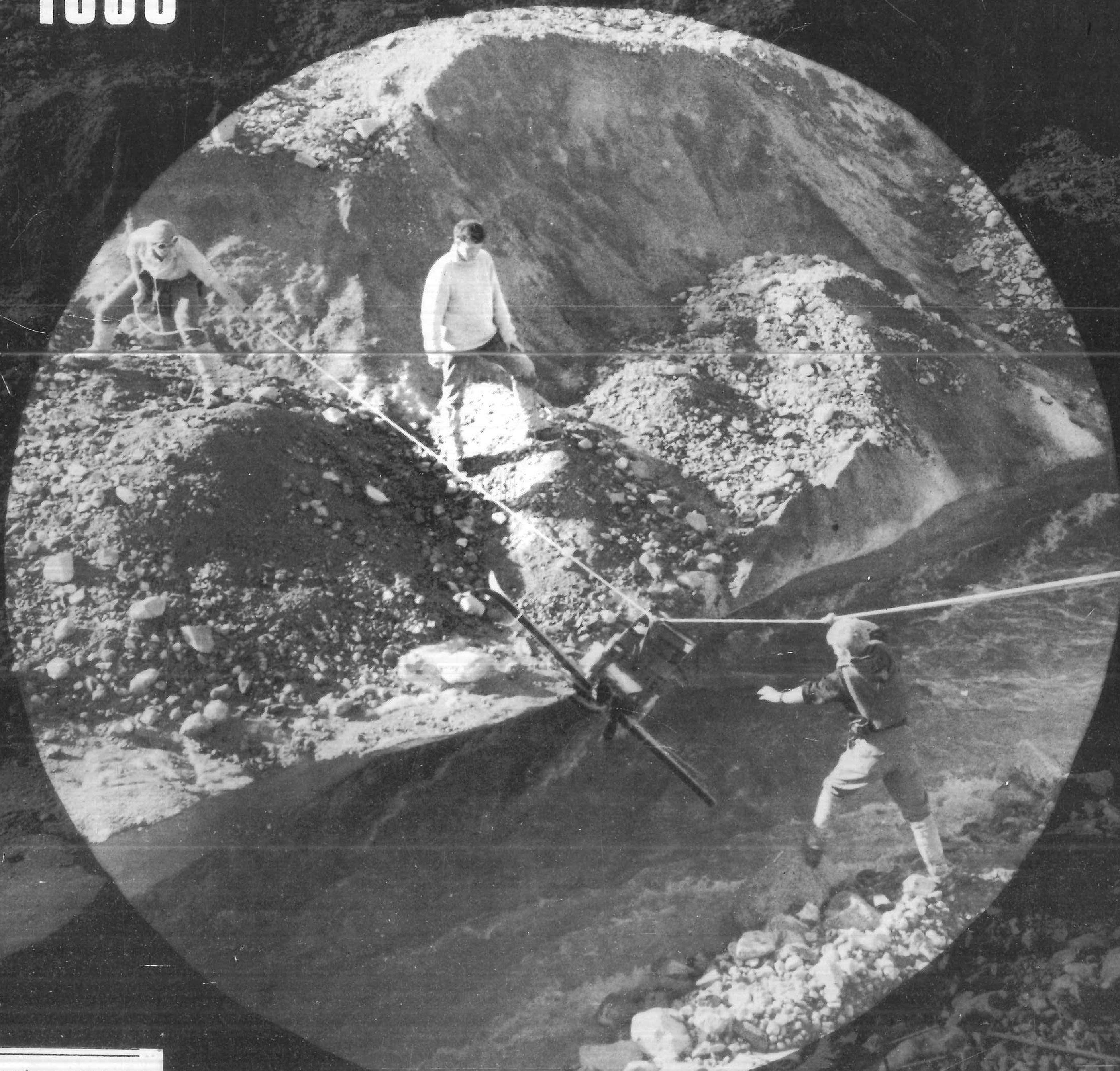
UNIVERSITY OF DUNDEE

SCORESBY LAND EXPEDITION 1968

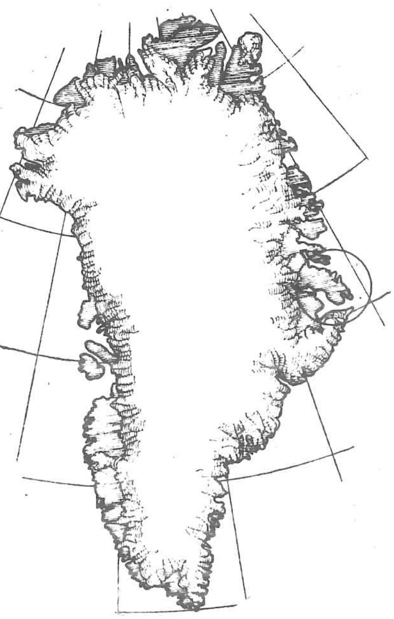


INTRODUCTION

Scoresby Land is a large tract of country on the East Greenland coast lying astride the 72nd parallel of latitude. The great range of the Stauning Alps, characterised by Avogadro's number of jagged granite peaks and glaciers, lies in its eastern three quarters but the remaining strip along its western side, abutting against Jameson Land, has lower hills and areas of rolling tundra. The northern Staunings are well known as they are easy of access, either by boat from Kong Oscar's or Alpe Fjords, or on foot from the Mestersvig airstrip. The southern part of the range has been less visited because of the logistic difficulties created by the long lines of communication, and no party has been able to do much there without air support. It was in these remote southern fastnesses that the expedition operated.

The expedition formed itself around a nucleus of students who had been concerned with the snow survey in Garbh Choire Mor in the Cairngorms. This was a project initiated and carried out by Dundee University students in their spare time and involved making a detailed large scale map of the upper corrie, on which were recorded the annual variations of the perennial snow bed which will eventually turn into our first glacier at the end of the present interstadial. Studies have also been made on the plant and animal life that is thrawn enough to exist in the draughty niches around Scotland's eternal snows. The scientific aspects are described by Berry (1967). These results were not obtained without substantial batterings from wind and rain, blown down tents, bivouacs under dripping boulders, broken car sumps, and the expenditure of considerable sums of personal funds - such is the curse of enthusiasm. The goings-on in the Garbh Choire Mor are now part of the University folklore.

The group gained during these years a great deal of field surveying experience, as well as know-how in catering and the logistics of maintaining a party at the end of a long line of communication. Lurking in the mist on the other side of the Lairg Ghru was R. O'Brien, a geomorphology graduate student who worked a soil movement experimental site on the plateau of Cairngorm itself. The combination of O'Brien and the hard core of the Garbh Choire Mor enthusiasts along with the advice of Dr. W.S.B. Paterson of the Canadian Department of Mines and Technical Surveys resulted in the main research project of the expedition centring on pingos, of which more later.



I.H.M. Smart became leader because he had been to Greenland before and R.C. Allen became the climbing leader, as befitted his talent and experience.

A second group from Dundee and Edinburgh arrived on August 1st with a charter flight organised by Dr. Slesser of Strathclyde University. These were John Watson, Kathleen Watson, Dennis Bethell, (Dundee University), Pauline Topham

(Scottish Horticultural Research Institute) and George Waterston and Irene Waterston (Scottish Ornithologists Club). They operated between Antarctics Havn and Mestersvig. They have kindly sent in their observations for inclusion in this report.

There were four stated objects of the expedition,

1. To carry out a geomorphological study of the pingos, or ice-volcanoes in the Schuchert valley.

2. To carry out certain ornithological studies particularly on the tern colonies of the Kong Oscar's Fjord Coast.

3. To explore the tributary glacier systems between the larger Lang and Roslin glaciers which discharge southwards into the Schuchert Valley.

4. To make a food and equipment store for a future return visit.

These activities are reported here in as general a manner as we can manage, so that it may interest as wide a readership as possible. To this end there is a certain amount of explanatory material scattered throughout the text for the sake of those that are interested in the Arctic, but are not narrow specialists. Most of the scientific material will appear at some tine in grim Technical journals. We hope particularly that our various sponsors will find our account enjoyable and some return on their investment.

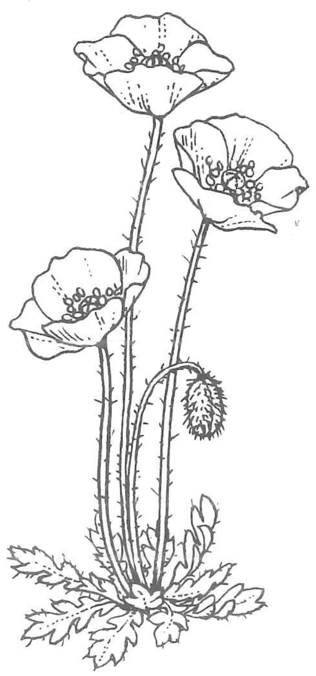
BERRY, W.G. : Salute to the Garbh Choire Mor, Scottish Mountaineering Club Journal, 1967, 28, No. 158, 273-276.

GEOMORPHOLOGY

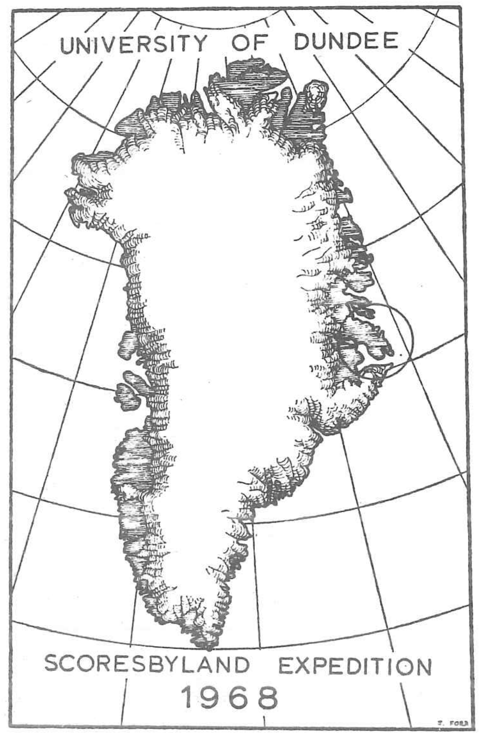
R. O'Brien

C.R. Allen (Appendix 1)

B. Dodson (Appendix 2)



Arctic Poppy



OBSERVATIONS ON PINGOS AND PERMAFROST HYDROLOGY IN SCHUCHERT DAL

INTRODUCTION:

Pingos are conical hills of heaved bedrock or recent deposits cored with massive lenses of injection ice, and are probably among the most striking morphological features of permafrost terrain. They may rise to heights of 50 metres or more above the surrounding terrain, and are found in the active state only in permafrost regions. The accepted theory of pingo origins distinguishes two main types, each associated with its own particular permafrost conditions; a closed system, and an open system or artesian type. The latter is typical of East Greenland between 71°N and 74°N. Here sub-permafrost or intra-permafrost waters, under relief induced hydrostatic pressure, are confined beneath and cause heaving of valley bottom zones of degrading permafrost or talik, emplacing a water body or hydrolaccolith which eventually freezes to form an ice body.

The thermodynamics of open system pingos are not clearly understood. The most important single contribution in this field is that by Muller (1959). Depending on the mechanical properties of the overburden, a hydrostatic pressure of between 6 and 22 atmospheres is considered necessary to cause uplift. The highest artesian pressures which occur naturally extend only into the lower part of this theoretical range, but these are reinforced by the pressures created by the crystallisation of the water body, and Muller suggests that an amplification of the artesian pressure is made possible by a hydraulic lift effect created in talik pipes. In addition both the volume and the temperature of the sub-permafrost water must be such that the thermal properties of the confining permafrost are not radically altered. High discharge springs in the area are not associated with pingos.

On the basis of temperature data from pingo ice and sub-permafrost waters, Muller concludes that the disintegration of open system pingos, without major changes in the hydrological regime, is initiated as a result of the liberation of latent heat during freezing of the water body, and a fracturing and thinning of the frozen overburden under the influence of continued upward pressure, thus permitting the escape of sub-permafrost waters and the penetration of summer warmth. This escape of sub-permafrost waters is usually confined to zones of least resistance at the flanks of the existing ice body, and here it may give rise to satellite pingos or reactivations. Progressive thawing finally leads to the replacement of the ice body by a crater lake fed by sub-permafrost waters. In simple terms pingo collapse is a result of the destruction of the permafrost seal at the basal end of the artesian system. Renewed pingo activity can only occur if this seal is reestablished at the point of emergence of sub-permafrost waters. The literature concerning pingos and other frost mounds has been summarised by Maarleveld (1962).

The observations recorded in this report were made during July 1968. The object of the field work was to obtain detailed descriptive data on the form, structure, and some of the hydrological processes connected with these particular pingos, so adding to the general body of literature concerning pingos, and testing the current hypothesis of open system pingo genesis.

THE ENVIRONMENTAL SETTING

Schuchert Dal drains large areas of the glaciated Stauning Alps and Werner Bjerge south to Scoresby Sund, and is itself partly glaciated. The valley is the topographic expression of the post-Devonian master fault (Skel Fault) which separates the crystalline complex of the Stauning Alps, to the west, from the southward dipping Permian and Triassic strata of the Gurreholms Bjerge (1000 metres), to the east. The Permian is represented by gypsum and dolomite, and the Trias by sandstones and shales. The whole sedimentary mass is cut by numerous faults and has been invaded by basalt dykes which radiate from the tertiary intrusion of the Werner Bjerge, to the north. Although not in evidence in Central Schuchert Dal, in adjacent Pingo Dal these dykes have an important hydrological affect in relation to the pingo formation, by causing a compartmentalisation of ground-water. (Muller, 1959, p. 10).

The region lies within, but close to the southern limit of continuous permafrost. Present climatic conditions vary greatly from year to year but are generally regarded as unfavourable for the conservation of existing permafrost or the formation of new permafrost in most years, (Muller, 1959, p. 36). The depth of permafrost varies greatly, but is generally thicker on slope-crests and tapers off towards valley bottoms. It is certainly absent under the Schuchert Glacier, (Kirschner, 1963). Streams flow all the year round, and the presence of sub-permafrost waters, under hydrostatic pressure, has been verified (Bondam 1955).

THE PINGOS

The pingos are found at intervals of about 2 kilometres along the base of the eastern slope of the valley, coinciding with secondary faults which strike north-east to south-west from the Gurreholms Bjerge. The major elements in the morphology of the slopes of East Schuchert Dal, and some of the pingos have been described by Cruickshank (1965). It would appear that some of Cruickshank's measurements and descriptions need revision and amplification. Five pingos were examined in the present survey. These illustrate various stages in the growth and disintegration of open-system pingos, though they are described in order of occurence, from north to south, along the valley. Profiles were surveyed across all five to provide a sound morphometric basis for the analysis of the descriptive data. The two most interesting pingos were mapped. In addition sections were dug in the crater area of one pingo and details of the surface contacts of and the petrofabric of the ice-body were examined. Discharge rates of pingo springs were measured and samples of pingo waters were collected for later chemical and isotopic analysis.

Pingo 1 (Fig. 1) lies some 2 kilometres downvalley from Lomsø. It is composed mainly of coarse river alluvium and sandstone material from the debris fan of the adjacent valley slope, and forms a hummocky ridge with long axis approximately north-east to south-west. Remnants of at least three pingo elements are identifiable. The whole complex measures 300 metres by 130 metres and rises to a height of 30 metres above the Schuchert River. The pingo presents a steep rectilinear slope to the main channel of the river which is now undercutting the northern and western flanks. The apex of the pingo is cratered and the ice body lies between 1.5 metres and 2 metres below the floor of the crater. The surface configuration of the ice body reflects that of the crater floor. The contact between the ice and the overburden is clearly marked and is separated from the overlying alluvial gravels by a variable thickness of frozen silt, which is regarded as a melt residue from the ice body. On the eastern rim of the crater are two conical projections of light coloured silt, 3 metres in height. These were found to be ice cored at a depth of 50 centimetres. Here the ice overburden/contact is highly contorted and clear ice is interfolded with frozen silts.

Petrofabric studies of the pingo ice mass were largely restricted to the ice/overburden contact zone. It was originally intended to penetrate the ice body, using explosives, but the available drilling equipment failed and charges could therefore not be placed. Using the rubbing technique (Seligman 1949) the fabric of the ice was recorded from six pits in the crater area. For the most part the ice was very pure and transparent. The texture was similar to that described elsewhere for pingo ice (Shumskii 1964), consisting of large granular crystals, with random crystallographic orientation. The largest measured crystal had an area of 58.3 cm^2. The mean crystal size for a total of 400 measured crystals was 2.9cm^2. This tended to decrease towards the base of the silt mounds where large numbers of fractures in the body of the ice were associated with groups of small cataciastic crystals and hexagonal crystals. These changes in crystallographic character were accompanied by increasing amounts of mineral inclusions and air bubbles. This mineral material resembled the silts of the mounds on the crater rim, and the ablation product at the ice surface.

The mounds are interpreted as surface icings, resulting from the forceful passage of sub-permafrost water, accompanied by large quantities of silt, through the ice body. The eruption must have occured fairly recently; fresh samples of Salix arctica were found beneath a thin spread of the silt on the crater floor. During July 1968 there was no observed discharge of sub-permafrost water, but the pingo may be considered to be in an early stage of disintigration; the upper surface of the ice body lies within the active layer of annual thawing, and there is evidence of periodic breakthrough of sub-permafrost water at several points.

Pingo 2 (Fig. 2) is situated at the junction of the Schuchert flood plain and the valley slope colluvium and incorporates material from both sources. It consists of a large central crater and two satellite craters, disposed along a ling running north-east to south-west. The central crater and the intersecting satellite crater to the north-east are occupied by a large lake 75 metres by 85 metres. The isolated south-western crater is a steep sided pit 35 metres in diameter and nine metres deep, which has been beached, and presumably drained, by lateral erosion of the Schuchert River. The pingo is not a conspincuous feature: the highest point is only 16 metres above the river. Outer slopes are low angled but in places slumping has produced steep inner crater walls. On the eastern flank the crater wall has been partly demolished by large scale solifluction movements, so that a small section of the valley slope now drains directly to the lake.

The surface of the lake is 8 metres above the river level and the maximum depth of the main basin is 5 metres. Within the area of the

satellite crater a steep sided sump was sounded to a depth of 11.5 metres. This may be the remnant of a talik pipe and present route of ascent of sub-permafrost waters. Discharge from the lake varied between 57 and 75 litres/min. Peak discharge coincided with periods of low barometric pressure. During the period of observation local surface runoff declined progressively, and at no time was there a measureably surface flow into the lake. A sub-permafrost source is inferred for the lake water.

Pingo 2 had reached an advanced stage of disintegration and there is no evidence of reactivation.

Pingo 3 (Fig. 3) is a low mound of heaved alluvial shingle rising directly from the Schuchert flood plain to a maximum height of 10 metres. It is elliptical in plan measuring 150 metres by 85 metres, the long axis running in a north-north-east to south-south-west direction. The apex is uncratered but the smooth profile is broken by transverse, longitudinal, and annular furrows. These are probably fracture lines associated with the pingo uplift. From a hollow on the southern flank a slick of light coloured silt spreads out onto the surrounding level and is indicative of a periodic flow of sub-permafrost water. Pingo 3 is a relatively young structure and is thought to be actively growing.

Pingo 4 (Fig. 4) is a striking morphological feature. It rises to a height of 24 metres above the Schuchert river and measures approximately 300 metres by 170 metres, the long axis bearing 244° magnetic. The larger eastern limb of the pingo is composed of bedrock which has been broken into large blocks by the pingo forming process. The western limb is composed of valley slope debris and river shingle. Steep slopes characterise all these materials. The crater walls have only been breached by outflow from the crater lake. There is no surface drainage into the lake and during July 1968 there was no observed outflow. The lake measures 46 by 42 metres and has a maximum depth of 7 metres. The profile of the bed is irregular and is probably the result of a fairly recent and rapid collapse. The general freshness of form, would also suggest that this pingo is a recent feature. To the south-west of the main pingo body a low, smooth-profiled mound is regarded as a focus of reactivation.

