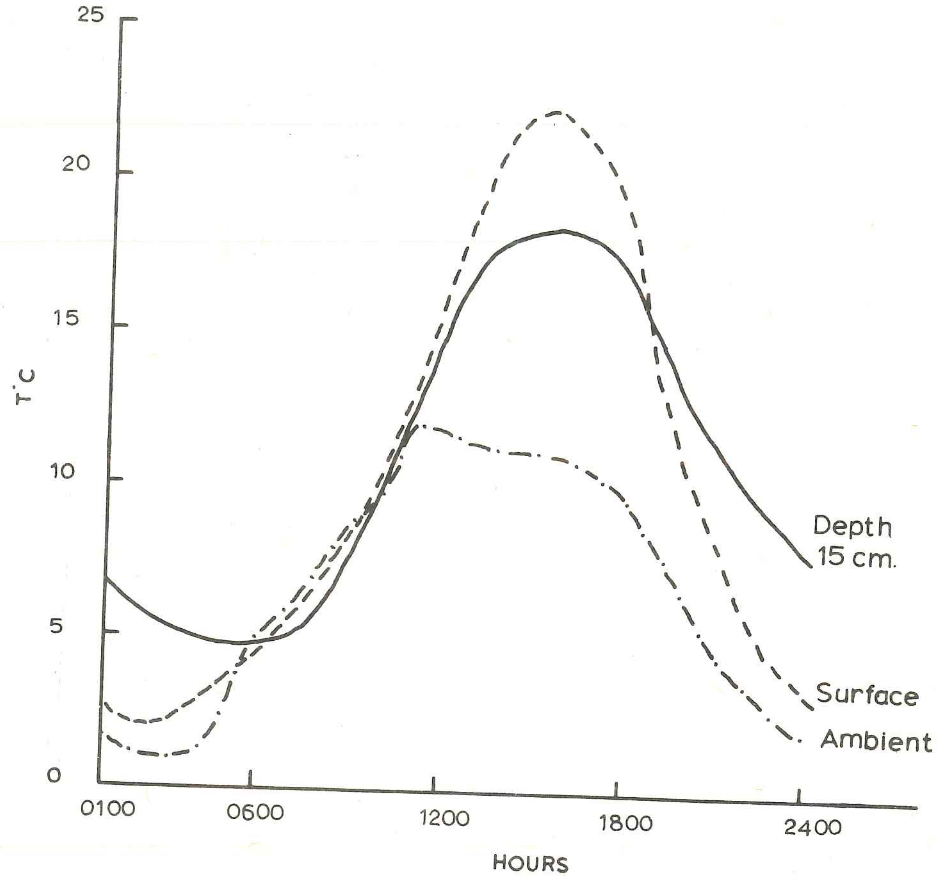
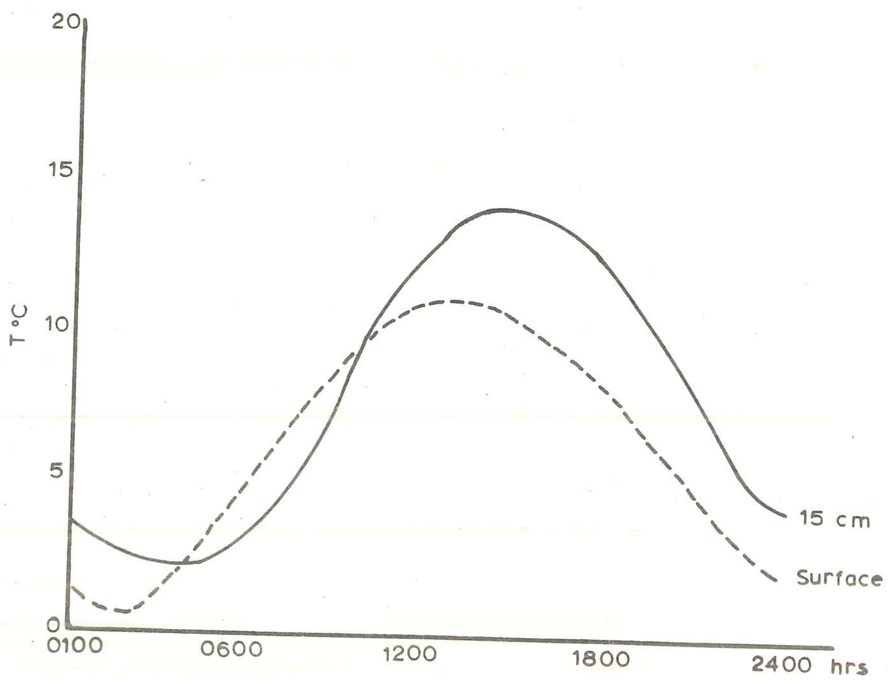


Fig. 4 Diurnal temperature fluctuation in the mobile dune tundra.



SOME OBSERVATIONS ON THE FAUNA OF AN ARCTIC TARN

M. J. Cotton

During the period of the expedition R. Summers and R. O'Grady took weekly net samples from a small arctic tarn (alt. 150m.) N.W. of Nyhavn. Little of the material has been identified and is now with the British Museum (Natural History), but some general comments on the fauna are of interest. In the first week (July 11th) the collection was mainly planktonic Crustacea (Ostracods), mosquito larvae and pupae but closer examination revealed four specimens of *Lepidurus arcticus* (Crustacea, Notostraca). This is an interesting arctic species with a large dorsal shield or carapace covering the trunk, and a prominent 'tail' projecting posteriorly. The specimens were small (total length 4mm.) but by the second week they were common and had doubled in size. Towards the end of the study they were the dominant member of the fauna and had attained sizes up to 29mm. The rate of growth was rapid for 4 weeks and then slowed considerably (fig. 1), while in the young individuals (obviously just hatched) the trunk was much longer relative to the 'tail'. The ratio of trunk : tail size fell from 2.66 (week 1) to 1.72 (week 4) showing that body growth was gradually decreasing relative to tail length. The apparent increase in size in week 6 is probably false since only ten individuals in each sample were measured.

There was a good variety of water beetles and their larvae, probably predators of *Lepidurus*, water mites and a fish, the 3-spined stickleback, was also found.

STAFF OF THE BRITISH MUSEUM (NATURAL HISTORY) WHO IDENTIFIED SPECIMENS

P. Ackery (Lepidopters)
Dr. K. Bannister (Fish)
Dr. T. Clay (Mallophaga)
B. H. Cogan (Diptera)
W. R. Dolling (Hemiptera)
Dr. V. F. Eastop (Aphids)
P. M. Hammond (Coleoptera)
T. Huddleston (Ichneumonidae)
A. M. Hutson (Diptera)
R. P. Lane (Diptera)
P. N. Lawrence (Collembola)
Dr. McKenzie (Crustacea)
Mrs. J. Palmer (Aphids)
Mr. Peake (Molluscs)
A. C. Pont (Diptera)
F. G. A. M. Smit (Siphonaptera)
K. G. V. Smith (Diptera)
Dr. Taylor (Molluscs)
P. E. S. Whalley (Lepidoptera)
I. H. H. Yarrow (Hymenoptera)