Pingo 5, (Fig. 5). This pingo is a much degraded feature rising to only 15 metres above the level of the marine terrace, through which it has erupted. The local bedrock has also been involved in the uplift; coarse bedded sandstone, dipping eastwards at 24°, outcrops beneath valley colluvium on the eastern side of the crater lake. The outer slopes of the pingo rise gently to a broad crater rim. To the east there is a break in this rampart which admits valley slope drainage to the crater. The lake measures 95 by 80 metres and is roughly circular. The bottom profile would indicate that a renewed domal warping is taking place beneath the lake surface, and in this respect pingo 5 resembles Goose Pingo on Traill Island (Muller 1969, p. 32).

There is no evidence for an influx of sub-permafrost waters. At the beginning of the period of observation, discharge was only 1.3 litres/min., and thereafter ceased completely, as did surface drainage into the lake. Discharge from the lake takes place via a steep sided gap in the crater wall and the volume of water using this route must formerly have been much greater than at present. Pingo 5 like Pingo 2 has reached an advanced stage of disintegration, and is probably very old. However, unlike pingo 2, the flow of sub-permafrost has ceased and the pingo is entering a phase of renewed activity.

PINGO HYDROLOGY

Samples of water from each of the three pingo lakes were subjected to chemical and mass spectrometric analysis but unfortunately a sample from the ice body of pingo 1 was lost during the return from Greenland. The analyses were expected to yeild information concerning the source of and history of the water.

Chemically the waters were characterised by low concentrations of carbonate and calcium ions and high concentrations of chloride and sodium ions (see Appendix 1). This characteristic is most strongly developed in the waters of pingo 5. These results can be compared with those from other permafrost regions. Data from the Cape Thompson region, Alaska, suggest that high chloride waters are derived from shallow aquifers and surface runoff, (Lamar 1966). In Central Yakutia, U.S.S.R., similar high chloride waters were recovered from the 1750 metre level in a borehole through mesozoic strata (Anisimova 1964). By contrast samples collected by Muller, from pingos in other areas of North-east Greenland, are characterised by very low chloride ion concentrations, and relatively high concentrations of calcium compounds, mainly sulphates, which would indicate a relatively shallow origin for these waters, compared with those of Schuchert Dal.

Epstein has argued that it should be possible to determine the origin and history of natural waters, marine, meteoric or juvenile, from observed variations of the O^{18}/O^{16} ratio (Epstein and Mayeda 1953). It should be pointed out that no positive identification of juvenile water has been made by this method. In the Schuchert Dal analysis the required precision (of measurement for quantity) was unattainable with the unspecialised equipment available. It appears safe to say no more than, that the pingo waters appear to exhibit enrichment in heavy isotopes, relative to 'natural abundance' (mean ocean water) (Appendix 1).

However, this enrichment can be tentatively explained, for O^{18}, by long contact at depth with rocks of mixed silicate type, and for deuterium, by prolonged evaporation from pingo lakes. The chemical and isotopic data together suggest that the pingo waters are derived from deep aquifers, characterised by low rates of transmission and recharge. There is a striking difference in both chemical and isotopic results between the three pingos. These differences would appear to be partly a function of time and support the morphological evidence suggesting the relative ages of the three pingos.

Flow rates for sub-permafrost springs have already been discussed in connection with pingo 2. In this case the flow was within the qualitative limits prescribed by Muller and failed to have a measureable affect on the temperature of the body of water in the lake, the thermal regime of which was almost identical to that of pingo 5.

The linear disposition and common orientation of the Schuchert Dal pingo groups suggests a hydrological connection with the local secondary fault system, such a system being most likely to accommodate deep seated ground waters.

AGE OF THE PINGOS

The upper limit to the edge of the Schuchert Dal pingos is set by the deglaciation of the lower and central sections of the valley. On the basis of a radiocarbon dated study of postglacial delevelling (sea level changes) (Washburn and Stuiver, 1962), Washburn has come to the following conclusions about the deglaciation of the Mestersvig district, to the north; 'The Mestersvig district was open to the sea and therefore deglaciated by 9000-8500 B.P. (before present) and has remained largely free of glaciers since that time. The climate since 8500 B.P. could not have been much more conducive to glaciation than at present. Deglaciation is closely related in time and effect to the Hypsithermal' (post-glacial climatic optimum).

It is likely that the course of events was similar in Schuchert Dal. Marine shells from a 40-50 metre bench in Schuchert Dal have been dated to 7900 ± 350 B.P. (Meyer, Rubin 1965). This date fits well with Washburns delevelling curve for Kong Oscars Fjord and would imply a date of around 8500 B.P. for the 67 metre bench (Cruickshank 1965) through which pingo 5 has erupted. There is no geomorphological evidence to suggest that the Stauning glaciers have extended far into Schuchert Dal during this period. The outermost moraines of the Ivaar Baardson (Roslin) glacier have been dated 1490 ± 250 B.P. (Harteshorne and Shafer 1965).

Age estimates for certain representative pingos in North America fall into two groups dated around 7000 B.P. and 4000 B.P., coinciding with the immediate postglacial period, and a post hypsithermal cold phase (Craig, 1959, Mackay, 1962, Muller 1962). These estimates, however, refer almost entirely to the closed system pingos of the Mackenzie Delta, N.W.T. The numerous open system pingos of Central Alaska are thought to have formed continuously during the last 7000 years, and do not appear to result from any single post glacial climatic fluctuation (Holmes et al., 1968). The lack of botanical or glaciological evidence to support the occurence of major climatic changes in East Greenland in recent times, would suggest a similar continuity of pingo activity from deglaciation to the present day. With the possible exception of pingo 5, the present generation of Schuchert Dal pingos are likely to be fairly recent in origin. In the mountainous terrain of East Greenland pingos are exposed to denudational attack on two fronts; from the river, and from the valley slope and relict pingos at any rate are likely to be but transient features of the landscape. It has been pointed out that disintegration is initiated by endothermic processes causing a breach of the confining frozen overburden. The above mentioned external denudational processes may recreate the required edaphic conditions for further pingo growth by resealing the artesian system.

CONCLUSIONS

The pingos of Schuchert Dal are compound, open system types, related to the ascent of deep seated ground waters along lines of fracture, causing heaving of frozen alluvial and colluvial materials and occasionally, the sandstone bedrock. The examples investigated ranged from active (e.g. pingo 3), to relict forms (e.g. pingo 2 and pingo 5). Pingo 1 represents a pingo in the early phase of collapse and pingo 4 is a relatively fresh form in which complete melting out of the ice body has only recently occured. Pingos 4 and 5 both show signs of reactivation.

All are regarded as being of recent origin. Periods of activity are thought to be related to relatively short term, and highly localised, edaphic changes, rather than to major, long term climatic episodes. The above observations support, rather than contradict Muller's theories concerning other open system pingos in East Greenland.

REFERENCES

ANISIMOVA, N.P. 1964. - On the chemical composition of deep-seated ground water in Central Yakutia - In : Data on the principles of the study of frozen zones in the earth's crust. Issue III National Research Council of Canada. Technical Translation 1088.

BEARTH, P. 1959. - On the alkaline mass of the Werner Bjerge., N.E. Greenland. Meddelelser om Grønland . Bd. 153 Nr. 4.

BONDMAN, J. 1955. - Geology and mineralisation of Mestersvig Area, East Greenland. Part I General Geology. Meddelelser om Grønland. Bd. 135, Nr. 7.

CRAIG, B.J. 1959. - Pingo in the Thelon valley, N.W.T. Radiocarbon age and historical significance of the contained organic material. Bull. Geol. Soc. America, 70 m 509-510.

CRUICKSHANK, J.G. and COLHOUN, E.A. 1965. - Observations on pingos and other landforms in Schuchert Dal, North-east Greenland - Geografiska Annaler Vol. 47 Ser. A. No. 4.

EPSTEIN, S. and MAYEDA, T. 1953. - Variations of O^{18} content of waters from natural sources. Geochimica et Cosmochimica Acta. Vol. 4, p. 213-234.

HARTESHORNE, J.H. and SHAFER, J.P. 1965 - Radiocarbon age determinations of Turf in Ivar Baardsons Glacier. U.S. Geological Survey, Professional Papers 525 p. A 117.

HOLMES, G.W., HOPKINGS, D.M. and FOSTER, H.L. - 1968 - Pingos in Central Alaska, U.S. Geological Survey Bulletin 1241-H.

LAMAR. W.L. 1966 - Chemical Character and Sedimentation of the waters, in : Environment of the Cape Thompson Region, Alaska (Editor Wilimovsky, N.J.) U.S. Atomic Energy Commission. Division of Technical Information.

MAARLEVELD, G.C. - Frost mounds - A summary of the literature of the past decade. Mededelingen van de Geologische Stichting, Nieuve Serie No. 17.

MACKAY, J. ROSS 1962. - Pingos of the pleistocene Mackenzie River Delta area. Geographical Bulletin Vol. 18, 21-63.

MULLER, F. 1959. - Beobachtungen uber Pingos, Meddelelser om Grønland Bd. 153, No. 3.

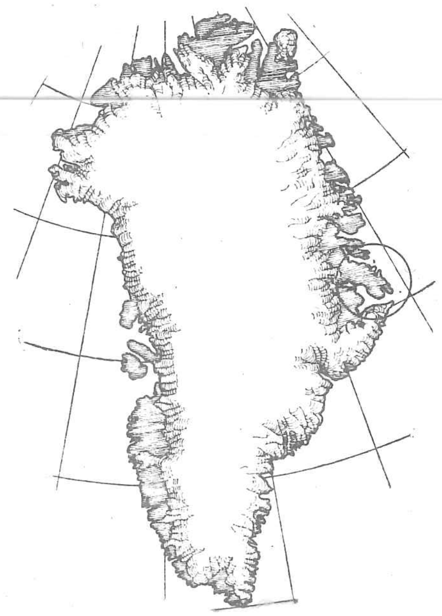
MULLER, F. 1962. - Analysis of Some Stratigraphic Observations and Radiocarbon dates from two pingos in the Macknezie Delta Area, N.W.T. Arctic Vol. 15, p. 278-285.

MEYER RUBIN, 1968. - Carbon 14 age of shells from Schuchert Dal. U.S. Geological Survey, Professional Papers 525, p. A 117.

SELIGMAN, G. 1949. - The growth of the glacier crystal. Journal of Glaciology. Vol. 1 No. 5. p. 254-276.

SHUMSKII, P.A. 1964. - Principles of structural Glaciology. New York.

WASHBURN, A.L. and STUIVER, M. 1962. - Radiocarbon-dated postglacial delevelling in North-east Greenland and its implications. Arctic Vol. 18 No. 1, p. 66-73.



APPENDIX I.

ANALYSES OF PINGO WATERS

(a) METHODS

pH Measurements (25°C)

Beckman "Research" pH Meter with combination glass/AcGl-Ag electrode.

Mg^{2+} and Ca^{2+}

By EDTA titrations: Ca^{2+} alone in 0.08M KCN + 0.2 M NaOH with Murexide indicate: (Ca^{2+} + Mg^{2+}) in 0.08M KCN + NH_3/NH_4Cl buffer to pH 10 with Eriochrome T indicator. Results for calibration solutions within ½% of calculated values.

Na^+ and K^+

By flame emission spectrophotometry (Hilgu); direct calibration curves were linear within ± 2% in the ranges used.

Cl^- and SO_4^{2-}

By conductinetric titrations (Cambridge conductance bridge, ± ½%), with 0.01M $AgNO_3$ and with 0.005 M $BaCl_2$, in neutral solutions, with correction of measured conductances for progressive dilution. Results for calibration solutions within 2% of calculated values.

Isotopic Composition of H_2O

Isotopic Analysis was attempted on an AEI MS-9 mass spectrometer with the necessary resolution of about 10,000. The instrument was a single collector instrument with photo-sensitive chart output bearing three simultaneous traces at different amplifications. Inter-trace ratios were reproducable to ± 5% only and inter-chart ratios within about ± 20% only. Peak height ratios on single traces were reproducible within ± 10% at the best.

(b) RESULTS

SOURCE	PINGO 2	PINGO 3	PINGO 4	MEAN OCEAN WATER
10^3 (Na^+)/mol lit.$^{-1}$	5.7 ± 0.4	5.8 ± 0.3	17.4 ± 0.7	457
" (K^+) " "	0.18 ± 0.01	0.22 ± 0.01	0.30 ± 0.01	9.8
" (Mg^{2+}) " "	1.297 ± 0.016	0.295 ± 0.005	3.467 ± 0.008	56.7
" (Ca^+) " "	0.640 ± 0.005	0.272 ± 0.005	0.005	10.1
" (Cl^-) " "	1.16 ± 0.04	2.82 ± 0.04	13.0 ± 0.1	536
" (SO_4^{2-})" "	1.62 ± 0.04	1.23 ± 0.05	4.83 ± 0.10	27.9
pH	8.05 ± 0.01	7.18 ± 0.01	8.00 ± 0.01	
Atom Ratio $^{18}O/^{2}H$	7.4 ± 0.7	5.1 ± 0.5	9.0 ± 0.9	13.1
Atom Ratio $^{18}O/^{17}O$	2.8 ± 0.6	2.9 ± 0.6	3.5 ± 0.7	5.5
10^3x Atom Ratio $^{18}O/^{16}O$	3.1 ± 0.3	2.1 ± 0.3	7.0 ± 0.7	2.04
10^4x " " $^{2}H/^{1}H$	4.2 ± 1.3	4.2 ± 1.3	7.8 ± 2.4	1.56
10^4 " " $^{17}O/^{16}O$	10.4 ± 3.1	8.1 ± 2.4	18.5 ± 5.6	3.70
10^3 (Anionic$^-$)/mol lit^{-1}*	5.35 ± 0.6	1.9 ± 0.5	2.0 ± 1.0	16.1

* Discrepancy between total positive and negative charge concentrations in the analyses given, expresed as singley charged anion; probably HCO_3^-.

APPENDIX 2

SURVEYING

(i) Method

For the contour maps of pingos 1 and 2 a network of stations covering each pingo was surveyed by triangulation using a base-line surveyed tachiometrically. From these station points radial lines at 10° intervals were surveyed tachiometrically. These points were chosen to be where the slope of the radial was judged to change. The number of lines was chosen so that the points covered the whole pingo evenly. Conspicuous points were also surveyed tachiometrically.

A similar procedure was employed for the profiles of the other pingos. Less stations were necessary for the selected profile lines surveyed.

A bathymetric survey was also made by dropping a sounding line from a raft as it travelled along a rope stretched across the pingo from two surveyed points on the shore.

The surveying for pingo 1 took 6 days, for pingo 2 3 days and the profiles 3 days including travelling.

(ii) Calculation

The positions of the stations were worked out by simple trigonometry. The tachiometric surveying of points on radial lines fixes the positions of these relative to the station and hence to some chosen zero. Assuming that the ground between adjacent points on a line can be represented by a straight line, the points where this line crossed horizontal planes of any spacing can be found. By suitable choice of these horizontal planes the intersection points are points on contour lines with the same spacing.

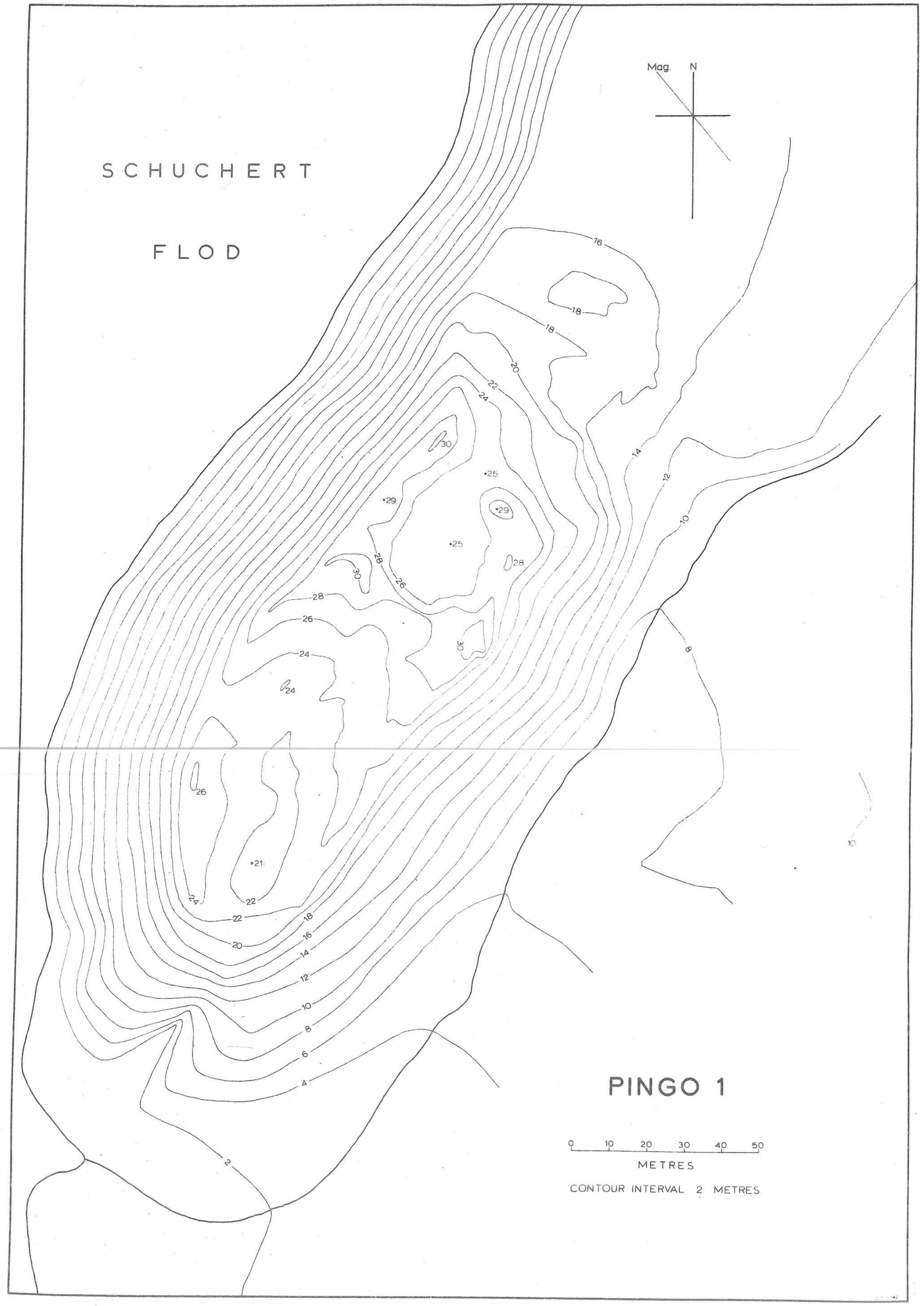
To calculate these contour points from the 1000 points surveyed would have been an enormous task. For this reason an Algol computer programm was written, which reads in values of theodolite angles and tachiometry staff readings and, using the procedure outlined above, computes contour points for each radial line. The data is output in metres and the contour interval was chosen to be one metre.

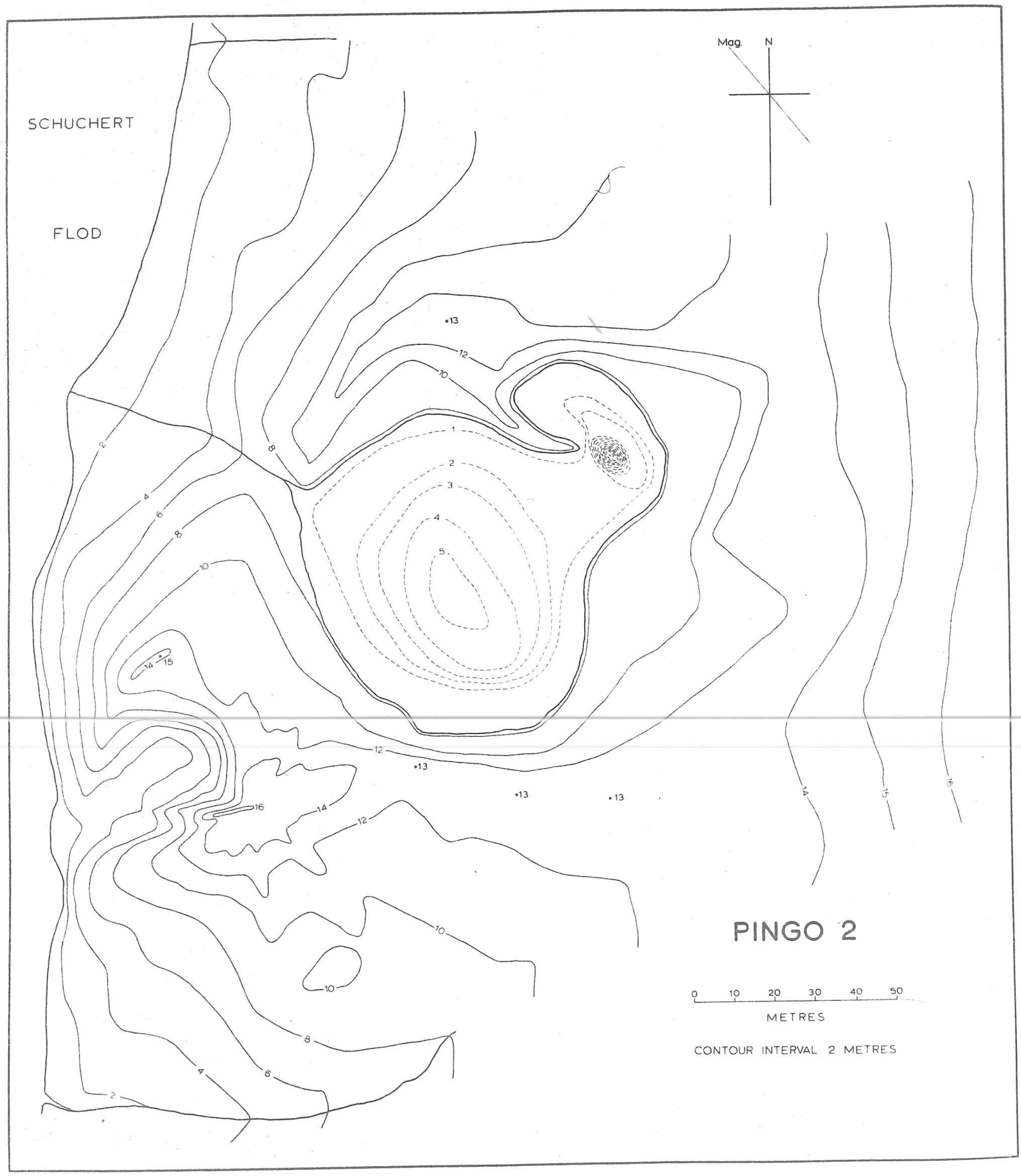
Each point provides six pieces of data and so punching the data cards was a formidable undertaking but much easier and shorter than doing the necessary computations by hand.

(iii) Instruments

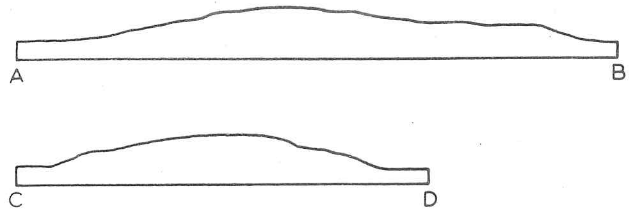
Royal Geographical Society Theodolite No. 502 (Watts Microptic Theodolite No. 1) with tripod. Dismountable 14 foot aluminium tachiometry staff 6' ranging rod.

Dundee University, Elliott 4130 Computer.



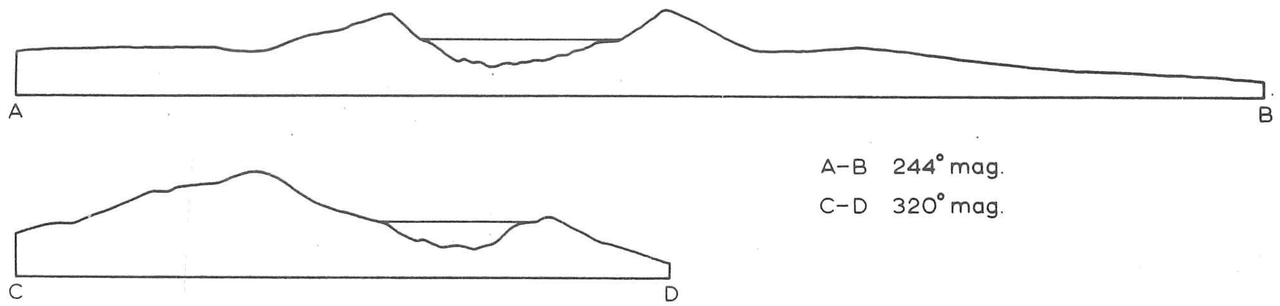


PINGO 3



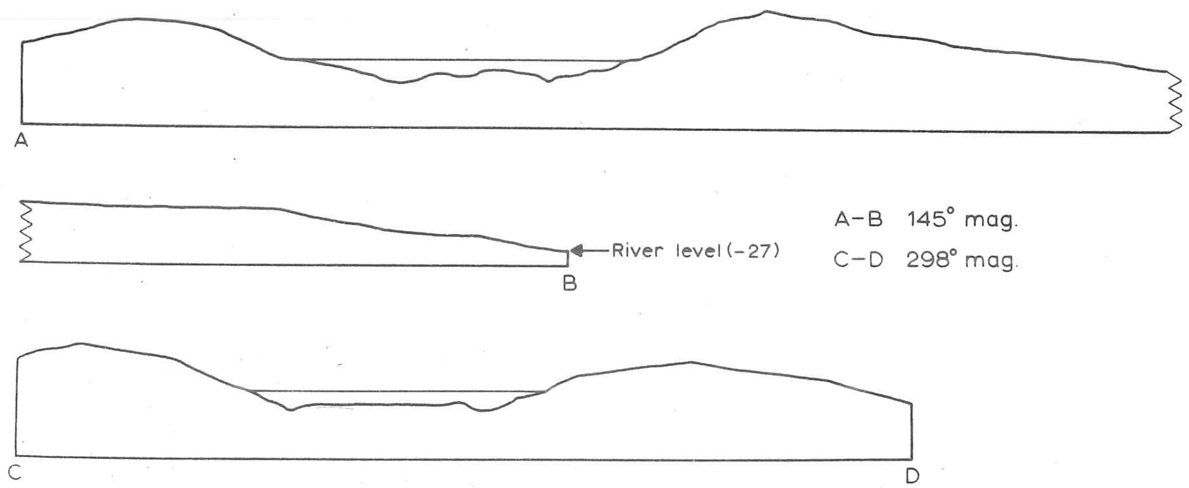
A–B 219° mag.
C–D 309° mag.

PINGO 4



A–B 244° mag.
C–D 320° mag.

PINGO 5



A–B 145° mag.
C–D 298° mag.

BIOLOGY

Iain Smart

George Waterston

Irene Waterston

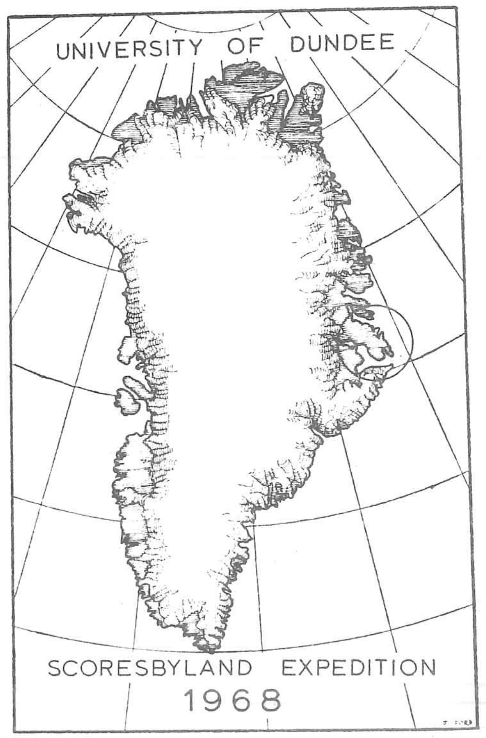
Pauline Topham

Incorporating notes from previous years by :

Douglas Scott

Iain Smart

Tom Weir



BIOLOGY

The Arctic Environment

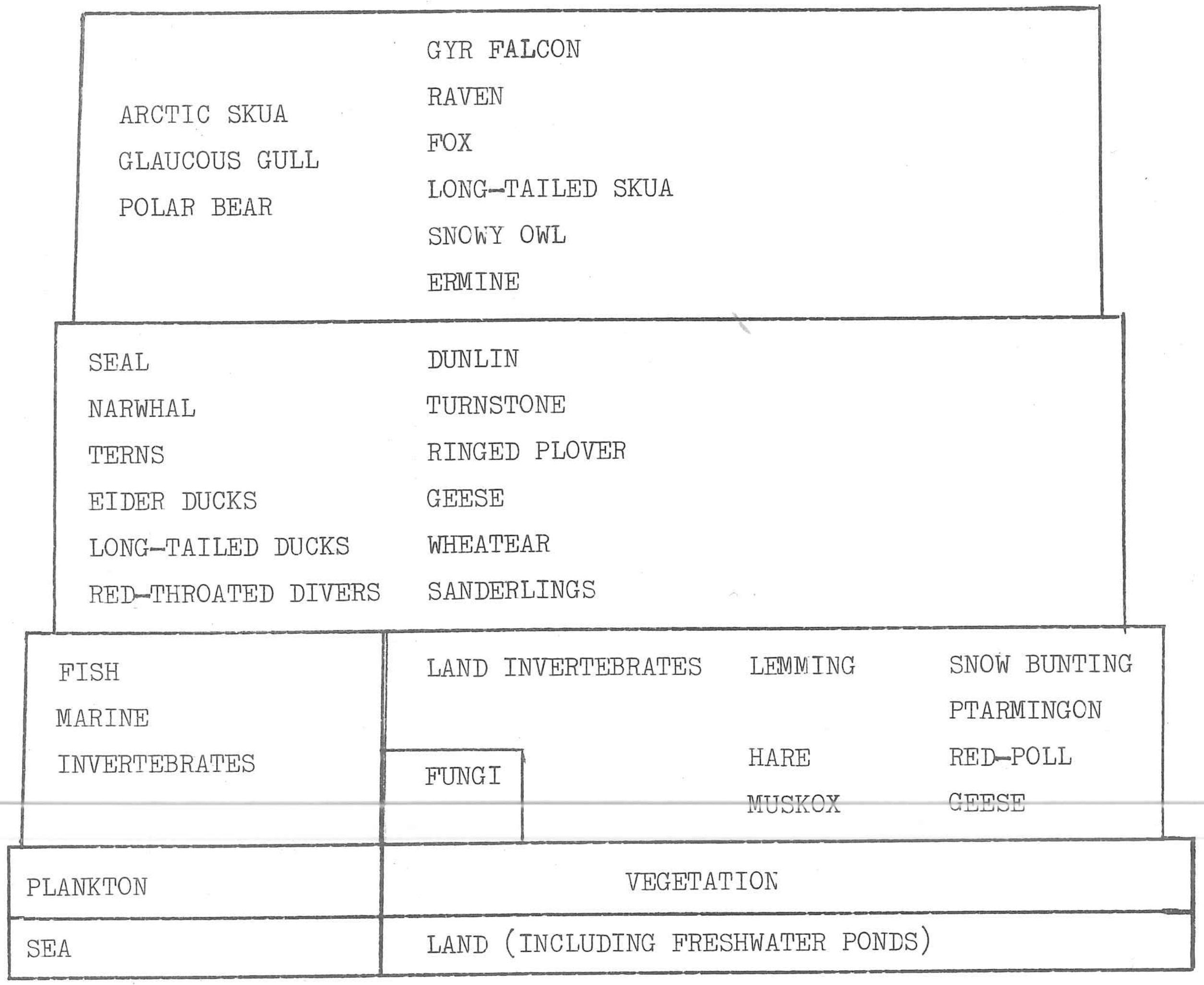
On the high arctic coast of East Greenland the summer season, if taken as the time from which the tundra emerges from under the snow until winter frosts kill back plant growth and insect life, lasts at a maximum from the end of June until the end of August. For most of this time the sun is above the horizon 24 hours a day and afternoon temperatures, particularly in sheltered inland areas, can reach the low seventies Fahrenheit. The energy from this brief period of intense sunshine causes plant life to burgeon. This vegetation forms the base of the energy pyramid which supports the animal life of the region. In summer the animal population is increased by migrants from the south, but there is only enough "winter keep" to sustain a few resident species of non-hibernating animals throughout the year.

The summer and winter energy pyramids are set out in the diagram on the adjacent page. Living directly on the vegetation, are three mammals (lemming, arctic hare and musk ox) and five birds (ptarmigan, red-poll, snow bunting, barnacle and pink-footed goose). There is also a wide range of invertebrates at this level on the pyramid about which the writer knows little apart from recognising flies, bees and at least one type of butterfly. The writer is similarly ignorant about fungi noticing only that types of agaric and boletus are frequent and that they too were in their turn eaten away by unknown organisms. On the next layer of the pyramid are the insectivorous birds, the wheatear, dunlin, turnstone, ring plover and sanderling. At the apex of the pyramid are the parasitic creatures and scavengers (arctic skua and raven and the blood-sucking mosquito) and the frank predators, the gyr falcon, snowy owl, fox and ermine which survive by preying on the second layers.

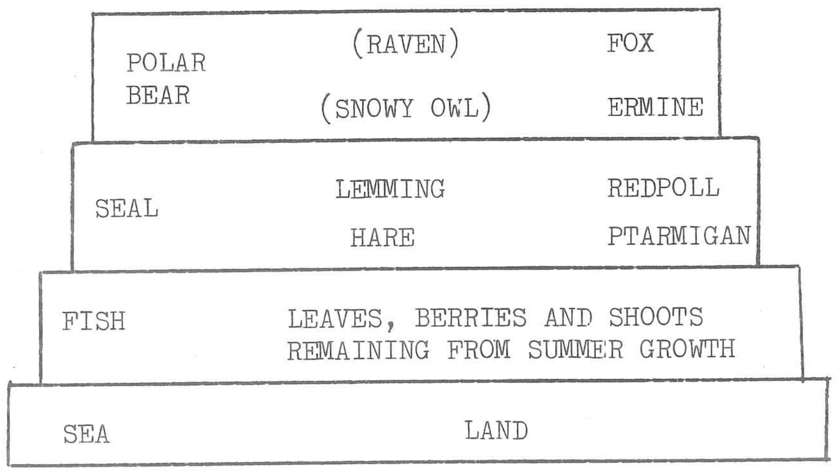
Half of the pyramid is based on the sea, which in Kong Oscar's Fjord remains ice covered until the middle of July, although areas at the mouths of rivers and in the inner fjords open a week or two earlier. During the summer a fairly rich plankton can be seen drifting on the tides. Upon this live marine invertebrates and fish. Arctic terns, eider ducks, long-tailed ducks red-throated divers and the two species of geese live on these marine organisms. Preying on them or their young and eggs are the raven, glaucous gull and fox, while the arctic skua lives parasitically on the terns, forcing them to disgorge the fish they have caught. A variety of seals and one cetacean, the narwhal, also frequent the inner fjords living on fish. An occasional polar bear has been seen, even in summer, in the Kong Oscar's Fjord area when as sometimes happens the pack ice remains longer than usual, or is blown in from the sea by easterly winds.

The first frosts of autumn in the second half of August drive the invertebrate life of the land underground, but on the sea-shore, which cools less rapidly, these animals flourish a week or two longer. At this time the wading birds move down from the tundras to feed on the beaches, and migrating flocks from further north pick up a living on the sea-shore as they progress south-wards. The winter energy pyramid is much smaller. Its base is the berries, leaves and new shoots of the previous summer. The lemming eats these from under the protecting snow where its runs are located along the interface between the snow and ground; the hare and musk ox, either clear away the soft dry snow of winter, or frequent

SUMMER ENERGY PYRAMID



WINTER ENERGY PYRAMID



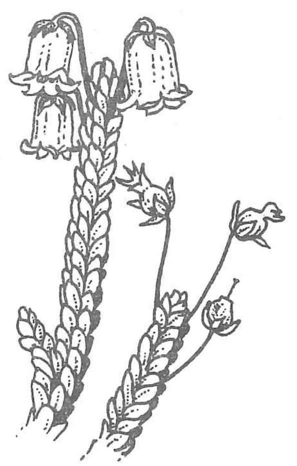
areas where the wind has blown the snow away; these latter areas are preferred by the ptarmigan and red-poll. The fox and ermine remain all winter. The raven usually does so too, living on musk ox carcases or the remains of seals killed by bears, or in the case of Mestersvig, what can be had from the rubbish heap of the radio station.

Each layer of the pyramid is by and large controlled by the layer below. As the base of both summer and winter pyramids is the energy trapped by plant life from the summer sun, the length and brilliance of the summer is critical, particularly the weather of spring and early summer when the maximum food is required for rearing young. A late Spring contracts the base of the pyramid and all the layers above it, the animals dependant on the land for their food supply being more severely affected than those dependant on the sea.

Scoresby Land lies entirely within the High Arctic region of East Greenland, and has both a coastal and continental type of High Arctic climate. The High Arctic is differentiated from the low Arctic by being drier and colder having a mean July temperature of less than $5^{o}C$. and fewer frost free days. It also supports certain characteristic plants and animals which are better indicators of High Arctic conditions than arbitrarily designated levels of rain fall and temperature. Fortunately Scoresby Land is situated in a fairly stable anticyclonic area with a great deal of clear weather and little wind. The coastal regions particularly in July are cool, as the ice lingers here into the middle of the month and temperature-inversion fog banks filter the sunlight. The lushest tundra is found in the inner fjords and valleys where there is a warm dry continental type of climate.

Biological research in the arctic provides information about the way plants and animals adapt to this particular climatic extreme, and also helps to define the physical limits which living organisms can organise themselves to exist in. The last is becoming of particular interest as more information comes in about the physical conditions on other planets. The ecology of the arctic was at one time thought to be simple, and therefore a good place to sort out the relationships of plants and animals to themselves and their environment, but as things have turned out, they are as complicated in the Arctic as elsewhere. What the arctic does show in this respect more clearly than elsewhere is the precarious balance a species is in, when it occupies the full potential of its range. The biological resources of the arctic can support only a few higher animals per unit area. For example, a fox, or a raven (or an eskimo if he is to live without imports) requires tens, possibly hundreds of square kilometres of territory per individual to acquire enough food to survive. When the population density is at the maximum the land will support, minor transiet climatic accidents can decimate animal populations and leave the survivors at subsistance level. This fundamental law of biology seen so clearly in the Arctic is of more than academic interest. Politicians, economists and town planners appear to be dedicated to planning the economy of their countries to take the maximum number of people that the resources will allow. This will produce an arctic type of situation with the same penalties. On future expeditions we hope to take along a few embryo politicians and planners, who on their return will do missionary work among their dangerously ignorant brethren.

THE FLORA OF SCORESBY LAND.



Cassiope tetragona

The Greenland flora includes 590 species about 490 of which are indigenous. Some of these, such as Saxifraga caespitosa and Silene acaulis, are common everywhere in Greenland, while others are characteristically High or Low Arctic plants, and others still have very local distributions. The Scoresby Land flora is of the High Arctic type, the most conspicuous of the characteristic species being Cassiope tetragona, a heath like plant with white bell flowers. Cassiope heath in full flower is one of the sights of the Arctic Summer. It is considered to be one of the best "biological indicators" of the High Arctic climate. Dwarf birch and willow, crowberry, blaeberry, black bear berry, Dryas octapetalla, arctic poppy and yellow mountain saxifrage are the other common and obvious flowering plants of the Scoresby Land tundra.

Arctic plants are adapted to make the most of their short growing season and harsh environment. As well as colonising small sheltered suntraps in the general terrain, the ground-hugging form of the dwarf vegetation takes advantage of the higher temperatures near the soil surface. Cushion-forming plants are particularly good at maintaining high local temperatures. An often-quoted measurement made in North Greenland gave an air temperature of -12°C outside a saxifrage clump and + 3.5°C within. Flowers, particularly dark flowers also function as heat traps, the temperature within being a few degrees higher than in the adjacent air. Some plants can grow while under 3 feet of snow cover, can respire at 0°C, and have roots which can accumulate starch and grow by cell-division while in frozen soil. Most have buds and flowers which can resist heavy frost. Some can miss a growing season altogether or set seed only in favourable years. The morphological and physiological adaptations of arctic plants to resist cold and wind, and to make the most of the available light energy are an interesting study in biological mechanisms sailing as close as they can into the wind of thermodynamic possibility. They have been well reviewed by Bliss (1962).