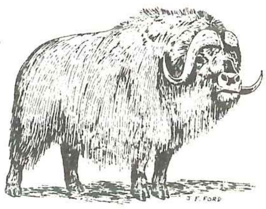
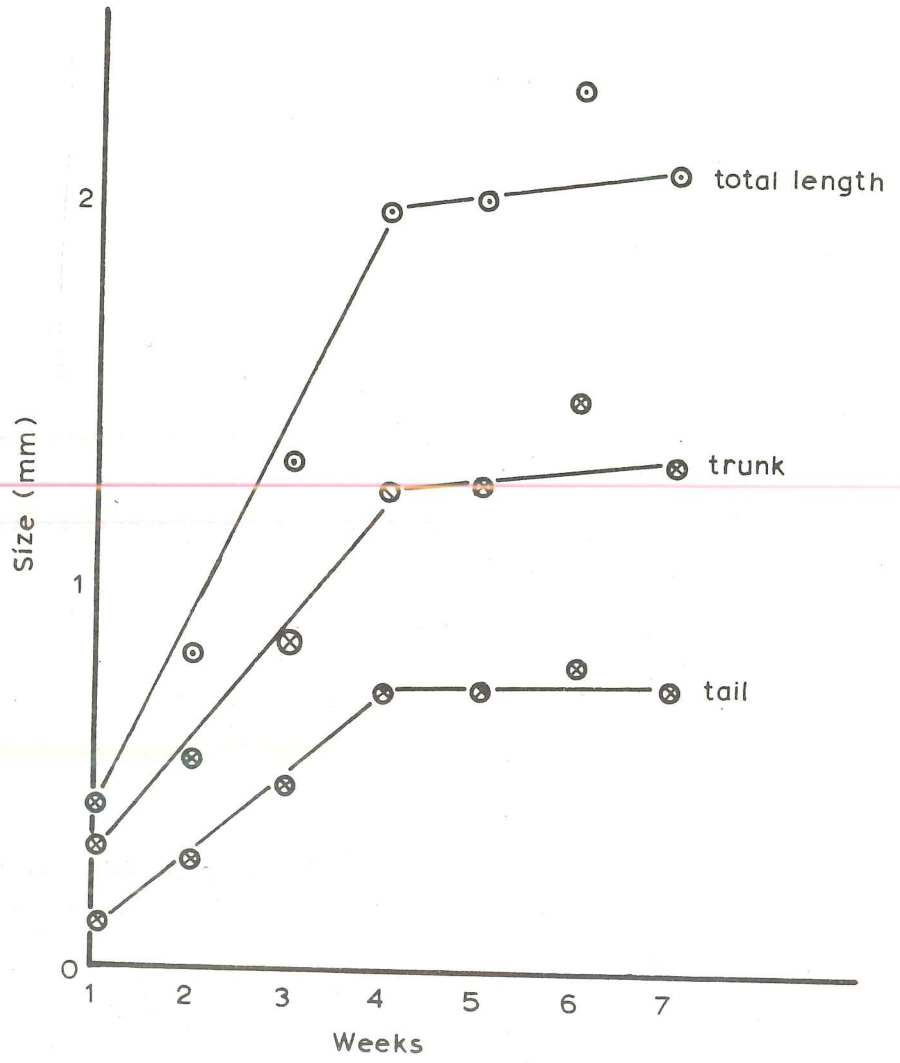


Fig 1 Rate of growth in <u>Lepidurus</u> <u>arcticus</u>



THE DIURNAL RHYTHM OF SNOW BUNTINGS IN CONTINUOUS DAYLIGHT

R. Summers

One of the most striking aspects of the Arctic environment is its unusual light regime. Instead of light alternating with darkness every 24 hours as in lower latitudes, there is a period of continuous light through the summer months. For visitors like ourselves this unaccustomed light regime disrupted our daily rhythm of sleeping. We found that getting to sleep was difficult unless we were physically exhausted and that our periods of rest would vary from 5–17 hours.

We however were not the only visitors to the Arctic. Many bird species come to breed in the continuous daylight of the Arctic summer after spending the winter at lower latitudes. How do these birds overcome the problem of continuous daylight? Obviously their very existence depends on how they utilize their day. The species chosen for study was the ubiquitous Snow Bunting *Plectophenax nivalis*, a small sparrow like bird. The investigation set out to discover the daily activities of the Snow Bunting and to look at factors which may relate to its diurnal rhythm.

It was found from a 24 hour observation on a nest that the rate of feeding of the chicks by the adult birds dropped off markedly for the period 2400–0300 (Figure 1). During this period the Snow Buntings were found to roost in small numbers (13–15, mainly males) on a small basaltic cliff upon which they were very conspicuous. *Caloplaca elegans* (a red lichen associated with well used bird perches) was much in evidence on this cliff showing that it was used regularly. Although this period of roosting and cessation of feeding of the young corresponded with the period of lowest light intensity, there was still sufficient light during these hours for food finding.

It was thought that the availability of food may be a factor determining the diurnal rhythm of the Snow Bunting. Adult diptera were found to be the main food, chironomids being most important numerically and tipulids most important in size. The availability of these insects to the Snow Buntings was measured in the following way. Assuming that Snow Buntings are active visual feeders, the more an insect moves about the more liable a Snow Bunting is to see it and give chase. Similarly an inactive insect is more liable to be overlooked by a Snow Bunting. Insect activity is therefore taken to be a function of insect availability. This admittedly is a crude approximation as it ignores the fact that extremely active insects may be more difficult to catch than not so active ones. Insect activity was measured from 2 lines of 50 pit-fall traps run over 4 hour periods throughout one day (Figure 2). The pit-falls were white in colour and therefore attracted flying insects in their vicinity. They also trapped ground invertebrates as is usual. From Figure 2 it can be seen that the period of least activity (insect availability) corresponds well with the Snow Buntings roosting period. It is assumed that the low temperature during this period (Figure 3, graph A) caused the low insect activity. It may be concluded that Snow Buntings cease to feed their young and go to roost when the availability of their main food items are lowest.

However, on a particular day there was a strong N.W. wind, the sky was overcast, there was frequent rain, and the temperature was continuously low (Figure 3, graph B). It was assumed that insect availability would be low in these conditions. Despite the poor weather the feeding rate of the chicks by the adults was as high as on a typical sunny day for the same hour (Figure 1, dashed column). The diet however had changed. Instead of the usual dipterous insects, the adults had collected caterpillars, mites and spiders as well as plant material. If, as shown, the Snow Bunting can food-find under unfavourable conditions, why don't they feed their chicks for 24 hours each day instead of roosting for several hours? This system would be advantageous in terms of chick production. Obviously the reason is that the birds cannot food-find continuously for 24 hours day after day. They require a period of rest and it is advantageous for them to take this during the period when the most nutritous food species are at their lowest availability.

Some interesting questions emerge from the above observations. Such as, why do adult Snow Buntings roost communally at regular sites in bright light? And why is the roost composed mainly of males? Surely they would be vulnerable to predation. Although no direct predation was observed at this roost, the local pair of Gyr Falcons *Falco rusticolus* were seen to bring adult Snow Buntings to their eyrie (Rick O'Grady, personal communication). Obviously the advantages of communal roosting, whatever they are outweigh the disadvantages of predation.

Also the question of the proxumate factor that stimulates roosting behaviour is not clear. In low latitudes the coming of night will stimulate roosting behaviour, but in Greenland where the

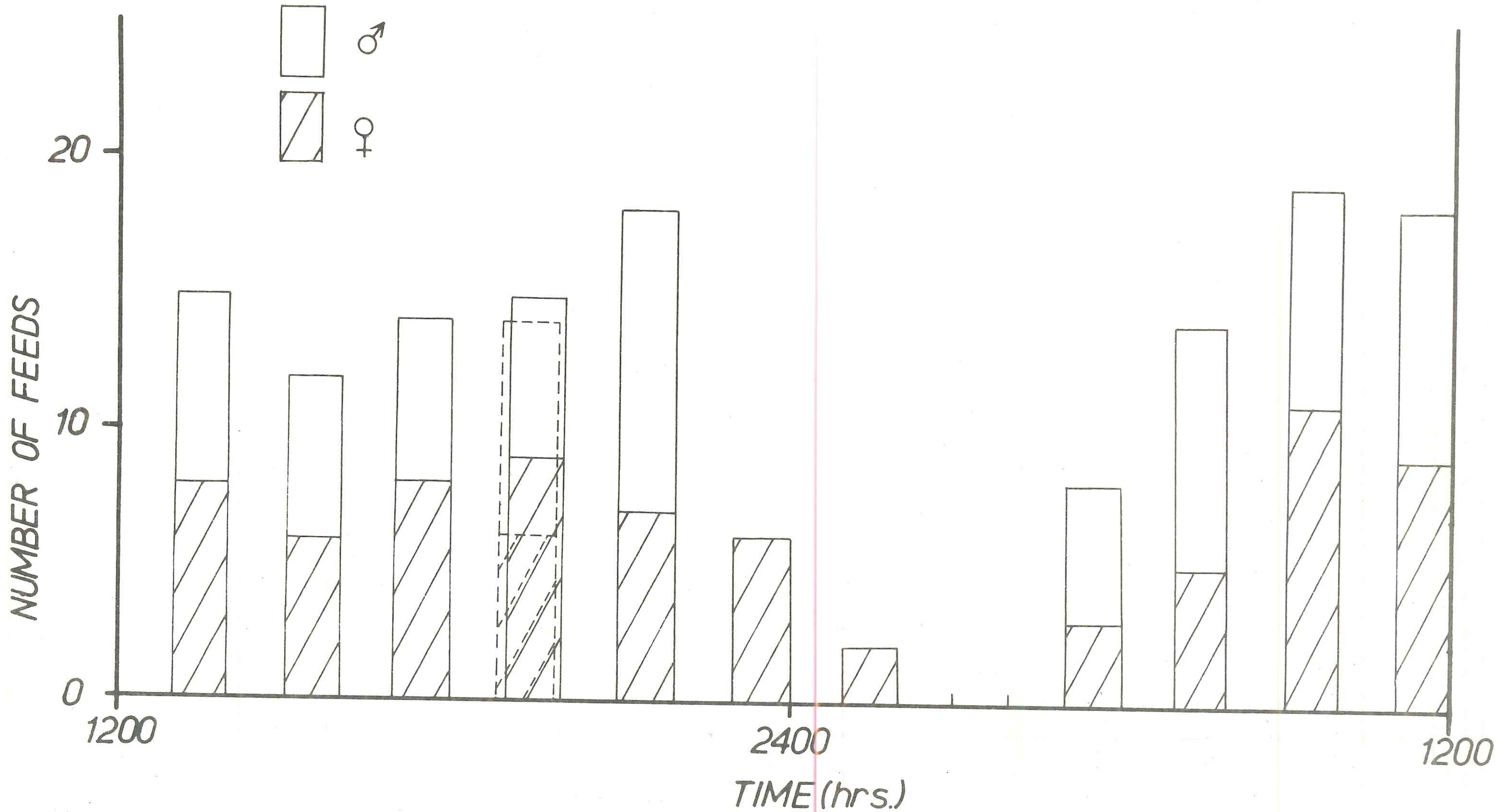


Figure 1. The rate of feeding of nestlings by adult Snow Buntings, based on hourly watches in every second hour. The dashed column shows the feeding rate during a day when weather conditions were poor (see also text).

FIG. 2.

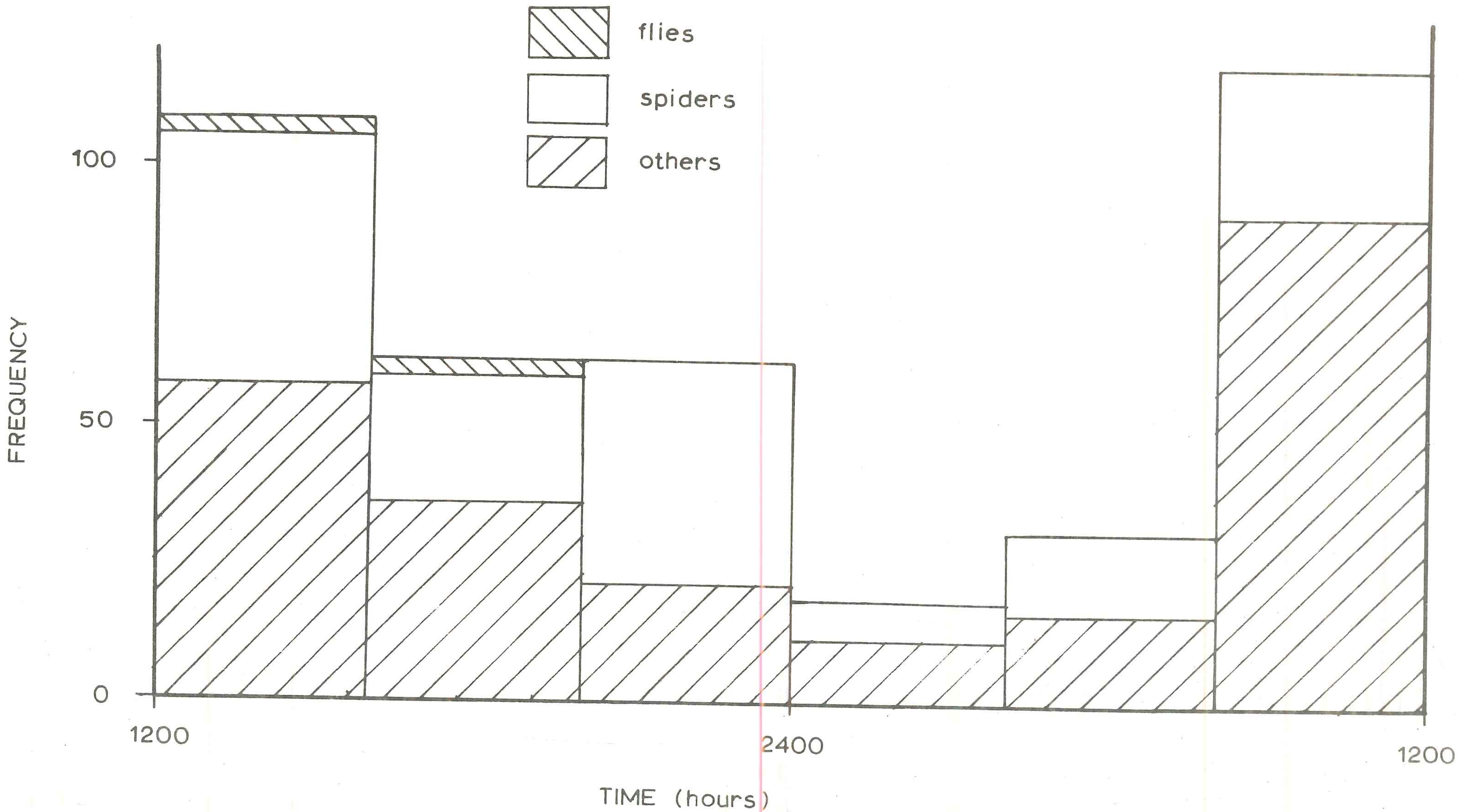


Figure 2. The number of invertebrates caught in 100 pit-fall traps run over 4 hour periods throughout one day.