The expedition had no botanical program but plants were collected for Dr. G. F. Halliday of the Biology Department, Lancaster University from specially requested areas; his report runs as follows:

I have looked through your collections and found quite a number of things we missed on Menanders in 1961, among them, the maritime sedge Carex glareosa, the maritime grass Puccinellia vaginata (known from Alpefjord) the white-flowered dandelion Taraxacum arcticum (from the Skeldal headlands). I was also interested to see the Braya linearis from your pingo site. I think it must be relatively frequent in Schuchertdal but apparently absent to the east and northeast.

REFERENCES

Bliss, L.C. Adaptations of Arctic and Alpine Plants to Environmental Conditions. Arctic 15, (2), 117-144 m 1962.

Bocher, T.W. and Jakolsen, K.H.K. The flora of Greenland, Haasa, Copenhagen, Price £5.

BOTANICAL NOTES FROM ANTARCTIC AND DELTA DALER

EAST GREENLAND 1968 - Irene Waterston.

Our party arrived at Antarctic Havn on August 3rd. Although flowering was far advanced we found Antarctic Dal (August 3rd - 14th) very interesting botanically and regretted that because of the amount of food and gear to be carried, we had to spend so much time back-packing up the north side of the valley and could not explore the shore of Antarctic Havn more thoroughly. We did however, find two specimens of Ranunculus glacialis which has been recorded here before but is not common. On the hillside near our first camp up valley, we also found Phyllodoce coerulea, and we did not see this again. The river flats were quite rich in plants, and it was very satisfactory to find a minute sample of Cardamine pratensis in flower, so often vegetative at this latitude. One of our camps halfway up the Dal was among the Stormviggan, a group of small hillocks and lakes. We spent several nights here and the most interesting plant we found was Tofieldia coccinea, which is less common than T. pusilla. Arenaria ciliata in full flower was another pleasing find. Once we were away from the coastal fog the weather became hot and sunny for the next two weeks. Each day the ground got drier and the plants rapidly passed out of flower. At Elefantbjeargj a promising stream bank was so dry that finding Gentiana nivalis the size of a Bluebell match-head was felt to be a major triumph. Our most significant discovery here was a good specimen of Lycopodium alpinum on the north bank of the main river, well north of its range. Our brief visit to Horsedal August 16th, was interesting, particularly the traverse of the long, rounded ridge south of the river. Composed largely of powdery sandstone and fine shale which blew in spirals at any breath of wind, it looked a barren patchwork of yellow and black, but it had a surprising amount of vegetation where late snow had lain, and where Taraxacum arcticum, Saxifraga tenuis, Draba subcapitata, Potentilla pulchella, P. emarginata and Campanula uniflora were still flowering. Near Sorte Hjorne hut, we found Agrostis borealis, again an extension of range. The lower slopes of Sorte Bjerg above the hut were covered with Betula nana, Salix artica, Arctous alpina, and Vaccinium uliginosum with a fine crop of ripe berries, but even in the few days we were there, these were stripped by the Snow buntings. The whole hillside was now coloured like a Persian carpet with the advance of autumn, the patches of scarlet Arctous brillian against the grey rocks. The night before we left for the Mine (August 24th) the first snow of winter fell, and we did not see clear ground again until we came through the hills to the coast. We spent a final night at Hamna hut on the south shore of Noret to look for one of the few known sites in the area of Matricaria ambigua, which we were pleased to find growing well.

Although August is really too late in the season for a botanical trip in the Arctic, for a very amateur learner it was most exciting and rewarding.

Report on the lichens collected during August 1968 in the Mestersvig area.

by Pauline Topham

Between 390 and 400 specimens of lichens were collected between Antarctichavn and Mestersvig; of these, 64 soil lichens, 16 specimens of yellow Rhizocarpon species and eight sterile leprose specimens were donated to the British Museum (Natural History). A collection of 12 species of Umbilicaria (Rochtripe), representing every species of this genus which had been previously reported from the area, was exhibited at the British Lichen Society's Annual General Meeting in January, 1969, when colour transparencies of lichen habitats were shown. Dr. O. Gilbert of the University of Newcastle upon Tyne is examining the spores from several Solorina specimens by electron microscopy; D.L. Hawksworth, who is specializing in the genus kindly identified 15 specimens of Alectoria. An aquatic Pyrenomycete collected on pebbles in the spray from a waterfall in Fundal has been identified as Thelenidium monosporellum, previously only known from the type specimen collected on soil near Zurich, Switzerland; it is to be the subject of a short note in the Lichenologist, written jointy with Dr. Swinscow, who compared it with the type. Contact has been established with a Dutch worker, Mr. F.J.A. Daniels of Utrecht, who is studying the lichen flora of the Angmagssalik area.

The area of East Greenland north of Scoresbysund was surveyed in 1929 and 1930 by two Norwegian lichenologists (Lynge and Scholander, 1932; Lynge, 1940), working from research shipe, but little or no work has been reported since. The lichen vegetation of the area shows several features of interest. It ascends to considerable altitudes, showing much greater tolerance than vascular plants. The influence of nitrogenous manuring is considerable, despite the absence of large seabird colonies such as are found elsewhere in the Arctic; so that the perches of snowy owls, ravens, skuas, and even snow bunting have an effect. There are some very specialized habitats - driftwood, muskox and reindeer bones (although reindeer are now extinct in the region, their bones and antlers are quite frequently found), whilst the dry climate slows down the decay of animal droppings which are often colonized by Caloplacea species. The slow rate of colonization of soil by higher plants, especially in areas of prolonged snow-lie, accounts for the richness of the soil lichens, both macrolichens and crustaceous species forming extensive communities with bryophytes, which have been little studied, and which are exceptionally well developed in the area. Raised beaches and terminal moraines on some of the smaller glaciers in the Pictetbjerge would offer favourable subjects for lichenometrical dating, though this was not undertaken. Differences in the ecology of several British mountain species found in the area were noticed. Cetraria delisei, a rare lichen of snow beds in the Cairnforms, was common but confined to lowland, coastal sites. Alectoria nigricans and Ochrolechia frigida, both common plants of exposed summit plateaux in the Highlands, were restricted to sheltered lowland habitats.

Bibliography.

Lynge, B. and Scholander, P.F. (1932) Lichens from North East Greenland collected on the Norwegian scientific expeditions in 1929 and 1930. I. Skr. Svalbard Ishavet, 41, 1-116.

Lynge B. (1940) Lichens from North East Greenland collected on the Norwegian scientific expeditions in 1929 and 1930 II. Microlichens. Skr. Svalbard Ishavet, 81, 1-143.

NOTES ON MAMMALS

Arctic animals have their own particular adaptations to the cold environment. Indeed they are so well insulated by efficient fur that their problem is the dissipation of heat during periods of exercise. Keeping the extremities warm is more of a problem but legs, ears, and snouts tend to be shorter than in more southerly forms. Also the tissues of the feet seem capable of remaining viable when they are at near zero temperature. Ther peripheral fat also has a lower melting point consistent with remaining oily at the local tissue temperature. No hibernating animals live at high latitudes. The frost is too great and penetrating, and the length of the winter too long for an animals' food reserves to be eked out even at the low level of consumption in hibernation.

There are five resident land mammals in Scoresby Land, three herbivores, the musk ox, arctic hare and lemming, and two carnivores, the fox and ermine. Two mammals the caribou and the polar wolf, have only recently become extinct. Marine mammals are four types of seal and the polar bear.

MUSK OX Ovibos moschatus.

A lugubrious animal common in Scoresby Land. Small herds of up to 5 animals and occasional single animals were seen by us in each area visited - Delta Dal, Ny Havn hills, Skel Delta, S. side of Alpe Fjord as far as Gully Glacier. The Schuchert Valley is the stronghold of the musk ox where there may be 10 animals in a herd, and the whole valley contains a minimum of 100 animals and possibly as many as 200. Solitary bulls can be troublesome to foot travellers. The members of the Danish sledge patrol regard the musk ox as more of a danger than the polar bear. Certainly, the only potentially dangerous encounter the expedition had with the Greenland wild-life was when a solitary musk ox charged a camp. It was halted in its tracks by the expedition members imitating the howls of the polar wolf, now extinct, but previously the musk ox's hereditary enemy. Presumably the performance awakened ancestral memories in the animal's mind. The series of trials of this musk ox repellant is too small to make any judgement about its general reliability.

ARCTIC HARE Lepus groenlandicus.

The hare remains white all summer and is consequently conspicuous against the brown and green of the tundra. It is more common between 200-500 m than at sea level. They were often seen singly or in pairs and occasionally in groups of up to 8. More common in Schuchert than around Mestersvig.

LEMMING Dicrostonyx graenlandicus

The lemming is a herbivore and in addition to fulfilling its own private destiny, converts vegetation into animal protein for a large number of predators, namely the fox, ermine, snowy owl and long-tailed skua. The lemming population is subject to fluctuations in numbers building up to a peak when it devours all its food supply and the breeding rate falls. The population then decreases to a fraction of its original size much to the dismay of the predators who are obliged to migrate elsewhere, while those that remain in their turn breed less successfully.

In neither 1958, 1960 or 1968 were lemmings very noticeable in Scoresby Land. In each year only two or three individual animals were seen by expedition members. In 1958 and 1960 the impression was that droppings and nests were more numerous and fresher looking than in 1968 although lemming predators (long-tailed skuas and snowy owls) appeared to be more numerous in the latter year. No doubt the predators are a better indication of the presence of lemmings than the heavy-footed explorer.

ARCTIC FOX Alopex lagopus

A common animal which used to support a thin population of Norwegian trappers until the 1950's, when the price of furs declined. Trapping was done in the winter when the pelts were at their best. Dead-fall traps can be found on most headlands and islets along the coast. The large number of coastal Fangsthytte , varying in size from dog kennels to roomy cabins accomodating 3 men, date from these times. The fox is troublesome around camps, the young ones are particularly bold and will take food and any other articles not too hot or too heavy from tent doors or from the sides of people sleeping out of doors. A great wanderer whose tracks we have seen high in the Staunings crossing quite difficult passes. There is a foxes den situated near the Mestersvig airstrip in a low grassy mound on the flat tundra about 1 km NW from Washburn's experimental site about halfway between it and the sea. The den is dug in sandy soil with about half a dozen entrances. Among the small number of animal remains around it was the wing of a skua (probably arctic).

ERMINE Mustela erminea.

The ermine unlike the hare changes in the summer from white to brown. It makes a living by eating lemmings all the year round and nestlings and eggs in spring and summer. One individual seen in 1958 at head of Alpe Fjord, in 1960 in Schuchert and in 1968. Ermines were seen by Dr. K.M. Watson on three occasions at Stormryggen and Elephant-bjerg. Characteristically inquisitive and unafraid coming within inches of an immobile watcher.

Thalarctos maritimus.

POLAR BEAR Ursus maritimas.

Usually lives on the pack ice during the summer and is consequently not seen on either the Kong Oscars Fjord or Scoresby Sound coasts of Scoresby Land. Occasionally, as in 1968, when pack ice remains in quantity in the inner fjords bears may be encountered. A mother and cub were reported by the Danes at the end of August on the pack ice a few kilometers from Mestersvig airstrip. The Cambridge Expedition working north of Ella Island were also much deaved by polar bears in 1968.

SEALS

The commonest is the 'fjord seal' Phoca vitulina, frequently encountered along the coast. The harp seal P. groenlandica, bearded seal, P. barbata and ringed seal, P. hispida have all been shot by the Danes in this area.

REINDEER Rangifer tarandus

The reindeer was once common in Scoresby Land to judge from the number of cast antlers and bones to be found in all areas of tundra, e.g. 20 cast antler were found on the second Menanders Is. alone. According to Alwin Pedersen they were last seen in this area about 1900. Their disappearance is a mystery. Possibly a series of bad winters reduced the population below the viable limit. One theory suggests that a freak winter thaw melting the usually powdery surface snow was followed by the return of the customary hard frost which covered the grazing grounds with an armour plating of ice through which the beasts gazed at their innaccessable food. Whatever the cause it is generally believed that there are now no reindeer on the entire east coast of Greenland. Two of the Scoresby Sund Greenlanders, however, have reported seeing reindeer hoof prints in the snow during a spring sledge journey at Turner Channel about 100 km south of Scoresby Sound. If this is so, then it is possible that there is a breeding population somewhere in the remote regions between Scoresby Sund and the Blosseville Coast.

POLAR WOLF Canis lupus.

The white polar wolf only recently became extinct in East Greenland. Alwin Pedersen encountered wolves every now and then during winter sledge journeys in the 1920's and gave northern Jameson land as their main territory where they were seen repeatedly, singly and in two's and threes. Possibly the extinction of the caribou removed an essential component from their subsistance diet which led eventually to a fall in numbers below the breeding minimum.

ORNITHOLOGICAL NOTES.

Some 20 species of birds are commonly seen in Scoresby Land and about half a dozen other species are occasionally encountered. Four are round-the-year residents, the ptarmigan, red-poll and to a lesser extent the raven and snowy owl. The remainder are summer migrants most of which breed but a few, such as the grey-necked phalarope, may be seen in passage to and from their breeding grounds which lie even further north.

Some of the species occur all over Greenland, and like the red-throated diver and glaucous gull, have no regional variations or physiological races. Other species which have a wide geographical distribution have complicated variations in size and colouring. Some birds have 'dark' and 'light' phases. The percentage of dark individuals in a given population decreasing towards the northern part of its range; for example, the populations of arctic skua and gyr-falcon in Scoresby Land are composed entirely of light phase birds. Other species constitute a 'cline' that is they show progressive gradations of size, and/or colour, and/or plumage affecting equally all members of a population across their range and not just an increasing proportion of individual birds. The gradation does not follow an invariable rule. Although some species forming a cline have a lighter plumage towards the north, e.g. the red-poll and snow bunting, others become darker, e.g. ringed plover and wheatear. The size may increase to the north as in the merganser and wheatear, or decrease as in the ringed plover and eider. In each case Scoresby Land is towards the northern end of the cline. Still other species have local geographical races which are not limited by intermediate forms, as in the case of the ptarmigan whose situation is further complicated by having two moults and therefore three annual plumages.

REFERENCES

Salomonsen, F. Birds of Greenland (3 vols.) Munksgaard, Copenhagen, 1950.

Hall, A.B. Goose observations from Scoresby Land, 1962. Wildfowl Trust. Annual Report 94-97.

COMPARATIVE BREEDING SUCCESS IN 1958, 1960 AND 1968

Ornithological records for three summer seasons are available for comparison. In addition to the notes of I.H.M. Smart for the expeditions in 1958, 1960 and 1968, the notes of Douglas Scott from the 1958 Scottish East Greenland Expedition and of Tom Weir from the 1960 British East Greenland Expedition are incorporated. George and Irene Waterston's notes from 1968 were also made available. The latter cover the months of August and were made during a stay in Antarctic Dal and subsequent journey back to Mestersvig airstrip. The other expeditions covered the coast between the airstrip and inner Alpe Fjord, and in each year the Schuchert Dal was visited. The three years for which we have records cover a "normal" summer (1958), an extremely late one (1960) and an unusually early one (1968), with corresponding variation in breeding success.

In 1968 Spring was early and snowfall in the preceding winter had been light. On our arrival on July 6th the snow line had receded to about 1200m and plant growth was well advanced. Flying young of snow bunting and ring plover were seen within a week of arrival indicating that they must have laid their eggs about the middle of June. The flying young of Dunlin were first seen about a week later (July 15th).

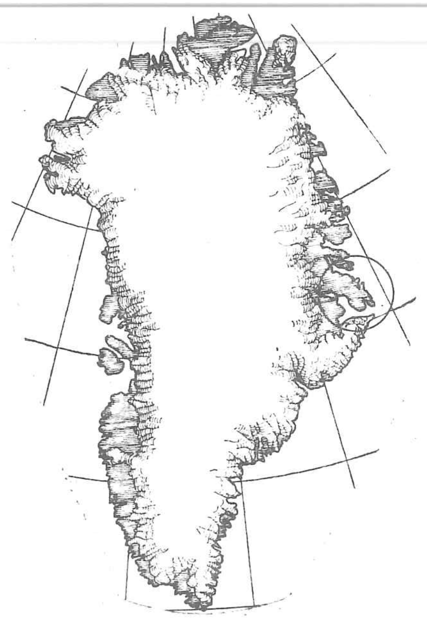
In 1960 on the other hand the summer thaw was slow and incomplete and followed on unusually heavy winter snow. On our arrival on July 5th snow still lay at sea level. July weather in that year was mainly overcast with frequent rainy periods with persistance of extensive snow cover into the middle of the month.

The variation in breeding success in the different years are set out in the accompanying table.

In 1960 with the late Spring and poor Summer, the two species of geese, red-throated divers, turnstones, sanderling, dunlin, glaucous gull and red-poll failed to breed even though in the other years they were common breeding birds. The geese failed because they are early nesters and their nesting ledges in the gorge of the Tunnel River near the airstrip were still snow-covered in early July or because banking of snow made the other ledges accessable to foxes. Red-throated divers presumably suffered from the persistance of ice on their nesting ponds. The waders were unable to breed because their nesting sites on level tundra were snow-covered and the low July temperatures of soil and air kept back the burgeoning of the invertebrates on which they breed. (The conspicuous lack of mosquitoes the whole season was a pleasant indicator of this). The glaucous gulls in the colony at Menanders Is. No. 1 laid a greatly reduced number of clutches and failed to raise any young. It is a mystery what the large numbers of gulls on this coast find to eat even in a good year. Presumably whatever it is, is less available in a bad year. The red-poll and ptarmigan population may have been reduced by the unusually heavy winter snow.

On the other hand, snow bunting, wheatear and ring plover bred with some success and in many cases no later than in 1958 and 1968. This can be attributed to their preference for nesting sites on rocky south facing hillside or ridges where snow cover disappeared early and provided micro-environments for the production of plant and invertebrate life. The ability to breed successfully in bad seasons no doubt accounts for the fact that these three birds are the most common land birds in the area. The other birds which did not suffer noticeably in 1960 were the eider duck and arctic tern. The former is a late nester and is also dependant on the less fickle sea for its food supply. Nevertheless it does not appear to be always immune to bad seasons; Bertram et al. (1933) reported non-breeding of eiders in Hurry Fjord in the bad season of that year . The Arctic Tern cannot nest until the Fjord ice goes out leaving its islands free from visits from foxes. It bred in 1960 but failed in 1968 when fjord ice persisted to some extent all season joining up the islands to the shore from time to time so that enterprising foxes could cross over and eat eggs and nestlings. When the minimum time of incubation and fledging is so close to the maximum duration of summer, periodic failure of breeding is only to be expected and it is probably to be regarded as a normal factor in the Arctic ecological cycle. Different species, however, fail to breed for different reasons.

Bertram, G.C.L., Lack, D. and Roberts, B.B. : Notes on East Greenland birds with a discussion of the periodic non-breeding among Arctic birds. Ibis, 1933, 816-831.



OCCURENCE AND BREEDING STATES OF BIRD SPECIES IN SCORESBY LAND IN THE YEARS 1958, 1960 and 1968.

	1958	1960	1968
Great Northern Diver Colymbus immer	+	-	-
Red-Throated Diver Colymbus stellatus	+++*	+++	+++*
Fulmar Fulmaris glacialis	-	-	+
Pinkfooted Goose Anser fabilis	+++*	+++	+++*
Barnacle Goose Branta leucopsis	+++*	+++	+++*
Longtailed Duck Clangula Liemalis	+++*	+++	+++
Arctic Eider Somateria mollissima	+++*	+++*	+++*
Red-breasted Merganser Mergus serrator	++	++	++
Ptarmigan Lagopus mutus captus	+++*	+*	+++*
Ringed Plover Charadrius Liaticula tundrae	+++*	+++*	+++*
Turnstone Arenaria interpres	+++	+++	+++*
Sanderling Crocethia alba	+++	+	+++*
Knot Calidris canutus	-	-	+
Dunlin Calidris alpina arctica	+++*	-	+++*
Grey Phalorope Phalaropus fulicarius	-	+	-
Arctic Skua Stercararius parasiticus	+++	+++	+++*
Long-tailed Skua Stercoarius longicaudus	+++	+++	+++
Glaucous Gull Larus hypertorcus	+++*	+++	+++*
Sabines Gull Xema sabini	-	-	+
Arctic Tern Sterna paradisaea	+++*	+++*	+++
Gyr-Falcon Falco rusticolus	+++*	+	+++*
Snowy Owl Myctea scandiaca	+		++
Greenland Wheatear Oenanthe oenanthe	+++*	+++*	+++*
Meadow Pipit Anthus praternsis	+*	-	-
Hornemann's Redpoll Carduelis flammea homemanni	++*	+	++*
Greenland Redpoll Carduelis flammea nostrata	-	-	++*
Snow Bunting Plectrophenox nivalis	+++*	+++*	+++*
Northern Raven Corvus corox	+++	+++	+++

+ - indicates seen on one occasion.
++ - on 3-5 occasions,
+++ - more than five occasions.
* - indicates successful breeding.