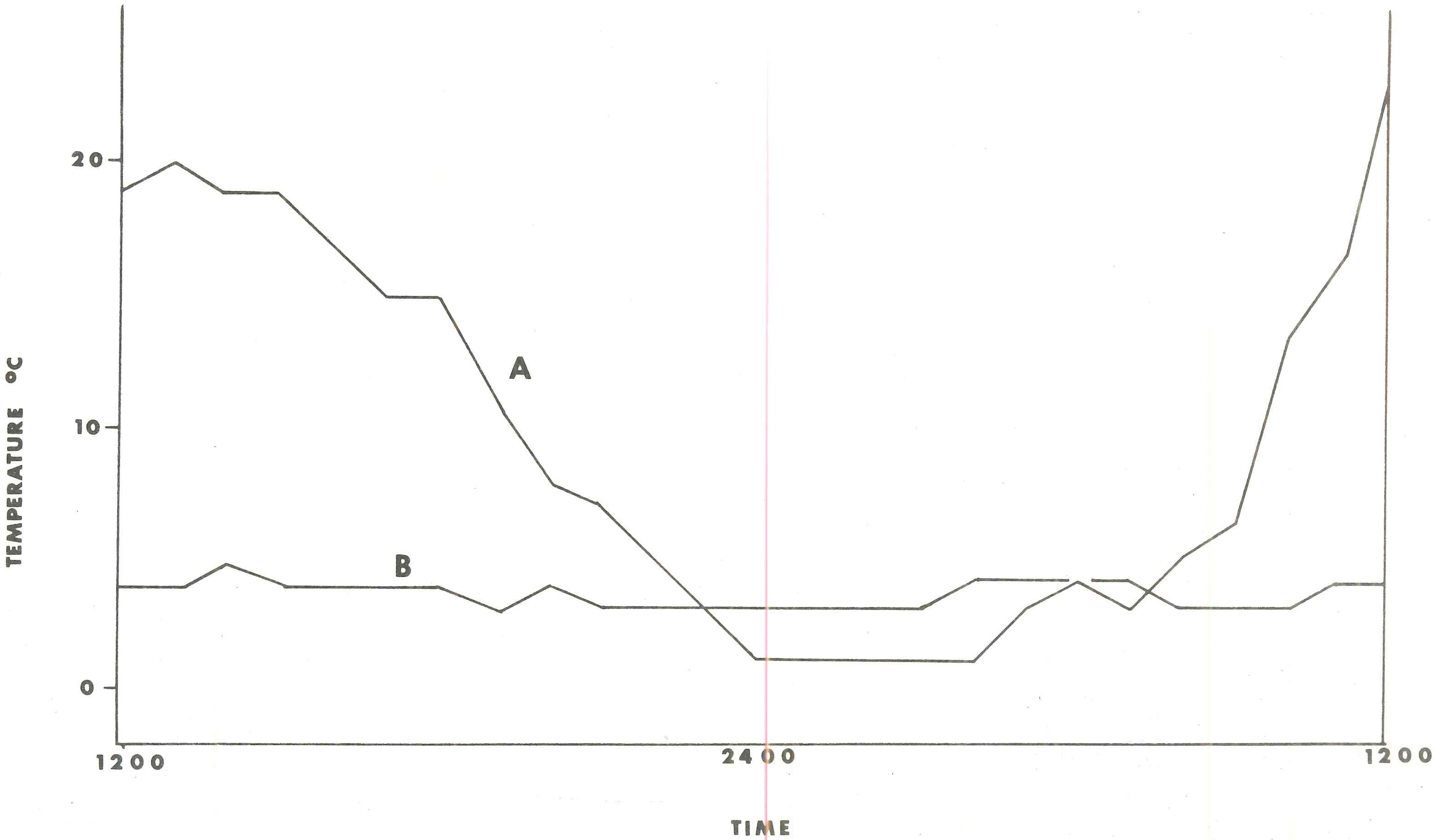
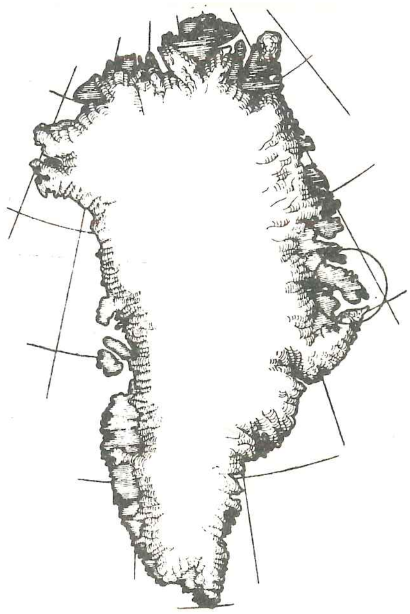
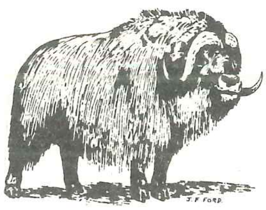


Figure 3. Temperature variations throughout 2 days as recorded by a Grant continuous temperature recorder. The probe was set at ground level.
Graph A. The temperature variations on a typical sunny day with cloudless skies and little wind.
Graph B. The temperature variations on a cloudy rainy day with a strong N.W. wind.

variations of light intensity through the day are so small and where weather conditions can have marked effects on the light intensity, it would seem difficult for the Snow Buntings to use this variable.

I hope the above observations and unanswered questions stimulate further observations on Snow Buntings, especially on their roosting behaviour.





NOTES ON ARCTIC TERN COLONIES IN KONG OSCAR'S FJORD

I. H. M. Smart

In 1960, 1968 and 1970 fairly detailed studies of the Arctic Tern colonies on the Menander Islands were carried out. In each year visits were made to other colonies as the opportunity arose.

Menanders Islands

The four Menanders Islands are part of a drowned escarpment running N.E. from the shore about 12 kms north of the airstrip at Mestersvig. They decrease in area and height seawards. The first island has no tern colony. The second island is made up of two parallel escarpments with an area of flat vegetated ground between. It is about 800 m x 400 m in area and 60 m at the highest point on the N.W. escarpment. The third Island is about the same height but about half the size with a vegetated plateau in its centre. The fourth and outermost islet is a rocky promontary about 40 m x 10 m in area and 10 m high.

Observations in 1960

In 1960 the first visit was made by canoe through heavy pack on the 19th July. About 200 terns were in possession but no nests were found. Fox tracks in sand and snow were found, also the feathers of six terns including the complete head of a freshly killed bird.

On the 24th of July the No. 2 Island was revisited and a camp established. Three nests with eggs were discovered and on subsequent days up to the 30th the rest of the birds layed.

The following incubation periods were established from marked nests.