SYSTEMATIC LIST

GREAT NORTHERN DIVER. Colymbus immer.

The northern limit of its breeding range is reported to be inner Scoresby Land. One bird only was ever seen by us - at Damen, head of Alpe Fjord in August 1958.

RED-THROATED DIVER. Colymbus stellatus.

The most widespread water bird in Greenland, it is frequently seen and heard along the Kong Oscar's Alpe Fjord coast. At this latitude in East Greenland nests with eggs have been recorded in July, downy young at the end of the month and full-grown by the beginning of September. No young were seen in 1960 although adults were about. In inner Alpe Fjord beyond Damen in that year a pair were regularly seen displaying throughout the second half of July on a small lochan about 400 m. above the south side of the fjord but no nest was discovered. Failure to breed that year can be explained by the late melting of the frozen ponds. Only one juvenile was seen in 1958 on a pond near Syd Kap, 20th August. In 1968 a pair with one young was seen on sea at Antarctic Havn on 3rd August, and at the end of the month two pairs with two young each were seen at the entrance to Noret. In spite of its relative frequency it does not appear to have a very high breeding success, perhaps because most of the ponds in the Scoresby Land area appear to be lacking in islets and nests located on the shore are vulnerable to enterprising foxes.

FULMAR. Fulmarus glacialis.

In Greenland the fulmar is a high arctic species thought to belong to a different physiological race from the atlantic population. Common on the outer coasts but seldom seen in the inner fjords. A small colony breeds about 150 Kms South of Scoresby Land on Raffles Island off the southern part of the Liverpool Coast.

One bird was seen in 1968 by G.W. off Kap Syenit on the 3rd August.

PINK-FOOTED GOOSE. Anser fabalis brachyrhyncus.

This species' Greenland breeding range is restricted to the middle of the East Coast, between Scoresby Land and Hochstetter's Foreland, with a single isolated colony at Mikis Fjord south of the Blosseville coast. Known to nest in the Canyon of the Tunnel River near the Mestersvig airstrip. There is no record of it nesting elsewhere in Scoresby Land although it may well do so. Goslings hatch out end of June and are at least a couple of weeks old when most expeditions arrive.

In 1960, according to the airstrip crew, most of Tunnel River population of eggs and goslings were taken by foxes as the Canyon was banked with snow and little open water was present even in Noret at time of hatching. No young and few adults were seen by us in that year. In 1958 flocks of 10-50 were common on coast; also seen in similar numbers in Schuchert Valley. Only 10 young birds were seen in that year. In 1968, the Pink-foot population was greater, particularly at the end of August, when flocks of several hundred were seen on the flats at the head

of Mestersvig inlet and smaller flocks around Mestersvig airstrip. About 30 young birds in all were seen earlier in the season in Schuchert Dal and at Kong Oscar's Fjord.

Our records indicate that it recovers from moult later than the Barnacle, flying birds being uncommon until mid-August, while Barnacles were flying at the beginning of the month.

BARNACLE GOOSE. Branta leucopsis.

Greenland breeding area restricted to High Arctic East coast between Scoresby Land and Germania Land where it is common. The Greenland population appears to winter around the island of Islay on our own West Coast. It is commoner in Scoresby Land than the Pink-foot.

Reported nesting in gorge of Tunnel River near Mestersvig airstrip along with the Pink Feet, and in 1960 suffered same fate but adult birds seen subsequently in greater numbers, flocks of 6-20 flightless birds being present among leads in ice of Kong Oscar's Fjord up to end of July and a flock of 20 flying on August 1st. No young birds seen that year. In 1958 flocks of 6-30 birds with up to half a dozen young in most groups were frequent. Flock of 20 birds first noticed flying 31st July. Flock of up to 100 present around Mestersvig at end of August. In 1968 large flocks of up to 100 birds with 10-20 young were frequent along Kong Oscar's Fjord coast. Flying birds first noticed on 3rd August of that year. Immense flocks of several hundred birds along with Pink Feet present at end of August on flats to north of airstrip. A few old goose nests probably of barnacles were found in upper South Hors Dal and upper Antarctic Dal by G.W. in 1968.

LONG-TAILED DUCK. Clangula hiemalis.

Widespread distribution in Greenland in all unglaciated coastal regions. Arrives beginning of July when first leads appear in fjord ice. Small flocks of 5-20 birds common in all years along Kong Oscar's Fjord coast. No young birds seen in 1960. In 1958 a group of two females with five downy young a few days old were seen on July 25th at the mouth of Skel River. In 1968 no young of the year were encountered.

ARCTIC EIDER. Somateria mollissima borealis.

The Greenland form of the Common Eider differs from the southern form in slight details of plumage and smaller size. It probably represents the northern type of a cline extending from Scandinavia northwards and eastwards to high arctic America. Its range on the East Greenland coast extends up to Germania Land (Lat. 76°N). Records indicate that it is a relatively late breeder for the high arctic, birds in down still being seen by many observers at the end of August.

Commonly seen by us in all years on Kong Oscar's Fjord and into Alpe Fjord in groups of 2-40. Even in 1960 it had a good breeding success, nests and young being as numerous as in the good year of 1968. One in two nests were found on most offshore islets. (Colonial breeding is not a feature of this area).

Clutch size varied from 2-6 eggs. Most striking feature noticed was the spread of the breeding season; birds in down were first seen at end of July and newly hatched birds were still present at end of August. Drakes disappeared about the middle of July.

KING EIDER. Somateria spectabilis.

The range of this high arctic species extends as far south as Scoresby Land. We did not see any drakes in the Kong Oscar's Fjord area and no females were identified as belonging to Somateria spectabilis.

GREENLAND RED-BREASTED MERGANSER. Mergus serrator schiøleri.

The Greenland form is thought to have a slightly longer wing and a broader bill than the more southerly race. A low arctic species sparsely distributed on the East Coast, extending northwards into Scoresby Sound which is considered to be its northern limit. This species was seen by us in each year and it is possible that it may breed in the Kong Oscar's Fjord area.

1960: One duck Menanders Island on 24th July. Duck and drake at Kap Petersen. (Late July). Six ducks at Kap Petersen. (Early August). Two ducks at Kap Petersen. (Early August).

1958: Three females and two males flying over Damen. One female in Alpe Fjord off Shaffenhauser Dal. (3rd August).

1968: Three ducks at Kap Petersen. (August 12th).

NORTH-GREENLAND ROCK-PTARMIGAN. Lagopus mutus captus.

The ptarmigan is one of the most variable of birds, having three moults a year. Moreover geographical variations are present and confusing. Three forms are found in Greenland. L.a. captus found in North East Greenland differs from others in details of autumn plumage and in being slightly larger and heavier.

In 1960 ptarmigan were virtually absent in the Scoresby Land area. Only one hen with about 4 young on the North side of the Skel River were seen by the entire expedition who covered a wide territory during their two months stay. In other years it was common, a few birds being seen each day wherever the expedition travelled through vegetated areas. Flying young 2-12 in a group were seen from end of July onwards.

RINGED PLOVER. Charadrius hiaticula tundrae.

The Greenland Ringed Plovers are smaller and slightly darker than those further south representing the northern end of a cline running from Britain to the high arctic; they also winter further south. It and the snow bunting are the commonest birds in Scoresby Land. An old world species its range extends from Angmagssalik Northwards to Peary Land. During breeding season frequents stoney plateaux and stoney valley sides up to 1000 m. By mid-August descends to coast on migration.

1960. The first young were seen on the 2nd August and they were about the size of the parents indicating that even in a late, poor season

some birds managed to nest up to time. Others, however, did not as a day later a nest with hatching eggs was discovered.

1958. New-hatched young found July, 17th and a young bird still unable to fly on 3rd August.

1968. Young birds able to fly were seen as early as July 12th. No non-flying young were seen after the 20th of July. G.W., however, records a young bird just able to fly on 11th August.

TURNSTONE. Arenaria interpres.

The Greenland birds belong to the European rather than the American subspecies. Compare to the birds in the southern part of the range the East Greenland Turnstones have a slightly longer wing and shorter beak. In Greenland it is a true high arctic species breeding even along the north coast.

1960. One pair and several solitary birds in breeding plumage were seen along the Kong Oscar's Fjord coast up to first week of August. Thereafter some passage migrants in moult. No nests or young birds were discovered in 1960.

1958. Three pairs about 1 Km. apart, were seen along the South side of Skel River near its mouth on 26th July. One pair was accompanied by one partly feathered young. A young bird seen flying inner Alpe Fjord August, 3rd.

1968. Two pairs were seen on South side of upper Schuchert near the uppermost pingo both behaved as if on territory. A nest discovered on level ground 100 m from riverside on the 14th July with 3 eggs in the process of hatching.

SANDERLING. Crocethia alba.

Reckoned to be a common breeding bird in high arctic Greenland, extending as far north as Peary Land. Fairly common in Scoresby Land where it undoubtedley breeds although no nests were found by us. In 1958 and 1968 single birds and pairs were seen on the Kong Oscar's Fjord Coast, in the Schuchert and around Lomsø in July, some being seen in the same area on different days. No nests or young birds were found in either year, however. It is possible that in these relatively good years the young of the year have already left there parents by the time the expedition arrived.

In the latter part of August migrating parties of up to 30 grey birds were common along the coast.

In 1960 only one grey bird was seen throughout the season.

KNOT. Calidris canutus.

The Greenland birds are thought to belong to the European race which differs from the American in certain details of plumage. Scoresby Land is the southern limit of the breeding area of this high arctic species. Not seen in 1958 or 1960. In 1968 one bird near Lomsø Hut on July 15th. It stayed in the same general area for the time of observation but was not seen on subsequent days. Also 2 birds at mouth of Noret (Hamna Hut) on 28th August.

DUNLIN. Calidris alpina arctica.

Schioler's Dunlin is the high arctic form of the old world Dunlin C.a. schinztii differing in detail of plumage and in having a shorter bill. It is restricted to the East Coast where its breeding range extends from the northern low arctic South of Scoresby Land.

In the good years of 1958 and 1968 seen and heard commonly along the Kong Oscar's Fjord Coast around Mestersvig and along side of Schuchert River during the month of July.

Flying young first seen in 1958 near Noret on July 23rd and in 1968 in the Schuchert Valley on July 12th. Did not breed in 1960.

GREY PHALAROPE. Phalaropus fulicarius.

A high arctic species breeding locally on the east coast between Germania Land and Scoresby Land. Only once seen by T.W. in 1960 on 15th July flying inland from mouth of Skel River.

ARCTIC SKUA. Stercorarius parasiticus.

Predominantly a low arctic species which extends into the southern regions of the high arctic. The dark phase, which is the commonest form further south, is considered to be absent from North East Greenland; dark birds in this area are usually found to be juveniles. Small groups and single birds seen from time to time along coast of Kong Oscar's Fjord and into Alpe Fjord in all years. Also seen in 1958 in Nord Ost Bugt near mouth of Schuchert. No nests or juveniles found in 1958. In 1968 two juveniles were seen flying in outer Alpe Fjord on 14th August. In 1960 a nest with a single egg was found at Kap Petersen on the 30th July which was still being incubated on the 21st August. Hatching usually appears to take place at the end of July suggesting that this particular egg was laid too late for successful breeding.

Arctic Skuas were seen robbing glaucous gulls as well as terns.

LONG-TAILED SKUA. Stercorarius longicaudus pallescens.

The Greenland population which is restricted to the high arctic belongs to the American subspecies which is paler than the European. Commonly seen in all years on heaths up to 500-600 m. and also at the coast. No nests or young birds were found in any years. It is said to live parasitically on lemmings which are necessary for its breeding success. As lemmings appeared to be scarce in all three seasons recorded by us this may account for the lack of young. Nevertheless, it is a common bird of the Scoresby Land tundra, (e.g. in 1968 12 birds were seen in the upper 10 Km of Pingo Dal).

GLAUCOUS GULL. Larus hyperboreus.

A common bird found in most parts of Greenland. Adult birds commonly seen in all coastal regions in all years mostly congregating

at river mouths in flocks up to 40. Also single birds seen scouting around far inland, e.g. terminal morraines of Schuchert glacier.

In 1960 the colony on the cliffs of the first Menanders Island was searched on July 24th. 20-30 empty nests and 2 nests containing one egg each were found. These eggs had not hatched by the end of August and no young birds were seen by any party in this year. In 1968, this colony was visited on the 17th August, 22 adult birds were counted, along with 3 flying young, 2 young swimming in the sea unable to fly, and 3 young almost out of down on the cliffs. In Alpe Fjord also in 1968, flocks of 30-40 gulls were present floating on the water at mouths of Sedgewick and Fangsthytte Glacier rivers in company with about a dozen seals on August, 12th. Two breeding colonies on the cliffs of the East side of the larger of the two Archer's Islands recorded by G.W. in 1968.

SABINES GULL. Xema sabini.

This gull is recorded as breeding on the East coast in Young Sound and in Germania Land some way north of Scoresby Land. Further south it has been seen between Mestersvig and Kongebjorg on Traill Island, but has not been proved to breed. In 1968 a pair of Sabine's Gulls were resident among the large tern colony on the 2nd Menanders Island and were seen daily for several days in August. They had no nest and were usually to be found sitting together on the escarpment of the Island. When flying they were often mobbed by terns.

ARCTIC TERN. Sterna paradisaea.

A common coastal bird in all years, breeding in colonies of a few to about 100 pairs on several small coastal islets between Noret and head of Alpe Fjord. It is the subject of a more detailed report elsewhere.

GYR-FALCON. Falco rusticolus candicans.

This bird has a complicated taxonomy on account of geographical and age variations. The white form found in Scoresby Land was relatively common in most years. Seen only once in 1960 being harried by terns as it passed the Menander's Island colony flying south on the 28th July.

In 1958 it was seen more frequently; around Mestersvig, in Alpe Fjord, in Schuchert Valley and, at coast near Nord-Ost Bugt, a young bird was noted on 23rd August.

In 1968 the number of sightings was similar. A young bird flying with a parent was seen at the airstrip on 28th August.

SNOWY OWL. Nyctea scandiaca.

In Greenland, breeds only on the high arctic East coast in the range of the Collared Lemming. None were seen in 1960. In 1958 one bird was seen at the Skel Dal Fangsthytte on the 3rd September and in 1968 one bird was seen in upper Pingo Dal on the 18th July, and another on the 28th August near the Mestersvig airstrip. No evidence of breeding was ever obtained.

GREENLAND WHEATEAR. Oenanthe oenanthe leucorhoa.

The Greenland subspecies is bigger and darker than the European. Chiefly a low arctic bird but extends into the southern high arctic. Fairly numerous in all years, around the Mestersvig Hills and in Schuchert Dal e.g. in 1958 10 family parties were counted by D.S. between Roslin Glacier and the coast during traverse on west side of the lower Schuchert. In 1958 the first fledged birds were seen on the 24th July yet in the bad summer of 1960 flying young were seen on the 13th of the month. In 1968, 3 pairs were found feeding young still in their nests on rocky outcrags in upper Schuchert between 14th and 16th July.

MEADOW PIPIT. Anthus pratensis.

Appears to have colonised low arctic East Greenland from Iceland in the last seventy years or so. First recorded around Angmagsalik about 1903. It probably bred at Cape Dalton near Scoresby Land in 1933 and there is a sight record from Scoresby Land settlement in 1934. In 1958 D. Scott definitely identified a pair with three flying young near Syd Kap on the 21st August.

HORNEMANN'S REDPOLL. Carduelis flammea hornemanni.

One of the three resident species of Scoresby Land. It is fairly common on the hillsides of Alpe Fjord and the Schuchert Valley.

1958. First seen 3rd August on hillside north of Shaffhauser Dal, Alpe Fjord, a pair with one flying young. One or more pairs with broods of up to 7 were seen most days, until end of stay in the Damen-Seftstrom area on 14th August. One pair with 4 young at camp on bluff 5 km up Sefstrom Glacier at about 3,500 ft. Small amounts of berry and seed bearing vegetation among rocks. Common on higher, rougher areas of Schuchert Dal, west side. Also on coastal hills by Syd Kap, at least on pair with young seen in Schuchert - Syd Kap each day from 16th to 27th August. 3-4 family parties with strongly flying young in the Mestersvig-Skel area from 28th August until our departure on 1st September. One pair with 3-4 young at site of camp by Damen, 30th August. Occasionally seen in mixed flocks with snow buntings.

1960. One family party 2 adults, 3 young in upper Schuchert on 25th August. None seen in Damen area of Alpe Fjord.

1968. Family parties commonly seen in upper Schuchert in July, and in August recorded by G.W. in the Hors Dal and Delta Dal.

GREENLAND REDPOLL. Carduelis flammea rostrata.

A low arctic race of redpoll which is believed to winter in Iceland. A family party of this form with six young recorded by G.W. in August 1968 at Elefantbjerg (Antarctic Dal) and one adult near Mestersvig airstrip. (See separate account by G.W. on the overlap of the two species of redpoll).

SNOW BUNTING. Plectrophenax nivalis.

The high arctic Greenland population have slightly longer wings and are whiter than more southerly birds. They are considered to be a phase of a cline extending from Iceland to the Bering Sea. Snow bunting were common in Scoresby Land in all years including 1960. Maximum number of young birds in nest or flying in a family party was five. In 1960 four nests with feathered young were found on south facing slopes between 11th and 13th July when tundra was still 75% snow covered. In the other years some pairs were still feeding young in nest in second half of July, although flying young were commonly seen prior to this. In 1958 cocks started to moult about July 14th and first flock of about 60 seen at Cape Michael on 3rd August. In inner Alpe Fjord snow buntings mixed with redpolls and in one instance a young redpoll was seen food-begging from a snow bunting.

NORTHERN RAVEN. Corvus corax principalis.

The Northern Raven is slightly bigger than the typical form (wing length about $\frac{1}{2}$ cm. greater). Mainly a low arctic bird but extends northwards for some distance into the high arctic. Usually common around seabird colonies and human settlements. It was seen by us in all years in about the same numbers. Single birds and pairs were observed in Alpe Fjord, Schuchert Dal and upper Pingo Dal. At Mestersvig airstrip, in 1960 a group of 5 were seen several times and appeared to reside in a small inaccessible cave high on a cliff to the North of the airstrip near Washburn's experimental solefluction slope. The rocks were whitened by droppings; probably a nesting site.

CLUTCH SIZE AND EGG SIZE IN COLONIES OF ARCTIC TERNS (STERNA PARADISAEA) BREEDING IN ICELAND AND HIGH ARCTIC EAST GREENLAND.

I.H.M. Smart

Introduction

The clutch size of certain species of birds varies with latitude, the average clutch size tending to increase from the tropics towards the poles (1). The increase is related to the available food supply and the variation in the length of day. Other things being equal, the longer daylight in the north permits longer hours of food collecting and the feeding of a greater number of offspring.

It is less well known that the egg size of certain species is also suspected of showing geographical variations. This is in many ways a more interesting variation as not only does the volume of an egg reflect the eventual size of the chick, but its surface area controls the respiratory exchanges taking place between the egg and its environment during development. This can be shown by weighing eggs of different sizes of any given species at daily intervals during normal incubation when it will be found that the weight loss each day by a given egg, is constant. If the weight is plotted against time, a straight line will be obtained, and the slope of the line will be found to be directly related to the surface area of the egg. This is a bit surprising as it might be expected that as the chick grew within the egg, its respiratory activity would increase and weight loss from the elimination of CO_2 and water would increase as incubation proceeded. However, some experiments carried out by Dr. Slesser of the Chemical Engineering Department of Strathclyde University indicate that outward passage of water vapour is the process that is limited by the surface area of the eggshell and there are reasons for believing that this maybe one of the rate limiting factors in the development of the chick. Both the humidity of the environment and the surface to volume ratio of the egg itself may have an interesting relationship to the rate of development of the chick.

The purpose of the project conducted on the 1968 expedition was to measure a population of eggs of the Arctic Tern breeding in Scoresby Land, where the breeding season is critically short and compare it with a standard population of Arctic Tern eggs measured in 1966 in the tern colony of Hjorsey in South Western Iceland, where the climate is temperate and the breeding season longer.

Geometrical Treatment

avian

Certain characteristics of the geometry of the ovarian egg make it relatively simple to compute volume and surface area from three linear dimensions which are easily made in the field (2).

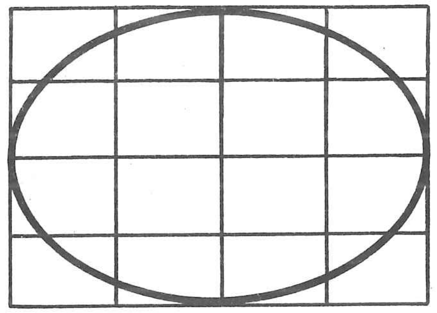


FIG. 1

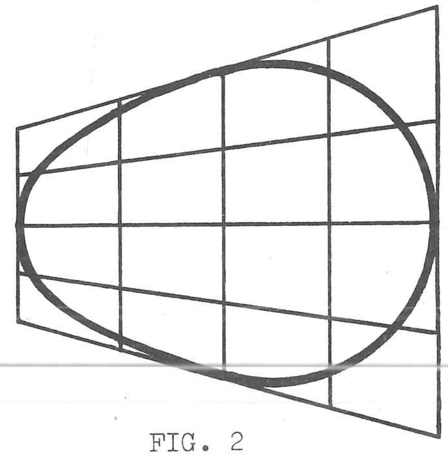


FIG. 2

The curvature of the profile of a typical egg may be obtained by subjecting an ellipse to a linear deformation as in Fig. 1 and 2. The curvature of such a body is rendered by the following modification of the ellipse equation:

$$\frac{x^2}{a^2} + \frac{y^2}{(b+x\tan\theta)^2} = 1 \qquad (1)$$

where a is half the maximum length, b half the breadth at the mid-point and tanθ the gradiant of the mid-point tangent or a measure of the egg's asymmetry. It can be shown that in an ellipsoid, if the length of the minor axis 2b remains constant, then neither change in length of the major axis 2a or change in the value of θ alters the surface to volume ratio of the body. This ratio is an important physiological constant determining the rate of development of the egg, and is a function of a single dimension namely the breadth of the egg at its middle.

In practice it was difficult to measure 2b and θ directly on the egg but the following method of estimating these dimensions using 3 linear measurements was used. First the length of the egg 2a was measured using a Vernier caliper. Then by placing the egg first blunt then pointed end into a second Vernier caliper whose jaws had been shortened to about 1 cm. as in Fig. 1, the diameter of the egg (2R and 2r respectively) was measured at a constant distance k, (the depth of the caliper jaws) from each end. It can be shown (2) that

$$b = \frac{R + r}{2\sqrt{1 - \frac{x^2}{a^2}}}$$

and

$$\tan\theta = \frac{R - r}{2x\sqrt{1 - a^2}}$$

Thus from three easily made linear measurements the unknown b, and tanθ in equation (1) can be found and the equation solved. The volume and surface area of the solid of revolution generated by this curve can then be calculated. At the same time the maximum diameter of the egg 2d was calculated and this was compared with the actual measurement of 2d made on the egg. If the calculated value of 2d differed

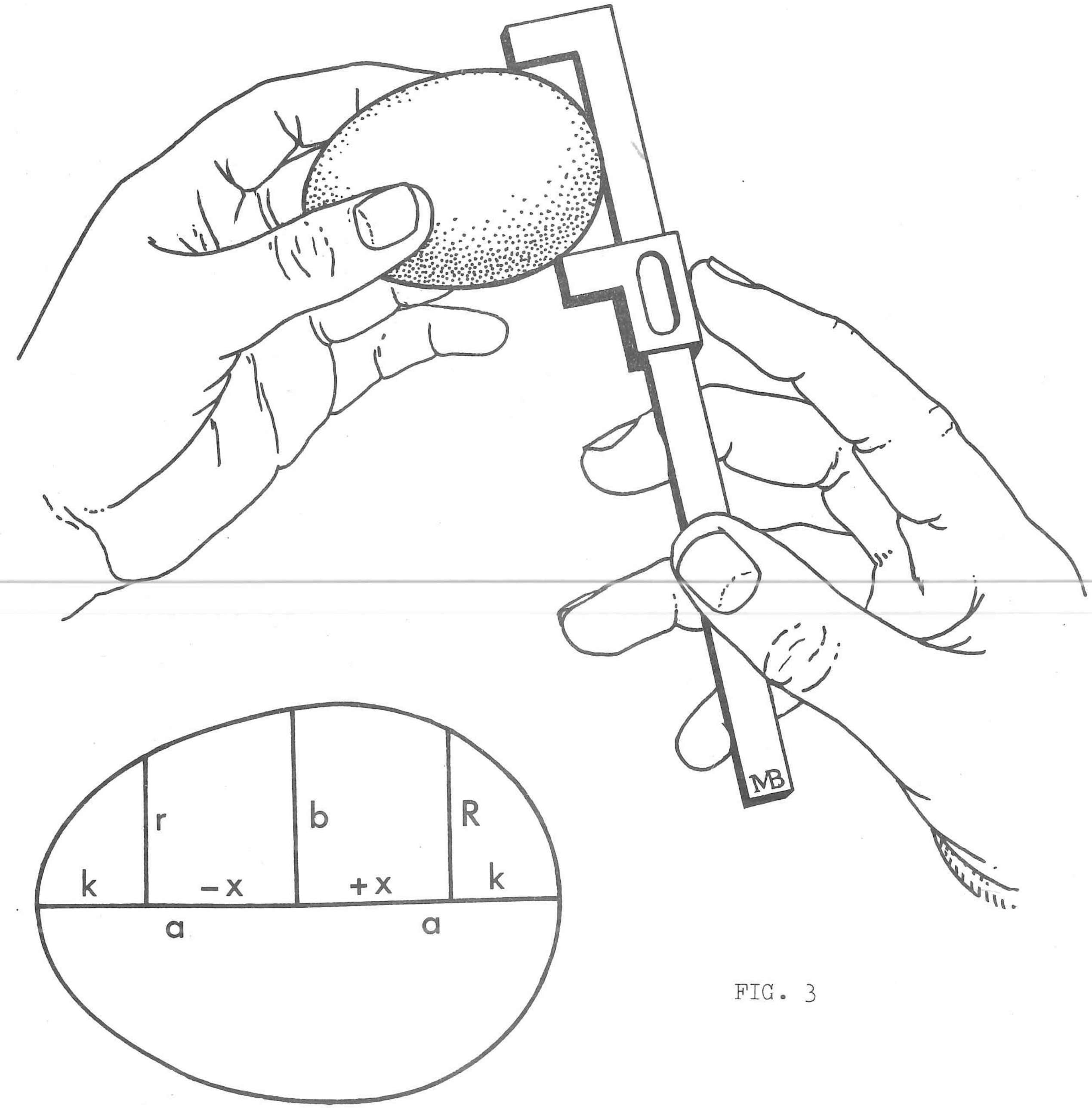


FIG. 3

from the measured value by 2% or more the set of measurements for that egg was discarded. This cross check eliminated mismeasurements and aberrantly-shaped eggs from the subsequent calculation of means.

Statistical Treatment

The Iceland and Greenland Terns lay clutches of one or two eggs. For purposes of comparison each population was divided into the following three groups:

(1) eggs of single clutches.
(2) larger eggs (by volume) of two-egg clutches.
(3) smaller eggs (by volume) of two-egg clutches.

The means and standard deviations for each group were calculated and compared using Student's "t" test.

Colonies

Iceland Colony

Hjörsey Sandur, Myrar, Iceland. This large colony was visited from 19th to 23rd June, 1966. The Tern colony is situated on southern and eastern side of this tidal islet which lies on the south coast of Iceland about 100 Km west of Reykjavik. At this time the eggs were about one week from hatching and all clutches could be considered complete. According to the local farmer in 1966, no eggs had been harvested by local residents.

Greenland Colony

Measurements were made in the colonies of terns breeding on the outer three of the four Menanders Islands, which lies in Kong Oscar's Fjord, about Latitude 72°N, some 15 Kms. north of the airstrip at Mestersvig. Measurements were made between the 3rd and 8th August, by which time clutches should have been complete.

Field Measurements

The length 2a and the maximum breadth 2d were measured first with a pair of standard Vernier caliper which read to 0.01 cms. The length a constant distance from each end was measured with a similar pair of calipers with shortened jaws, whose depth was 1.05 cms. The same calipers were used in both colonies.

Results

Clutch Size. The percentage of one-egg and two-egg clutches in Greenland was 60% and 40% (Table 1) while in Iceland the percentages were 53% and 47% respectively.

Egg Size. In each of the three groups the dimensions of the Greenland eggs are smaller than the corresponding dimensions of the Iceland eggs by what appears to be a significant amount (Table 2). The sole exception is the length 2a, which was significantly different for the eggs of one-egg clutches but not for the eggs of two-egg clutches.

EGG MEASUREMENTS FROM TERN COLONIES IN ICELAND AND GREENLAND

The figures in brackets in the second column indicate the number of eggs rejected when the measured and calculated values of 2d differed by 2%. The value for p is the percentage probability that the difference has occurred by chance as derived from Student's t test. ± limits quoted are in standard deviations.

	Number of eggs measured	2a/mm	2d/mm	2b/mm	Volume/cm^3	Surface Area/cm^2	Surface/Volume Ratio
				1 egg clutches			
Iceland 1966	192 (-15)	40.7 ± 1.7	29.4 ± .84	28.7 ± .87	17. 6 ± 1.33	28. 7 ± 1.53	1.64 ± .05
Greenland 1968	73 (- 4)	39.9 ± 1.7	28.6 ± .77	28.0 ± .77	16. 3 ± 1.31	27. 5 ± 1.58	1.69 ± .05
p%		< .1	< .1	< .1	< .1	< .1	< .1
			Larger egg of 2 egg clutch				
Iceland 1966	167 (-18)	40.7 ± 1.7	29.3 ± .75	28.7 ± .75	17. 5 ± 1.23	28. 8 ± 1.48	1.64 ± .04
Greenland 1968	47 (- 5)	40.3 ± 1.6	28.8 ± .78	28.1 ± .82	16. 7 ± 1.21	28. 0 ± 1.40	1.68 ± .05
p%		< 50	< .1	< .1	< .1	< .5	< .1
			Smaller egg of 2 egg clutch				
Iceland 1966	167 (-14)	39.5 ± 1.6	29.2 ± .82	28.7 ± .84	17.02 ± 1.29	27.94 ± 1.47	1.64 ± .05
Greenland 1968	47 (- 2)	39.2 ± 1.4	28.7 ± .81	28.1 ± .86	16. 3 ± 1.22	27. 2 ± 1.38	1.68 ± .05
p%		< 50	< .1	< .1	< .1	< .5	< .1

Discussion

The tern population of the Kong Oscar's Fjord area appears to lay smaller clutches than the more southerly situated population on the south-west coast of Iceland. The clutch size according to Lack (1) is a function of the available food supply and the length of day available for feeding young. Given these conditions, clutch sizes increase with latitude. In the Kong Oscar's Fjord area these advantages may be counterbalanced by the critically short period available for breeding. Until the sea around the islands on which the terns breed is clear of ice, no egg laying is possible because of the predations of foxes. This occurs at the earliest, sometime in the third week of July, leaving a maximum of 8 weeks for incubation and fledging and preparation for the southerly migration. It may be that under these circumstances concentration on feeding fewer offspring more frequently, promotes a rapid growth rate, which is biologically more advantageous than greater numbers.

The Kong Oscar's Fjord population also lays on the average smaller eggs than the Icelandic. The difference in volume is small (of the order of 1 cc) but appears to be statistically significant at the .1% level. It is interesting to note that the mean value for 2b and therefore the mean value of the S/V ratio is practically the same within each colony whatever the volume of the eggs, but significantly different from the mean of the other colony. The variation in volume is thus a function of the variation in the length of the egg rather than in its breadth. As no correlation was found between 2b and volume, this suggests that the diameter of the uterine proportion of the oviduct is slightly less in the Greenland birds. It is known that younger birds lay smaller eggs than older birds of a population (3) and this may reflect a younger age structure in the Greenland colonies. On the other hand it may represent a genetic characteristic of the Greenland birds. In which case, the resultant increase in the surface volume ratio may have some adaptive significance, as this increases the rate of weight loss during incubation and may be associated with an increased rate of development, as suggested in the introduction.

(1) Lack, D. The Natural Regulation of Animal Numbers, Chapter 4. Oxford University Press, 1954.

(2) Smart, I.H.M. The method of transferred coordinates applied to the deformations produced by the walls of a tubular viscus on a contained body: the avian egg as a model system. J. Anat. 1969, 104, 507-518.

(3) Preston, F.W. Variation of egg size with age of parent. Auk, 1958, 75, 476-477.

GREENLAND REDPOLL *Carduelis flammea rostrata* BREEDING IN HIGH ARCTIC REGION

By George and Irene Waterston

(Scottish Centre for Ornithology and Bird Protection, Edinburgh)

Salomonsen (1950) states that the Greenland Redpoll *Carduelis flammea rostrata* is a Low Arctic breeding bird and has never been found breeding in the High Arctic region in Greenland where it is replaced by Hornamann's Redpoll *Carduelis flammea hornamanni*. He records however that the boundary between the breeding areas of these two birds has changed in recent times. Owing to the amelioration of the climate, the southern form *rostrata* has extended its range considerably to the north, while the northern form *horemanni* has withdrawn correspondingly.

The Greenland Redpoll has now occupied the whole Low Arctic region on the West coast. This is also the case on the East coast where however no distributional change has been noted. According to Salomonsen, *rostrata* is one of the commonest breeding birds in the Angmagssalik District, breeding northwards to the Blossoeville Coast. Degerbøl and Møhl-Hansen shot an adult ♀ at the head of Ravn's Fjord (Lat. N. 68° 30'), on 26th July 1932, and several young birds were also seen in this locality which constituted the northernmost breeding-place on the East coast.

Hall (1966) saw only *hornemanni* in 1962 in the Holger Danskes Briller/Nordost Bugt area of Jameson Land. Hall and Waddingham (1966) saw *hornemanni* in All days Dal and Upper Pingodal in 1963 - but no *rostrata*.

As members of the Dundee University North Scoresby Land Expedition, we spent August 1968 in Antarctic Dal; Deltadal; and Mesters Vig areas. On 11th August we saw a family party of two adult Greenland Redpolls with six young near Elefantbjerg, Antarctic Dal. The young birds were soliciting food from the adults. Later, on 19th August, the party was reduced to six birds. The birds were much darker than *hornemanni* and showed the characteristic dark striations on the flanks. We are both familiar with this form on autumn migration at Fair Isle, (See Williamson, 1956). A single adult was seen near Mesters Vig Airstrip on 30th August.

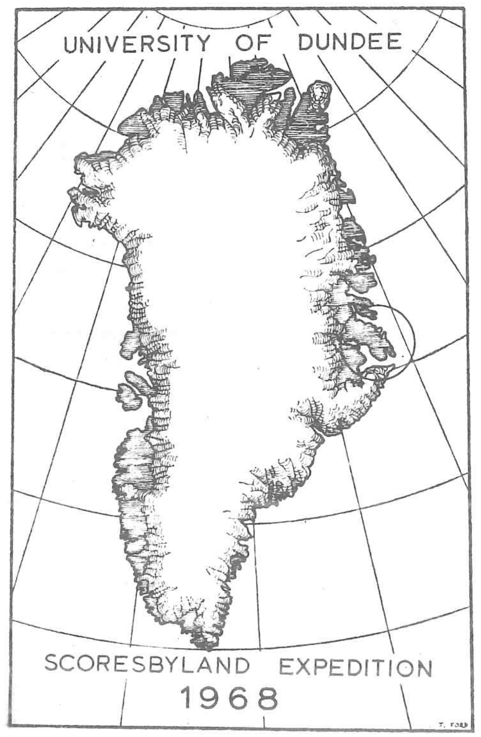
The family party seen by us at Elefantbjerg must have been reared locally. At Lat. 72° N. this is apparently the most northerly record of breeding on the East coast of Greenland and the first record of breeding in the High Arctic Region.

Hornemann's Redpoll was also encountered during our visit. A family party of two adults and two juveniles was seen in Horsdal on 16th August. Two adults at Sortebjerg Hut, Deltadal, on 24th August; and a family party of two adults and three juveniles at Hamna Hut, Noret, on 29th August.

Salomonsen has referred to the tameness of Redpolls in Greenland at the close of the nesting season. All the birds seen by us were not only tame but inquisitive of man; on many occasions Redpolls would fly towards us from quite a distance and fly twittering around us at a range of a few yards.

TRAVEL AND EXPLORATION

R. HEYWOOD



REFERENCES

HALL, A.B. 1966: The Breeding Birds of an East Greenland Valley 1962 - Dansk Ornith. Foren. Tidsskr. 60: 175-185.

HALL, A.B. & WADDINGHAM, R.N. 1966: The Breeding Birds of Orsteds Dal, East Greenland, 1963 - Dansk Ornith. Foren. Tidsskr. 60: 186-197.

SALOMONSEN, F. 1950: Gronlands Fugle (The Birds of Greenland), Vol. 3. Copenhagen.

WILLIAMSON, K. 1956: The Autumn Immigration of the Greenland Redpoll Carduelis flammea rostrata (Coues) into Scotland. Dansk. Ornith. Foren. Tidsskr. 50: 125-133.

Melandrium affine

EXPEDITION ITINERARY

July 1st - 4th	From Leith to Reykjavik by M.V. Gullfoss.
July 4th - 6th	Camp in Reykjavik.
July 6th	Leave Reykjavik and arrive at Mestersvig airstrip.
July 7th	All depart Mestersvig by lorry to disused mine at Blyklippen. Walk to Sorte Hjorne hut in Delta Dal (5 hrs.)
July 8th	Cross Mellom Pass to Malmbjerg mine (12 hours).
July 9th	Bad weather. Stay at Malmbjerg.
July 10th	Descend Schuchert Glacier, cross Sirius Glacier, and struggle through morraines to tundra on west side of Schuchert, thence to Lomsø hut (12 hours).
July 11th - 27th	Work on pingo project on east side of Schuchert.
July 21st - 28th	Advance party reconnoitre Gannochy glacier, climbing two peaks, and finding route into Roslin system.
July 28th	Gannochy party return to Schuchert and rendez-vous with Pingo party. Dodson dislocates shoulder crossing Schuchert River.
July 29th - 31st	Smart and Petit to Mestersvig. Dodson and Runcie (both injured) as far as Sorte Hjorne.
July 30th - 4th August	Heywood and O'Brien relay supplies from Gate of Gannochy to Nevis camp. (14 km. and 1100 m.).
August 5th	Heywood, O'Brien, Carvell ascend. Dudhope
August 6th	Petit and Allen arrive from Mestersvig.
August 7th - 8th	Relay supplies to Eagles Eyrie 400 m further up Gannochy.
August 9th	Petit, Carvell, O'Brien, and Heywood ascend Bonar Bjerg from Nevis Camp.
August 10th	Transfer camp to Eagles Eyrie.
August 11th	Reconnaissance crossing of Courier Col by Petit, Heywood and O'Brien. Ascent of Wedge Peak
August 12th - 17th	Heywood and O'Brien take Carvell to other side of Mellom Pass. Carvell return to Mestersvig to fly out for examinations.
August 13th	Ascent of Wedge Peak.
August 14th	Camp moved to Dalmore Glacier
August 15th	Ascent of Pinnacle Peak.
August 16th -20th	Snowbound at camp on Dalmore Glacier.
August 21st	Retreat down Roslin Glacier to Schuchert Valley
August 22nd - 23rd	Reach Malmbjerg in poor weather.
August 24th	Rest day at Malmbjerg. Smart brings boat from airstrip to Kinlochmestersvig.
August 25th	Cross Mellom Pass and rendez-vous at Sorte Hjorne.
August 26th	Petit and Heywood by boat with heavy equipment to airstrip. Others walk back via Expedition Hus.