21 days	9 hours	± 3 hours
21 days	12 hours	± 12 hours
21 days	8 hours	± 20 hours
23 days	21 hours	± 16 hours
21 days	21 hours	minimum
21 days	9 hours	"
21 days	0 hours	"

The incubation periods agree closely with those reported for the British Isles (Handbook of British Birds: average of 43 clutches–21 days 18 hours).

Dates of Hatching

The first chick was found on August 12th. Allowing a 21 day incubation period this indicates that the egg was laid about July 22nd which is the time the island first became free of ice.

Measurements of Wt. and linear growth

On the day this part of the programme was to start the mountaineering section of the expedition requested our assistance. Returning about a week later the hatch was found to be over and the opportunity lost. The following few measurements were obtained before departure.

Weights

New-born chick	10.8, 13.7, 14.7 gms
2 days old chick	16.7 gms

Linear Measurements

New-born chicks (average of 5)

Bill from tip to base of crown	–	10.4 mm
Leg (Tip of claw to tarsal joint)	–	31.0 mm
Total length	–	72.0 mm

4-days old (1 specimen)

Bill	–	14.0 mm
Leg	–	37.0 mm

About 14 days old (aged from ring) (2 specimens)

Bill	–	21 mm
Leg	–	38 mm

Flying Juveniles

In both the above two-week old birds the primary feathers were all well grown. They would probably fly within the next few days.

The first young tern was seen flying on 26th August. As it is very unlikely that this bird hatched much before the 12th of the month, it would seem that the young terns are able to fly in just over two weeks. On subsequent days more flying juveniles were seen. These flying young birds were kept over the land by the concerted action of many adult birds who would swoop down to head off a juvenile as it neared the coastline. Similarly swimming juveniles were driven into the shore by the adult birds if they swam more than a few metres out to sea.

Mortality

Accidental

One broken tern egg-shell discovered on 25th July.
1 egg disappeared before possible hatching date.
2 nests were known to be abandoned.
1 chick, one-day old, was found dead below its nest having fallen a couple of metres.
A very young bird, still unable to fly was seen to drift out to sea unable to make way against strong tide and wind.

Predators

Glaucous gulls nesting on an adjacent island about 1 km. away were frequently mobbed by the terns, but were never seen to cross the islands' coastline.

Ravens were seen on several occasions flying determinedly over the tern island, mobbed by terns. During one attack by a pair of ravens one bird landed and acted as a decoy but were not seen to be successful. On the other occasion a week-old bird was taken and carried for a few yards until the raven was forced by attacking terns to drop the dead chick.

A Greenland Falcon, was observed on one occasion being pursued in a southerly direction by the entire agitated colony. Arctic Skaus were seen on only one occasion robbing terns in the vicinity of the colony.

Observations in 1968

In 1968 the first visit was made to island No. 2 on the 3rd August. Between the 3rd and 10th nests with eggs were discovered. The first chick hatched on 9th August. Allowing a 21 day incubation period, this gave a laying date of 19th July. On returning to the island on 18th August after an absence of 8 days, the colony was deserted. Fox tracks were found all over the island. Dense ice floes had filled this part of the fjord during the week and presumably they had used this route to get on and off the island.

Observations in 1970

In 1970 Menanders Island No. 2 was first reached on July 28th. Fifty nests found on the first day, and three were opened to find out the state of incubation. Two contained embryos of over a week old and one appeared fresh and unincubated. On 31st July an egg was discovered in a marked nest which had been empty the day before. A total of 75 nests with eggs were found. Left the island on the 2nd August and returned for a few hours on August 9th. One chick was now found newly hatched, indicating it had been layed on July 18th; all other nests still incubating. A return to the island later was prevented by the appearance of dense ice floe blocking access to the islands from Mestersvig.

Observations on the other Menanders Islands

Island No. 3

1960, 1968, 1970. In each year about 20 nests were found. In 1968 the colony was taken by foxes along with the one on island No. 2.

Island No. 4

1960–1 nest, 1968–1 nest, 1970–3 nests.

Other Islands

Conglomerate Island at Kap Petersen

1958	
1960	Terns present but no nests discovered
1968	Terns present no nests.
1970	Aug. 2nd. 17 nests (12 with one egg, one of which was a miniature). Also 2 eider nests with 4 and 2 eggs. Aug. 9th. 2 nests with hatched eggs.

Akerblonis Island

1970	No colony

Arwidson's Island

1970	Aug. 5th–Colony of about 30 breeding pairs on tundra near stony beach at S.E. extremity of island. Many chicks ranging from new hatched to more than a week–at least one just nosing down took to the sea and was able to paddle away from the shore.

Island at mouth of Noret

1958	30th August–young birds paddled away from shore.
1960	28th August–no sign of adult terns or young.
1968	16th August–no signs of adult terns or young.
1970	10th August–a few adults feeding in vicinity but no sign of nesting.

Conclusions

1. All tern colonies found were on sea islands.
2. Successful egg laying and incubation began when the island became free of ice. The time of hatching thus varied from island to island.
3. The major predators were foxes which prevented the onset of egg laying and made opportunistic raids on islands which became connected to the shore by drifting ice. Otherwise only ravens were actually seen to take young terns.
4. Successful egg laying and incubation began when the sea ice broke up and consequently the time of hatching varied from island to island.
5. Although the islands in Segelsèllskabet Fjord are ice free earlier than others and far enough away from the mainland to avoid temporary connection to the land by drifting ice, they do not contain particularly large colonies. On the other hand, the Menanders Islands, in spite of their late connection to the shore and proneness to temporary bridging, seem to attract a large colony each year.
6. The Menanders colony each year laid about July 18th or later and therefore had the major hatching period at August 9th or after. Flying birds appeared at the end of August which is perilously close to the end of summer weather.

SYSTEMATIC LIST OF BIRDS OBSERVED

compiled from the notes of R. Summers, R. O'Grady and I.H.M. Smart

Great Northern Diver–*Colymbus immer*

July 23rd. 1 adult Gaasesø. Present for a few hours only. Harried by resident pair of Red-throated Divers. August 1st. 1 adult at Nyhavn Bay. July 18th. 1 adult at Bjorne Øer.

Red-throated Diver–*Colymbus stellatus*

Common bird in all areas. 1 pair attempted breeding on Gaasesø near Mestersvig. Egg found on 23rd July. Gone by 13th August. No chick–may have been taken by predator. August 3rd. One pair with two very young chicks in pond 1 km. east of mouth of Skel. Adult flew in with a long (20 cm.) thin fish in bill. A pair also bred successfully on the pond near the airstrip rubbish dump.

Pink-footed Goose–*Anser fabilis brachyrhyncus*

July 6th. About 8 nests found on ledges in gorge of Tunnel River. Two still being incubated, one seen to have 3 eggs. Others contain hatched egg shells. One may have been taken by Arctic Fox as it was surrounded by feathers including primaries. July 8th. One pair with 5 chicks a few days old in pond in Labben hills. July 19th. 3 pairs with 2, 2 and 1 young 2-3 week old in pond above Nyhavn. July 10-22nd. Adults and young common in Schuchert Valley, Nord-Ost Bugt and Bjorne Øer.