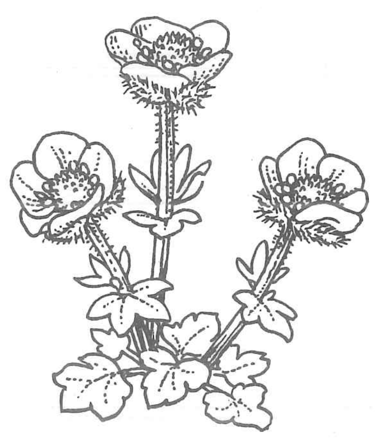
SCOTLAND - GREENLAND

From Leith to Reykjavik, and return by M.V. Gullfoss of the Icelandic Steamship Company. Outward by 2nd Class on 1st July. Return by 3rd Class on 1st September. This vessel is booked up over a year in advance. It is the cheapest way to get to Iceland and provides a pleasant, well fed three-day voyage.

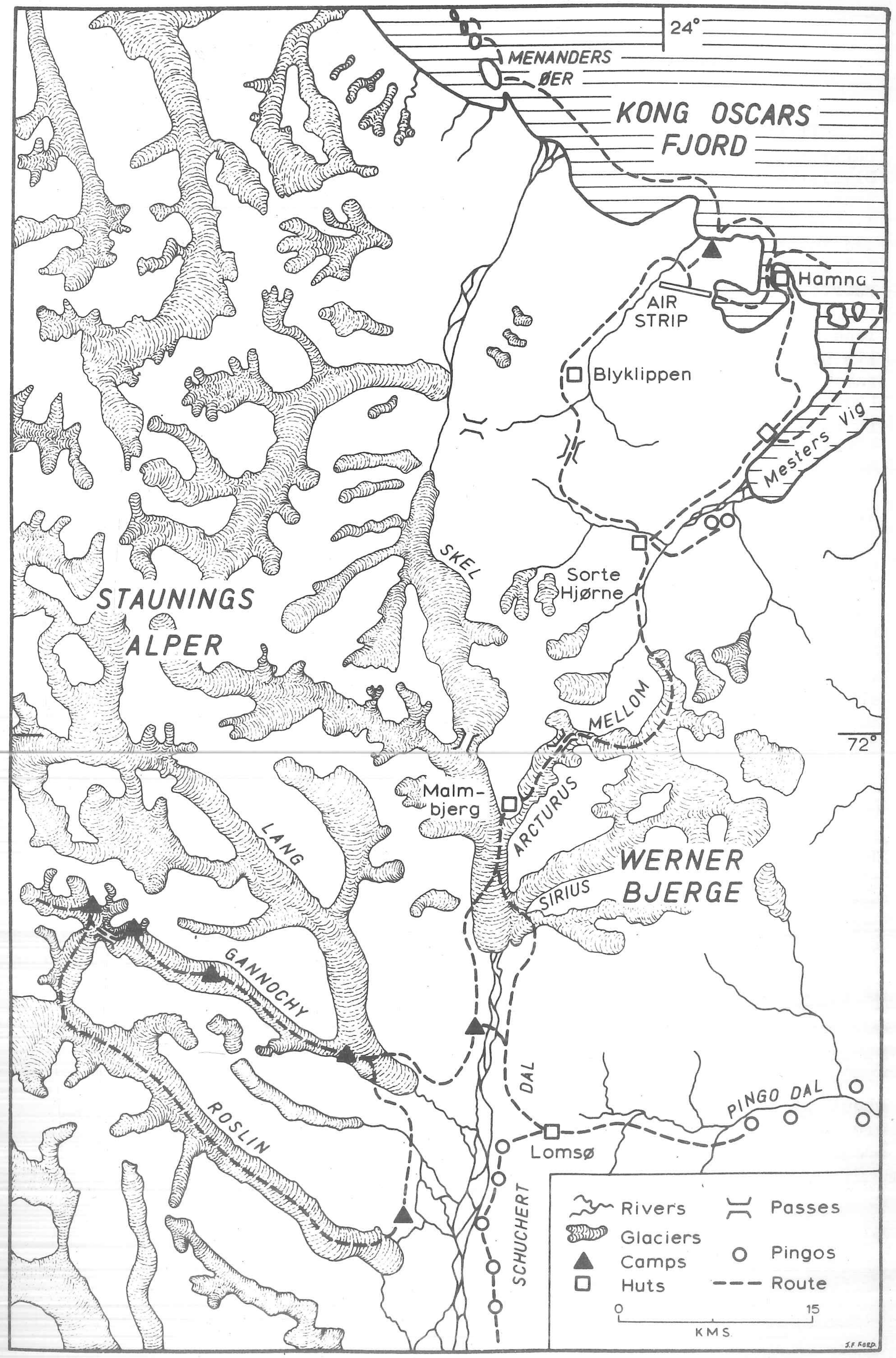
In Iceland the expedition camped in a well-known hanger at Reykjavik airport and each evening we were entertained by Olafur Gudmundsson and his daughter Lara and her friend Inge, the girls being students at Dundee University. A picnic with Icelandic delicacies by the side of Thingvellirvatn at midnight in still cloudless weather remains an indelible memory..

From Reykjavik to Mestersvig, East Greenland on July 6th in 2½ hours by chartered DC 6B of Icelandair. The outward charter was administered by Dr. Peter Friend of Cambridge, and the return charter by Dr. Slesser of Strathclyde University to both of whom we are indebted. Dr. Slesser's outward charter flew in on August 1st with a large number of small expeditions. These expeditions combined with the Dundee and London groups for the return journey on the 31st August. This arrangement made it possible to fly with a full payload in both directions.

Three cases of provisions were shipped up to Mestersvig via Copenhagen and arrived there at the end of July. The food came in handy at the end of the expedition and some was left for a return visit in 1970.



Ranunculus sulphureus.



THE JOURNEY TO LOMSØ OVER THE MELLOM PASS.

It is generally possible to hire a lorry, as we did, to take a party from the airstrip along the 14 km of road to the now disused Blyklippen Mine. From here it was a 5 hour walk along a bulldozer track over a 1000 m pass to the well-appointed hut at Sorte Hjorne. A couple of 100 m below the hut a bulldozer trail was picked up which led through the tedious moraines of the receded Mellom glacier to within 1 km of the glacier snout. A half-hour struggle across the shortest distance between road and glacier brought us to the glacier ice, after which travel on the glacier was easy. The Mellom Pass leading to the Arcturus Glacier lies about 8 km up the glacier, not at its head but on the true right side, just where the glacier turns fairly sharply to the west. The slope up to the pass is fairly steep (200 m approx), and in 1968 was badly crevassed, although in some years it is a straight-forward snow slope. Thick soft snow was first encountered at this final slope enhancing the danger of the crevasses. On the other side of the pass the descent was easy and skis were used to within a couple of kilometres of the jumbled buildings of the Malmbjerg mine. The journey took us 12 hours, an unfit party carrying about 40 lbs each. Shelter was found in a couple of disused huts. The next morning we found about a dozen Danes (North-miners and Geodetic Surveyors) in other huts. The next leg of the journey has increased in difficulty over the last few years as the Schuchert glacier has receded, leaving enormous unconsolidated moraines and deep gorges have been cut in the decaying ice of the glacier snout. It is fairly straightforward getting to the tundra on the west side of the Schuchert although even here getting off the ice onto the unconsolidated moraines has its moments. It is best to get onto the nearest tundra to the dry glacier as indicated on the map.

It is more difficult to reach the east side of the Schuchert valley in the warm weather of July as the ice gorges and run off streams are a problem. Probably the best route is to cross the snout of the Mellom above Malmbjerg and then across the morraines to the Sirius glacier. Cross this without descending much, and then climb onto a small unnamed glacier. Cross this glacier and then make your way as best you can among the thrice-accursed unconsolidated boulders of the left side of the receded main glacier for a few kilometres, climbing up to a small valley between the old lateral moraine and the mountain side. We made the mistake of going too low and getting tangled up in the fearsome ice gorges, one of which was about 200 feet deep. In July the above route is the best but later in the season a more direct route is possible when the streams are lower. From the first tundra to the Lomsø hut we took about 3 hours more. It involves a slow climb of about 300 metres. Just before the hut there is a deep gorge which can be crossed at the same altitude as the hut. Our time from Malmbjerg to Lomsø was 12 hours.

THE TIME SPENT AT LOMSØ

Lomsø was our base for our research programme. There is a small hut about 12 km west of the lake belonging to a mining company, and it is still sometimes used by its geologists as a base for prospecting the surrounding mountains. It has a bedroom with two bunks, a small kitchen and an annex where food is stored. We arrived on July 10th to find an Austrian and his cook, a Danish mining student, occupying the hut. The helicopter had left our food and equipment by the hut so we pitched camp on the nearby tundra 500 m above the Schuchert valley and 4 km from Pingo 1.

The weather for the next eleven days was gloriously sunny. Although the air temperature was never much above zero, there was very little wind and continuous daylight, something that none of us except Smart had experienced before. Apparently, it is not unusual to have long stable periods of good weather with plenty of warning of any bad weather approaching. The air is very clear so distances can be very deceptive, often twice what you originally imagined. The view from Lomsø was magnificent. Across the Schuchert valley were the Stauning Alps, many of the peaks as yet unclimbed. To the North we saw the Schuchert Glacier disappearing in its dog-leg path. To the South we could just see the huge icebergs of Scoresby Sund, 40 miles away, while behind the hut lay the tundra of the gentler coastal mountains. The best time was in the cool of the evening when the sun was at its lowest. Then you were in your sleeping bag, the billy can on a tundra fire for a cup of coffee, looking across to the mountains and tracing imaginary routes up precipitous faces. The bad times were forgotten, the long march out with blistered feet, the pack hauling with aching shoulders, the wet sleeping bag and leaking tent and the biting mosquitoes. You remembered only the good times, the recent tot of whisky, the pipe full of Wills Golden Cut Bar ready rubbed, the skiing down the glacier, the sight of arctic hare or musk oxen. These were the fruits of the months of planning and organization, the time which you thought would never come. However, back to reality! The day after we arrived was spent relaxing, a wash for some in the nearby lake and a stroll down to Pingo 1 with our shovels, picks, theodolite and tripod, and drilling rods. The following day, July 12th, found us again down at Pingo 1 busy surveying the mound. During the afternoon, three members, Heywood, Petit and O'Brien continued down the valley for 1½ miles to Pingo 2. This Pingo contained a lake and a bathyometric survey was taken to record the depth of the lake. A length of string graduated in 2 metre lengths was placed across the lake and a person, on a lilo + inflated car innertube, paddled himself across the lake using a plumbline to discover the depth every 2 metres.

Bathyometric surveys and other observations were carried out on Pingo 3 and 4 during the following two days.- Pingo 3 and 4 being a further 5 and 7 miles respectively from Pingo 2. This took us up to July 14th. This was the last evening to be spent in the company of the two prospectors, so out came the whisky bottle and a small party followed.

Two more glorious sunny days followed with us all down at Pingo 1, either busy surveying, or digging holes in an attempt to get at the ice below. One of the projects was to reach the ice, drill a hole some way into the ice, place explosives (which we had managed to buy from the mining company) and blow it up. The crystallography of the ice could then be examined. July 16th saw us taking down the dynamite etc. for a trial blasting operation. We drilled, using our had drill, into the soil for about 2 metres and placed two sticks of dynamite and retired to a safe distance wearing our climbing helmets. The dynamite was detonated, and instead of an ear shattering explosion, all we saw and heard was a faint sound and a small puff of dust. Unfortunately the hand drill broke when we were trying to drill into the ice and so this particular project had to be abandoned.

Pingos 2, 2½, 3 and 4 were to be surveyed but not in as much detail. Smart, Dodson and Heywood set out on July 17th and surveyed Pingo 2. July 18th and 19th found them at Pingos 3 and 4 respectively. On the return, July 20th, Pingo 2½ was surveyed. During this time the remaining four members had continued to dig holes and collect soil samples etc. During the evening of July 20th a council of war occurred where it was decided that Smart, Carvell, Petit and Heywood would leave the research base camp the following morning, cross the river, find the food dump at the foot of the glacier and continue on into the mountains. This party would then return to the river bank on July 28th i.e. one week later to meet the other three members, who by this time would have completed the research.

Early on the morning of July 21st the advanced exploration party set off leaving O'Brien, Dodson and Runcie to complete the research. This was duly done in the next 5 days, including a trip into Pingodal, a valley east of the Lomsø hut, for a brief examination of the Pingos there. So, on July 27th our research project on Pingos was wound up.

THE RECONNAISSANCE OF THE GANNOCHY GLACIER

The tasks of the advance party were (a) to locate the food and equipment which had been placed somewhere near the snout of an unnamed glacier on the opposite side of the Schuchert valley; (b) to find the best possible way to the head of this glacier and locate the easiest pass into the big eastern branch of the Roslin Glacier; and (c) to explore and climb some of the peaks at the head; (d) to take bearings from these peaks so as to produce a more accurate map of the area.

The party of four set off at 4 a.m. on July 21st from the Lomsø hut with 8 man days of food. The river was reached at 6 a.m., the best time to attempt to cross as it would then be at its lowest. A point was chosen where the river split into about 5 channels about 2 km from the terminal morraines. The first four channels were waded, water reaching up to the thighs at times, but the final channel was too deep and too fast flowing. Another attempt was made further up but again without success although the opposite bank was only 10 m away. It took two days by way of the Sirius and Schuchert Glaciers, the only alternative route, to reach this point on the other side of the river. The night of July 21st was spent at the edge of the moraine south of the Sirius glacier. This glacier was crossed the following day and also the Schuchert glacier with another night spent on the tundra just above the glacier. July 23rd saw us passing the point of the attempted crossing, two days previously. Four hours later the food dump was reached, after crossing more of the dreadful terminal moraine at the snout of the Lang Glacier. The party was still relatively fresh so some food and paraffin was dumped about 6 km up the unknown glacier which we have named the Gannochy Glacier. The only difficulty was a short stretch of steep contorted ice and dried up melt-water, gorges, just above the confluence of the Gannochy with the Lang. This was negotiated by cutting steps up a long fin of ice which led through the major difficulties. The party returned and set up camp by the food dump.

Unfortunately the weather was bad, low mist and drizzle for the next two days, so these days were spent 'festering'. However, the morning of July 26th saw the sun out and the party preparing to move out. The plastic sledges were to be used on the dry ice, since it takes less effort to drag 40 lbs on a sledge than to carry it on ones back. After a few adjustments they were a great success, but the load had to be kept low, and the pulling rope to be as long as possible for maximum efficiency, so heavy food boxes, climbing equipment and fuel cans were carried on the sledge, and sleeping bags and personal equipment on your back. The party passed the first food dump and had travelled for about another hour before the mists came down again. They walked on for another hour on a compass bearing before the tent was again pitched. This was perhaps the wisest move as rather large crevasses and seracs had been seen earlier in the day and by then the dry ice had been left behind.

A short rest of only a few hours was taken before the mists lifted and the tent was struck. The seracs and crevasses provided some problems and much zig-zagging was done to avoid some of the larger crevasses. At mid-night the party decided to leave the tent and food and reconnoitre the land ahead without the cumbersome weight. They put on the wooden cross-country skis which helped in making the crevasses safer to cross. Since the snow was frozen hard, trying to travel up hill was made difficult by the skis tending to slip back. The foot of the col was made without much further difficulty and the skis were left here. The col was reached by cramponing up the fairly easy ice slope. It was seen from here that the descent into a large glacier, which we named Dalmore Glacier, (an eastern tributory of the Roslin Glacier) was feasible and that this gave access to a number of impressive peaks. It was our first glimpse into the chilly heart of the Stauning Alps. We noticed particularly a fine rock and ice peak at the junction of the Dalmore, Lang and Seftstrom Systems, the highest in the neighbourhood which we set our hearts' on. The party now turned east up a snowfield to a small subsidiary summit and then north along a snòwy arete to the expeditions first virgin peak. The party returned and pitched camp just below the seracs at the last point where there was running water. It had taken about 12 hours to climb this first peak, later to be called the Dome.

The following day, July 28th, saw the party up early, 1 a.m. and off by 1.45 a.m. It was quite cold at that time with the boots frozen solid. The party reached the base of the col in record time, then turned roughly west into a large snow-bowl. The skis were left at the head of the snow-bowl and then a steep snow slope led us onto the ridge of our second virgin mountain. Lunch was taken and then the bergschrund crossed and up the steep snow slope, belaying all the way to the false summit. ½ hour scramble along the broken ridge led us to the summit, 5½ hours after leaving camp. A magnificent ski run down took us to the seracs agains where we left our skis and roped up for the crevasses again. We reached Nevis camp, as we came to call this camp just below the seracs, about 3 p.m.-about 11 hours after leaving. It was decided that a new route should be found through the seracs as some of the snow bridges were a little precarious. This would have to be done later as it was time to retreat back down the glacier and meet up with the remainder of the party at the attempted crossing of the Schuchert river.

An Interlude of Injuries.

During the following few days the expedition met a number of difficulties which caused a slight alteration in the plans. The original plan was that the advance reconnoitering party should meet the three members, who had been left to finish the research at the river crossing on the evening of July 28th. Then, Smart and one member would travel to Mestersvig, so that Smart could continue his research on tern colonies in and around Mestersvig for the month of August. The member who had accompanied Smart would meet R. Allen, (the remaining member of the expedition) who was flying out to Mestersvig from Glasgow, and return to the main expedition at the head of the Gannochy Glacier. The expected arrival of R. Allen and 1 member at the head of the Gannochy was around August 6th. Meanwhile, between July 28th-August 6th, the rest of the expedition would transfer all the necessary food and equipment to the head of the Gannochy and continue the exploration

of this area.

On returning down the Gannochy Glacier on the evening of 28th July, Heywood and Carvell remained at the food dump at the snout of the Glacier, while Petit and Smart carried on in heavy drizzle to the river crossing three hours further on, where they met the research party. The research party had attempted the crossing but in the process Dodson had dislocated his shoulder and Runcie had aggravated his inflamed Achilles tendon. It was decided that Dodson and Runcie should accompany Petit and Smart as far as Sorte Hjorne where Dodson and Runcie would rest and recover. When Petit and R. Allen were returning a few days later they picked up the two members who had recovered sufficiently from their injuries. This left only three members to move the stores to the head of the Gannochy.

RETURN TO THE GANNOCHY

Between August 1st and 4th Heywood and O'Brien ferried loads from the dump at Gate of Gannochy to Nevis camp. In the next few days joined by the others they ferried loads to a rocky platform below the north side of the Courier Col which we named the Eagles Eyrie. On the 9th from Nevis Camp an imposing peak on the south side of the glacier was climbed. This, the best ascent of the expedition we called the Bonar Bjerg.

OVER THE COURIER PASS TO THE DALMORE GLACIER

On the 11th August the Courier Pass was crossed with some difficulty encountered on the descent of its far side and a camp established on the Dalmore Glacier one of the major eastern branches of the Roslin system. From here a number of ascents were made, but time was short as two people had to escort Carvell out of the glaciers to return to Mestersvig, and home to resit a failed exam. This reduced the climbing strength.

It was the evening of August 16th that the snow came, and lasted intermittently for the next 36 hours. The new snow put all the rock routes out of condition and all the snow slopes were avalanche prone, as was shown the following day August 19th when numerous avalanche scars were seen down the couloirs and steep snow slopes. August 20th was set aside for a major assault on the largest and most impressive peak at the head of the Glacier but the mist and snow came again and that was the end of our mountaineering expedition.

RETREAT FROM THE SOUTH STAUNINGS

Morning of August 21st saw two ropes of three ski-ing down the sinister gloom of the Dalmore Glacier. Each member with a fairly heavy pack and the front two members of each rope pulling a heavily laden sledge. This was only to last 3 hours, for after this time we had reached the Roslin Glacier which was unsuitable for ski-ing. From here it was safe to walk unroped as the Roslin Glacier is very wide and flat with no dangerous crevasses. It was a long walk to the end of the Roslin, another 12 hours, and we made a mistake when we came off the glacier too soon adding another three hours to our journey before we reached the tundra. We reckoned we had travelled 25 miles that day, from our camp in the Dalmore Glacier.