Barnacle Goose–*Branta Leucopsis*

July 6. 8 adults with several very young chicks, Gaasesø. July 8. 19 adults with two clutches of 5 and 2 chicks, less than one week old. July 9. Disturbed several adults on cliff next to Washburn's solifluction site. Found several recently empty nests and put up one closely sitting adult from a nest with 4 eggs. July 10–Mid-Aug. Adult and young at different stages of development, frequently encountered. End of August. Flocks of about 100 birds frequent; barnacles were also common in the Bjorne Øer and Nord-ost Bugt area. Flightless birds were encountered during last two weeks of July and first week of August.

Arctic Eider–*Somateria mollissima borealis*

Common or usual everywhere along Kong Oscar's Fjord Coast and in inner ScoresbyLand.

King Eider–*Somateria spectabilis*

Christian Kjort's party identified several females of this species some with young during a visit to Traill Island.

Long-Tailed Duck–*Clangula hiemalis*

Small parties seen regularly around Gaasesø, Hyhavn, and Kong Oscar's Fjord Coast. Also around SydKap and Nord-ost Bugt. July 9. 1 nest with clutch of 5 eggs near marshy pond at oil drum dump near Nyhavn. Subsequently disappeared. Probably taken by predator. July 20. One pair with 2 downy young on pond above SydKap houses. July 21. One pair with 2 ducklings on sea near small islands 3 kms. off Syd Kap. July 30. Menanders No. 2, nest with 5 eggs. Menanders Ö No. 4, nest with 6 eggs. Later in season flocks of 20-40 encountered along coast.

Greenland Rock Ptarmigan–*Lagopus mutus captus*

Occasionally encountered in groups of 2 or 3 in all areas. August 4. 2 hens with 10 three-quarter grown chicks, Nyhavn. August 15. 2 hens with 10 almost fully grown chicks, Nyhavn. August 22. 1 hen with almost fully grown chick, Nyhavn.

Ringed Plover–*Charadrius hiaticula tundreae*

Common in all areas. The following observations of young birds were made:–

July 11. Pair with 3 flying young in upper Schuchert Dal. July 18. One chick 2-3 days old ringed near Skeldal hut. July 31–August 11. Small parties of flying young and juveniles encountered in Nyhavn area.

Turnstone–*Arenaria interpres*

3 pairs breeding near road between airstrip and Nyhavn.
July 8. Two newly hatched chicks ringed. Later found dead at same stage of development.
July 11–12. Common in Schuchert Dal, 1 pair every half hour's march. Commoner here than other waders. July 17. Last birds of season seen.

Sanderling–*Crocethia alba*

Fairly common around Mestersvig tundra areas between July 6 and August 13.
July 22. 2 chicks a few days old at south side of Noret. Small flocks of 8 and 10, July 19 and 21 near Noret.

Knot–*Calidris canutus*

July 12. Middle Schuchert Dal bird put off nest with 4 eggs which were just hatching. July 23. 1 adult giving distraction display middle Ørsted Dal. August 4. 1 near Gaasesø.

Dunlin–*Calidris alpina arctica*

Common in Mestersvig area, Schuchert Dal and Ørsted Dal.
July 9. Nest with 4 eggs near Nyhavn. July 10. 4 newly hatched chicks in hills behind Nyhavn.
July 17. Nest found on July 9, just hatching. Another next with one egg hatched, other three chipping. 1 later found dead in egg.

Red Necked Phalarope–*Phalaropus Lobatus*

July 18. One female on rock basin pond in Nyhavn hills. Nest searched for in vain.

Grey Necked Phalarope–*Phalaropus fulicarius*

July 16. One pair on a pond on one of the Bear Islands. Chasing each other and landing on the water. Eventually flew off and did not return. Nest searched for in vain.

Arctic Skua–*Stercorarius parasiticus*

Less common than long-tailed skua. Pairs and individuals, at scattered points along Kong Oscar's Fjord coast. July 7. One "dark phase" individual was reported near Nyhavn.

Long Tailed Skua–*Stercorarius longicaudus pallescens*

Observations by R. O'Grady.

3 pairs nested in the area between the end of the Mestersvig air strip and the big oil drum dump, on the last corner on the road to Nyhavn.

Pair 1–6th July, watched them mobbing a Glaucous gull near Gaasesø, in vicinity of eventual nest. 7th July, nest found, one egg, no more laid, egg already predated by G. gull perhaps? 19th July, egg disappeared, no chick was ever found, nor did the behaviour of the adults ever suggest that there was one.

Pair 2–12th July, nest found on left of road to Nyhavn, near oil drum dump. One egg, one newly hatched chick. Both eggs eventually hatched. 19th July, one chick ringed, could not find the other one. 7th August, both chicks flying strongly.

One or both of the adults from this pair came regularly, every day after the chicks had hatched, to cheese and other offal, such as the remains of skinned lemmings, which were thrown out for them, outside the hut we were using at Nyhavn. The cheese was an eight pound block that had "gone off" and lasted for almost the whole of July. The adults gave the appearance of feeding the chicks almost entirely on cheese while it lasted, as at any time one could be seen at the cheese, and then flying off strongly in the direction of the chicks.

After the chicks fledged on the 7th August, both were brought to the scrap dump, including the ringed chick, and the chicks could be watched being fed by both parents on cheese and lemming remains. 19th August, watched both adults harrying Arctic terns which were fishing in a large flock at the east side of Nyhavn bay. The terns were nesting on Ran Island to the west, and were being intercepted on the return journey and forced to drop their catch, and return to the fishing flock.

Pair 3–13th July, both eggs newly hatched, in nest to the right of the road to Nyhavn, just before the line of the Langdyssen hills to the right. All 3 nests were thus within an area of diameter 1 km. Could not find the chicks later to ring them. 7th August, both chicks flying strongly (1 had been out of the area for 48 hours). 11th August, 10 adults indulging in noisy aerial displays, over breeding area, including the breeding pairs. 8 still present on the 12th. By the 16th August only the two successful pairs remained and their chicks. Some adults and juveniles were still present on the 23rd August when I left, but I am not sure if they were all present or not.

Glaucous Gull–*Larus hyperboreus*

Common along coasts and occasionally inland.
July 18. Bear Island, one nest with fairly big downy chicks. August 4. About 20 seen around the breeding colony on Menanders Ö, No. 2.

Great Black-Backed Gull–*Larus marinus*

August 12. Immature flew over Nyhavn in westerly direction. The Swedish ornithologists reported carcasses of this species lying around the airstrip where they had been shot. The Angmagssalik area is reported by Salomonsen as being the northern limit of the range of this species on the East coast.

Arctic Tern–*Sterna paradisaea*

Common breeding species on islands and islets of Kong Oscar's Fjord, Royal Swedish Yachtclub Fjord and inner ScoresbyLand.

Snowy Owl–*Nyctea scandiaca*

Not seen by our parties but the Swedish ornithologists reported seeing a single male on Traill Ø in the first week of August.

Gyr-Falcon–*Falco rusticolus candicans*

Observations by R. O'Grady.

6th July, probable sighting on a pole near Mestersvig–a large white bird was being mobbed by a Long tailed skua. As a nest was later found in the Tunnel gorge, it was probably a Gyr and not a Snowy Owl, as was tentatively thought. Distance very great. 6th July, one adult seen by Mr. and Mrs. G. W., R. S., and R. O'G., in Tunnel gorge. 26th July, visited nest in Tunnel gorge, to left of highest point on the road to the mine. 3 large chicks almost ready to leave the nest, exercising wings. Adults brought lemming and Snow-bunting in to the chicks during the several hours I watched. The nest appears to be on old site, judging by the extensive growth of red lichen (calo-placa elegans) below. In addition the nest is easily accessible with a rope and the presence of three, well-rusted, iron pitons in the rock at the back of the nest cavity, testify that someone has been there before, probably to take the young for falconry, as tying the young to the nest site until they were fully grown used to be a standard technique. 7th August, one adult, one juvenile flying near nest. 17th August, adult, and juvenile flew over Noret dunes. 17th August, Long tailed skuas mobbing juvenile Gyr. All three chicks fledged safely and were seen together frequently in the vicinity of the Mestersvig base, by the Swedish ornighologists who were camped there.

Greenland Wheatear–*Oenanthe leucorhoa*

Frequently encountered in rocky areas around Mestersvig, Schuchert Dal, Syd Kap and Bear Island. Juveniles encountered end of July.

Redpoll–*Carduelis flammea?*

July 23. Adult in Ørsted Dal. August 7. Juvenile in party of juvenile snow buntings. Nedre Fundal.

Snow Buntings–*Plectro phenox nivalis*

Common everywhere. July 6. nest with 3 newly hatched chicks and 2 eggs. July 7–15. 6 nests with young discovered in area around Nyhavn. July 13 onwards parties of fledged juveniles common–some flocks of up to 150.

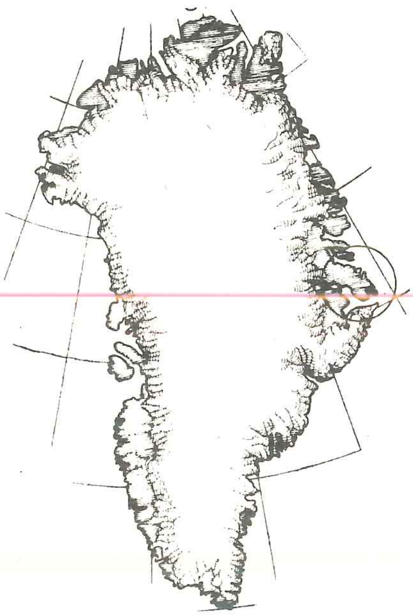
Northern Raven–*Corvus corax principalis*

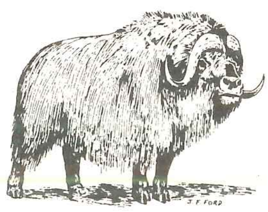
Observations by R. O'Grady.

One pair was redisent in the Mestersvig airstrip region. The pair and their 2 possibly 3 chicks were frequently seen in the Labben, Noret, Nyhavn, region. The nest site was not found and the old site mentioned in the 1968 Report did not seem to have been used this year. The Danes told me that a complete family of Ravens had been wiped out by one of their "trigger happy" number, who had since moved on. They thought that the present pair were new incomers and have retained some of their comparative tameness, as no-one molests them now, in contrast to the previous pair which was very wary, but unfortunately unused to the very long range of some of the new rifles. This could explain why the old nest site was unused.

The present pair and juveniles were first seen on the 8th July, and were frequently seen after that especially around the Mestersvig dump, the Noret dunes, and Nyhavn where they fed on our food dump. The juveniles were especially confiding, but both adults and juveniles approached to within 3 metres, when I was working on the Noret dunes. They were also suspected of pulling up the insect pit-fall traps, set in the dunes, and scattering them about, but thankfully after 2 or 3 weeks tired of this.

In august they could often be seen at Nyhavn feeding on Blaeberries. The nest site could be in a small recess in the cliffs at the east end of the Labben hills.





ORGANISATION REPORTS

ORGANISATION

Travel Arrangements

The main travel arrangements were made with Exploration and Travel Ltd. resulting in the expedition joining in a joint charter from Reykjavik to Greenland. This included a reduced return air fare from Glasgow to Reykjavik.

Arrangements had been made to send heavy equipment by sea freight from Leith to Reykjavik but a strike in the Icelandic Shipping Company forced us to air freight all our supplies and equipment at the last moment. This cost a lot.

Food

The rations and packing were similar to those used in the 1968 Expedition. These boxed rations were used only by the hydrology and mountaineering parties. The Gurreholm and Mestersvig biology parties existed on bulk supplies shipped in the year before.

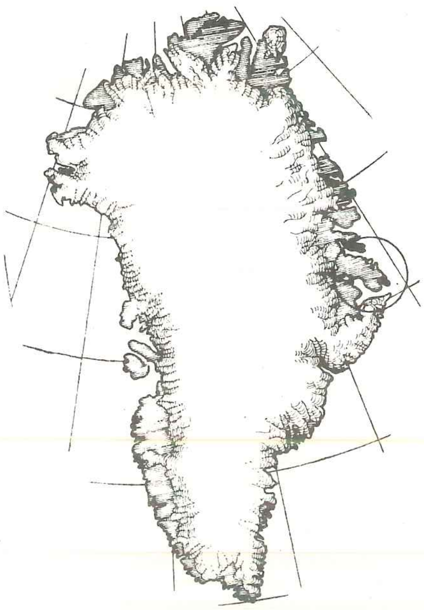
The following firms and organisations denoted consumables:–

Arthur Bell Ltd.	–	Whisky
British Eggs	–	Dried Egg powder
British Sugar Corporation	–	Sugar
Cerebos	–	Salt
Duncan MacBeth Ltd.	–	Whisky
Glaxo Laboratories Ltd.	–	Ostermilk, glucose
Oxo	–	Tinned meat, stock cubes
Quaker	–	Rolled oats
Shippam Ltd.	–	Meat pastes, tinned meats
Wander Ltd.	–	Biscuits
W.D. & H.O. Wills	–	Cigarettes, pipe tobacco.

Packaging was supplied by Thames Board Mills Ltd.

Medical Supplies

The 1968 medical kit was left in Greenland and reused in 1970. Only minor cuts, bruises and abrasions were suffered in 1970 and no illnesses occurred.



EQUIPMENT

J. Peden

The following equipment (other than scientific equipment was taken.

Camping Equipment

4 Arctic Guinea tents
1 Blacks Mountain tent
1 Good Companions Major tent
1 Andre Jamet tent
7 1 pint Primus stoves
1 ½ pint Primus stove
4 Blacks Nester sets of pots
Assorted mess-tins, etc.
4 Woolworths Nylon pot scourers
4 Collapsible canvas water buckets.

Climbing Equipment

2 300′ 9 mm Kernmantel Ropes
2 150′ 11 mm Kernmantel Ropes
2 120′ No. 3 Hawser-laid Ropes
8 Stubai 2200 kg screwgate karabiners
24 Cassin-Bonatti 2200 kg karabiners
20 1″ Tubular tape slings
25 Assorted Leepers, angles and blades
8 MOAC chockstones
4 No. 4 Peck Crackers
4 No. 2 Peck Crackers
10 Salewa tubular ice-screws
4 Dead man snow belays
4 Dead boy snow belays

Personal Equipment

Ice axe
Snow goggles
Boots
Gaiters
Spare clothing
Eating utensils
* Tin opener
Sleeping bag
* Pack Frame
Cagoule
* Foam mat

The following additional equipment was carried by the climbing party:

Crampons
Crash helmet
Peg hammer
* Skis
* Plastic sledge
* Space Blanket
Long johns
Duvet jacket

(Items marked (*) were provided from expedition funds)

Miscellaneous Equipment

Boot polish
Glacier cream
Lip salve
Mosquito repellant
2 Awl-U-Need lockstitching kits
Assorted sailmaker's needles, waxed twine, nylon cord, adhesive tape, etc.
2 Screwdrivers
2 Files
Fishing net
2 Shotguns

Performance and usefulness of equipment in the field

Camping Equipment

Arctic Guineas provided the backbone of the accommodation. In the climbing base seven people lived comfortably in two Guineas and one Mountain tent, while on the traverse, for weight considerations only the two Guineas were used. Flysheets were not used since precipitation is normally low in E. Greenland during the summer. During one spell of rain a temporary fly-sheet was made using two space blankets, nylon cord and adhesive tape. This was successful owing to the absence of strong winds. Flysheets were not necessary in snow conditions. Pegs were not taken by the climbing party since boulders are plentiful!

The one-pint Primus stoves were ideal and only one failed for want of a spare lead washer. Spares should certainly be taken though a delay in transport prevented us from obtaining them. Although small amounts of spirit and solid fuel were taken, the stoves were invariably and successfully started using their own paraffin burning on an improvised wick. If this policy is adopted, ample supplies of prickers should be taken!

The Black's Nester sets of pots were excellent, apart from the handles which tended to bend under the weight of a full pot. The scourers were essential, but the lact of soap powder, etc., was not critical. Collapsible water buckets represented a "good buy" in terms of their usefulness/weight ratio.

Climbing Equipment

Because the climbing party was smaller than planned, the amount of climbing gear taken was rather excessive. The final climbing party comprised seven men, of whom not more than four were ever climbing at any one time. Of the ropes the 300 ft. 9 mm. ropes were found to be most useful, being suitable for abseiling and glacier work as well as for climbing. These would themselves have been quite sufficient.

Since much of the rock encountered was heavily jointed and weathered granite, chockstones were found to be preferable to pitons, and while some pegs should be taken, future expeditions should consider taking plenty of jam-nuts especially MOACS which can provide a good main belay.

Personal Equipment

Members provided much of their own equipment, leading to plenty of variety. Sleeping bags used included Fairy Down Everest and Blacks New Summit, Polar, Icelandic and Norseland bags. These ranged from excellent to adequate. Long johns and Duvets were worn continuously in the glacier regions and cagoules were found to be very useful.

The climbing party were provided with 3′ x 2′ Karrimats; thin sheets of flexible closed-cell expanded polystyrene. These were superb, being waterproof, giving very good insulation, on ice, adequate padding against rocks and were not particularly bulky. In addition small pieces out from them were good, for padding boots, sacks, etc. The biology parties used thick foam mats which were also efficient although absorbent and rather bulky.

Rigid climbing boots, especially the toes, wore badly with crossing the large amounts of moraine. Bendy walking boots survived better but were not so good for the mixed climbing. A compromise of semi-stiff boots would seem to be best. Kiwi "Wetpruf" (rather than dubbin) was acclaimed as the best treatment for boots since it gave good waterproofing without undue softening of the leather.

Karrimor Tote-em-Pack pack frames and sacks were used and apart from one frame which suffered total collapse these survived to a greater or lesser extent, sustaining normal loads of 70 lbs. and exceptional loads of 130 lbs. They did, however, suffer from many annoying faults and were uncomfortable. The loops holding the sacks to the frames all showed signs of coming adrift on the first day of use. Many subsequently did and repairs were frequently necessary. The webbing on the frame protecting the back, while wide enough, was too thin and tended to wear through. The frames themselves had a habit of working loose and regular tightening of the screws holding them together was necessary.

Norwegian Langlauf skis were taken for travel on the high glaciers, but much of the ice was bare and rutted making progress difficult for the one pair with steel edges and impossible for the rest without. On this expedition they were certainly not worth carrying, being used for only a few miles. In a snowy season, however, they could weel prove their worth.

The use of plastic sledges for carrying high density loads on glaciers was adopted from the 1968 expedition and were again found to be a tremendous boon. Their resilience to sharp rocks and ice has to be seen to be believed.

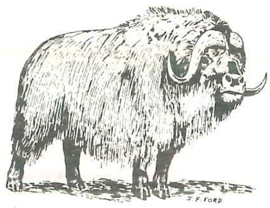
For eating utensils a fork was unnecessary, since a spoon is as good, if not better for coping with expedition food. Each member also carried a small tin opener of the type which folds flat and costs 6d, thus the classic situation of tins and no tin-opener never occurred.

Miscellaneous Equipment

Plenty of materials for improvisation and the repair of boots, rucksacks and tents, etc., were taken and made good use of. Files were useful for crampon points and screwdrivers for adjustments to frames, skis, etc.

Glacier cream and lip salve were indispensible in the mountains. Mosquito repellant was likewise essential on the tundra and the general feeling was that it would be difficult to take too much. Apart from various proprietary brands which were more or less effective, Army issue 'Mosquitofax' was used and found to be very effective over long periods. The number of mosquitos varies from year to year. 1970 was a particularly bad year for the beasts.

The fishing net was most useful and the two days spent by Nord-Vest Fjord were thereby highly nutritious. The guns were primarily for collecting specimens of fauna for scientific purposes, but were also considered to be sufficiently noisy to deter the possible unwelcome visits by inquisitive polar bears.



FINANCIAL STATEMENT

Income

Surplus from sale of 1968 Expedition Reports	21
Income from lectures on 1968 Expedition	30
Personal Contributions	910
Carnegie Trust	450
Mount Everest Foundation	400
Contributions by staff members from University Travel Fund	375
Royal Society	250
Gannoch Trust	200
Personal donation from Sir Herbert Bonar	150
Godman Trust	150
Gino Watkins Foundation	60
Bank of Scotland	50
Royal Bank of Scotland	50
British Linen Bank	25
	3121

Expenditure

Personal return air fares and charter costs Glasgow–Greenland	1366
Air-freight Glasgow–Reykjavik	150
Helicopter charter (2 hours)	350
Incidental costs in Reykjavik & Mestersvig	42
Food	420
Camping and mountaineering equipment	310
Research equipment	85
Sea freight sent in 1969	25
Sea freight sent in 1970 including insurance	98
Personal accident insurance	70
M.E.F. interview expenses	22
Film	40
Gun and ammunition	22
Oil and petrol	20
Miscellaneous expenses	9
Advanced to 1972 Expedition	30
Cash in hand for publication of report	49
Unaccounted for	3
	3121

ACKNOWLEDGMENTS

The Expedition wishes to acknowledge with deep gratitude the assistance of many individuals and organisations without whose support this venture would not have taken place. Many are mentioned in appropriate sections of the text.

We especially wish to thank the Principal and the University of Dundee, and our local benefactors Sir Herbert Bonar and the Gannochy Trust. Substantial support was also given by the Carnegie Trust for the Universities of Scotland and the Mount Everest Foundation.

To the Danish Government we are grateful for permission to visit Greenland and to the Mestersvig personnel of the Statens Luftfartswaesen, particularly the manager, J. K. Hansen, for invaluable assistance in the field; also to Herr Erich Hintsteiner and other members of Nordisk Mineselskab A/S for numerous civilities.

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