We were away by 1 p.m. the next day. It was another hard slog in that we had to cross the terminal morraines of a small unnamed Glacier and of the great Lang Glacier itself. We eventually reached the point where the attempted crossing of the Schuchert river was successful and unsuccessful depending on which party you were in. This had been a long 10 hour walk as all our gear had to be carried on our backs and not by the sledges.

The weather had not been too good for the last two days, misty and overcast, but August 23rd was worse, low cloud with drizzle. Since we had travelled the distance between the tundra camp and Malmbjerg mine before navigation was not too difficult. We walked along the tundra and crossed onto the Schuchert Glacier at the cairn, which had previously been built to mark the most accessible points onto the glacier. The long pull along the dry ice led us to the mine, 8 hours after setting off. We were all tired at the mine after three long days and very little sleep, so August 24th was to be our rest day.

There was some discussion on whether to return the same way via Sorte Hjorne or try a new route over the Skel col. The weather on August 25th made the decision for us. It was again misty and snowing so we took to the Arcturius Glacier. It took us three hours of zig-zagging to reach the col. It is interesting to note that when Heywood and O'Brien had escorted Carvell over the col the whole of the Arcturius Glacier was dry ice, all the crevasses could be seen, and it took only 1½ hours. Now all the crevasses were covered with a thick layer of snow. However, when Smart had crossed this col on a previous expedition in 1958 he had crossed alone and no apparent danger. That year there must have been a large thickness of snow which completely covered the crevasses.

Another 2½ hours saw us at the end of the Mellon Glacier and Sorte Hjorne in view. It was another three hours before we reached this hut and there to meet us was our leader, Smart.

The next day we reached Mestersvig. Heywood and Petit taking the small boat and equipment and sailing in and out of the ice floes around the coast, whilst the others strolled along the tundra with light packs to the airstrip at Mestersvig.

THE GANNOCHY - COURIER COL - DALMORE GLACIER ROUTE

The use of the Gannochy and Dalmore Glaciers offers an alternative route to the upper Roslin Glacier, for parties approaching from the Schuchert Glacier. It is more interesting than the monotonous trek up the Roslin itself.

Approaching from the North by the tundra beside the Schuchert flood-plain, it is best, on nearing the terminal fan of the Lang Glacier to follow the vegetated ground upward to the right (W.) : one thus follows the crest of a spur to gain about 150 M of height and overlook the area of confluence of the Lang and Gannochy glaciers. It can then be clearly seen that the best procedure is to contour along the lower edge of the tundra until a comparatively short moraine crossing gives access to the true L. side of the Lang. A direct approach can then be made to the 'gate' of the Gannochy, over smooth easy ice (2 hr.). Here for a short section, where it is funnelled through a relatively narrow defile, the Gannochy is comparatively steep and contorted; the best route through lies on the true R. edge (1 hr.). Above this the glacier is smooth and far less steep; crevasses are rare and can be crossed merely by a stride. The true R. side (S.) remains the best route; the winding of the glacier makes for pleasant variations of scene.

The only ice-fall in the Gannochy occurs much further up (5 hr.). The fall is not high (perhaps 100 m) nor excessively steep; the Serac/crevasse area stretches the whole width of the glacier and again the true R. side affords the easier maze; a slow trend towards the centre is helpful.

Above the icefall ($1\frac{1}{2}$ hrs.) the glacier is again smooth and there are few crevasses; snow cover probably obtains from this point throughout the year. About half-way to the Col, a rock platform backed by an ice-wall is obvious on the true L (N.) bank : it affords splendid camp site. Below the Courier Col the slopes steepen, reaching perhaps 40°, and may be hard enough to make crampons useful; towards the N. corner there is no bergsschrund, but crevasses on top of the Col require care (1 hr.). This Col is the only easy escape from the Gannochy.

On the Dalmore side of the Col, the face on the N. side is of rock, and a 45-60° ice slope abuts below it. The easiest reversible descent is to follow the edge of the rocks down and round until a clear continuous slope leads down to easy ground ($\frac{1}{2}$ hr.). One thus descends to a minor tributory of the Dalmore, easily descended by a central line (though a few detours may be needed to avoid crevasses 2-4 m. wide). Lower down it is probably best to veer towards the foot of the bounding ridge on the R (N) side (1 hr.). It is advisable to cross the Dalmore at this point and descend near its true R. edge which then gives easy going, with few crevasses. However, a more central line leads easily to the junction with the upper Roslin, about 25 km above its snout, where 'dry' ice is likely ($3\frac{1}{2}$ hrs.).

Times throughout are estimated for a heavily laden party.

The Dalmore Glacier marches to the north with the Lang Glacier. No easily negotiated pass exists between them. To the north-west it is separated from the Sefstrom Glacier by a barrier of mountains with no easy exit. To the west a ridge of impressive rock peaks divides it from a system of smaller subsidiary glaciers, all unnamed, which drain into the Roslin. Probably the least difficult exit from the head of the Dalmore is the Col to the south of Gog Magog but this leads back into the Roslin system. Thus the Dalmore gives access to its own circumscribing peaks but provides no prospect of a trade route into other systems.

ADMINISTRATIVE REPORTS

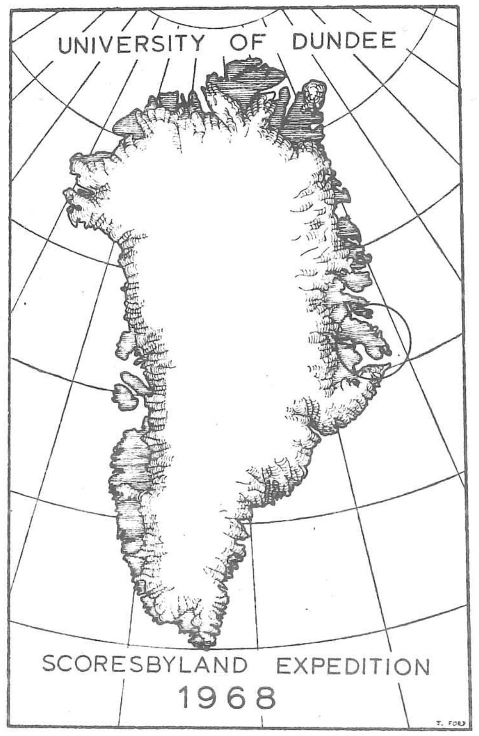
Financial Report

Medical Report - J. Carvell

Equipment Report - C.R. Allen

Food Report - B. Dodson

Acknowledgements



FINANCIAL STATEMENT

The expedition owed its existence to the support given to it by the individuals and trusts listed below. 90% of our funds were raised in Scotland as was only right, all eight members being Scots, four by birth and four by willing adoption. As with most expeditions, the financial situation was at all times precarious, but due to practically all the imponderables working out in our favour we eventually came out with a small surplus. The key to our solvency was the extremely economical charter arrangements made possible by sharing a large aircraft with other expeditions. For both outward and return journeys it was possible to fill the entire 6450 Kg payload of a DC 6B, the largest plane in the Icelandair fleet. The advantages of a large aircraft can be seen from the following table which compares the various aircraft available for hire on this route.

Aircraft	Payload	Charter Fee	Cost/Kg
Bonanza	270 Kg	£ 270	20/-
DC3	1500 Kg	£ 963	12/9
Fokker Friendship	3500 Kg	£1167	6/9
DC 6B	6450 Kg	£1570	4/9

The other major item of expenditure was the hire of a helicopter which cost £170 for a 55 minute charter. This saved something of the order of two weeks of expedition time (or 112 man/days), and was consequently a good buy.

The expedition also has in hand a fair amount of capital equipment in the form of 7 pairs of skis, a tent, and climbing equipment, as well as a certain amount of food stock-piled in Greenland pending our return.

INCOME:

	£
Personal Contributions 8 x £75	600
Dundee Courier	300
Combined Value of Research grants made by Carnegie Trust to I.H.M.S., R. O'B. and B.D.	215
Gannochy Trust	200
Bonar Trust	100
Mount Everest Foundation	100
Dundee University Travel Fund Grant to I.H.M.S.	58
International Geographical Congress Award to R. O'B.	50
Royal Bank of Scotland	50
Bank of Scotland	25
British Linen Bank	25
Donation from Principal James Drever	25
Sale of Expedition Envelopes	24 - 10 - 0
Donation from Professor D.A.T. Dick	5
From sale of places on returning empty aircraft	56
Income from one lecture	5
	1838 - 10 - 0

EXPENDITURE:

	£	s	d	
Travel:				
Share of outward charter costs Iceland - Greenland	333	4	0	
Share of return charter costs Greenland - Iceland	205	10	0	
Fare for C.R.A. Iceland - Greenland return	90	0	0	
Return fare for J.C. Greenland - Iceland	26	6	8	
2 Single flights J.C. and I.S. Reykjavik - Glasgow	51	7	0	
Return air fare Glasgow-Reykjavik for C.R.A.	37	0	0	
Sea passages to and from Iceland	209	15	0	
Charter of helicopter	169	18	0	
Other transport costs in Greenland	21	10	0	
Costs in Iceland	20	0	0	
Travel to London for M.E.F. Interview	12	0	0	1176-10- 8
Freight:				
Within Scotland	16	0	0	
Outside Scotland	49	6	0	65- 6- 0
Accident Insurance	43	0	0	43- 0- 0
Miscellaneous Items	12	0	0	12- 0- 0
Equipment:				
7 pairs of Skis with accessories	68	0	0	
4 Sledges @ 32/6 each	6	10	0	
4 Tripax Frames and Sacks	24	2	6	
4 Ex W.D. Carrying Frames	10	7	0	
Aerial Photographs	3	2	7	
2 x 300 ft. No. 2, 2 x 120 ft. No. 3 Nylon ropes	27	11	0	
Slings, Karabiners, Pitons Campomats	28	13	10	
Tent	26	0	0	
Primus stoves and cooking pots	9	3	0	
Tea chests and boxes	13	3	0	
200 litre of paraffin from Copenhagen	9	0	0	
Films	39	11	10	
Hire of R.G.S. Equipment	17	5	0	
Replacement of lost equipment	9	10	0	
Medical Supplies	36	10	0	
Food 1968	140	5	0	
Food stored for 1970	50	0	0	518-14- 9
Miscellaneous items	16	15	0	16-15- 0
Cash in hand	6	3	7	6- 3- 7
				1838-10- 0

MEDICAL REPORT

The medical kit taken was too comprehensive, too heavy, and too expensive. It was often remarked by others in the expedition that two medical men were more of a liability than an asset, as a medical man tends to cover himself for any emergency and loads the unfortunate members of the expedition with material and equipment that are very unlikely to be used. The position was aggravated by the 3 dentals who contributed some fearsome pincers and gouges, judged to be just the job for toothache.

The medical kit was divided into the 3 lots:

(1) Personal kits comprising bandaids, aspirins, emergency dressings and a few tablets of pethedine carried by each member.

(2) A minor kit containing suturing equipment, an inflatable splint, and a fairly wide range of drugs which we carried on the glaciers.

(3) A major kit, very comprehensive, that was taken to and from Lomsø by helicopter but did not get carried.

Blisters with and without infection were unnecessarily frequent due to untried boots and long initial march-ins. Mosquito bites and infections from scratching also gave some trouble. Other ailments encountered were swollen ankle, Achilles tenosynovitis, cellulitis of ankle (all from boot trauma), lacerated foot requiring stitches, abrasions, dislocated shoulder which reduced itself in 14 hours as both medical men were absent at the time. Indeed the expedition members seemed always to prefer to treat their own injuries, if possible.

The items from the medical kits actually used were:

Ampicillin 250 mg. (caps), Pethidine tabs, 20 mgs., Savelon, Elastoplast strip, Antibiotic powder (Penicillin and sulphathiozine), Paracetamal, Bandages, Zincoxide strip, Cotton wool, Syringes and needles (disposable), Silk sutures 3/0 and 5/0 and needle holder and forceps, Bandaids.

Mosquito repellant was necessary in July but not in August. For some reason the mosquito population dropped to almost nil in the last few days of July - long before the first frosts.

Accident Insurance

An insurance policy was taken out through Mountaineering Activities Ltd. of Birmingham. For £5 per head we were insured for 2 months, the cover given was for transport costs of up to £500 for up to two rescues.

EQUIPMENT REPORT

Climbing

Expedition equipment was provided to the following extent per four men: 120 ft. hawser-laid nylon No. 3, 300 ft. hawser-laid nylon No. 2; 6 assorted Leeper and 3 Chouinard chromalloy pegs, 1 inch tape slings, No. 3 rope slings, and 'Asmu 3,400' and 'Stubai 2,200 karabiners were used as standard. Members provided their own clothing (including protective helmets), ice-axes, hammers, crampons and day-sacks. All members wore 'Long Johns' continually on the high glaciers, but duvet jackets were not universal and at least two members "didn't miss them". Snow goggles and lip salve were essential and glacier cream very useful.

Camping

Two Black's 'Arctic Guinea' tents in 'Protex' were used without flysheets, throughout the expedition. A Black's 'Mountain' tent in 'Ventile' was less often used. The 'Arctic Guinea' tents held three in comfort and four in need. In all cases, camping on stone-strewn ice was more than the groundsheets could stand, and an extra polythene sheet per tent would have been worth its weight.

Each member had a 4 ft. x 2 ft. 'Kampmatt', used inside a polythene bag. These provided sufficient insulation and comfort even on the ice. 'Fairy Down Everest' and 'Black's Icelandic' sleeping bags were used - the former excellent, the latter adequate.

Half-pint 'Primus' paraffin stoves were adopted as standard; however the one-pint 'Primus' would have been a worthwhile improvement in 'lightability' and power. The fuel allowance of $\frac{1}{4}$ pint/man-day proved somewhat excessive but we were fortunate in terms of melt-water in the high camps (collapsable PVC water-buckets were very useful). The use of pan-scourers eventually became essential.

Travelling

Two kinds of skis were taken; Norwegian cross-country skis with hardwood edges, and some rather heavier Austrian skis with metal edges. The advantages of metal edges were marginal in almost all the conditions encountered. 'Tempo' and 'Kandahar' bindings were used so that climbing boots would be sufficient for all purposes, two of the former broke. Cane sticks were used and found to be adequate. The skis were carried for about 90 miles and used for about 10; this imbalance was due to the earliness of the 1968 season.

Two kinds of pack-frame were used: ex-Army aluminium gridle frames were not very comfortable, but were strong and durable. B.B. 'Tripex' frames were very uncomfortable in use, dispite many ingenious efforts to pad them out: and worst of all, they were frail. Fractures of tubes and rivets, tearing of straps and sacs, all occurred: only one frame out of four came back to Scotland. The other three were abandoned in various states of decrepitude (and fury) along the route. All four ex-Army frames were brought back in fully re-usable condition.

The standard maximum load per man was 75 lbs. including skis and sticks.

'Spares and Repairs'

No spare skis, sticks, or boots were taken. One spare stove turned out to be needed; the precise failure and fate of the original remain delicate mysteries. A lead washer was the only other 'spare part' employed. Wax boot-maker's thread and an awl were invaluable for booth and rucksack repairs. One spare axe was taken and used, owing to the loss of one axe in a desperate river-fording episode. Two cameras were drowned.

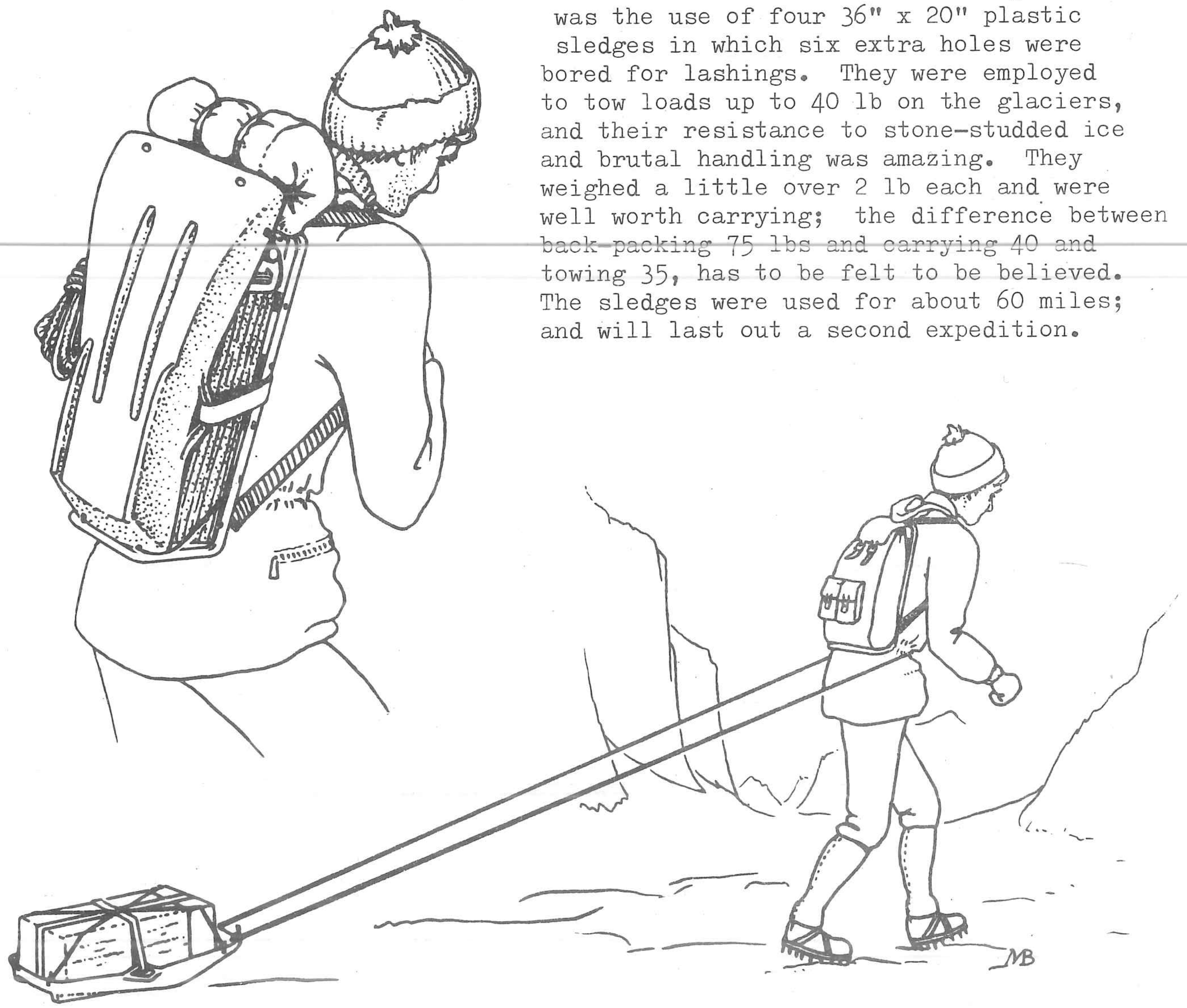
'Profol' solid fuel was very poor for lighting-up on cold mornings and 'Meta' fuel was notably better.

Errors and Omissions

A telescope or a pair of binoculars would have been well worth carrying. No other omissions were discovered. The 'Tripex' frames were a serious error.

The "Doggie" or One-man-Sledge

The best innovation of the Expedition was the use of four 36" x 20" plastic sledges in which six extra holes were bored for lashings. They were employed to tow loads up to 40 lb on the glaciers, and their resistance to stone-studded ice and brutal handling was amazing. They weighed a little over 2 lb each and were well worth carrying; the difference between back-packing 75 lbs and carrying 40 and towing 35, has to be felt to be believed. The sledges were used for about 60 miles; and will last out a second expedition.



FOOD

Three weights of food box were provided according to the distance they had to be carried. Light and medium boxes contained 8 and the heavy boxes 4 man/days of food.

	Heavy	Medium	Light
BISCUITS : Healthy Life, Ryvita, Ovaltine, Digestive.	3ozs/man/day	3ozs/man/day	3oz/man/day
CEREAL : Porage oats	2½	2½	2½
SUGAR	3½	3½	3½
MEAT/FISH : Meat bar, dehydrated stew, corned beef, chopped pork, tinned herring, tuna, sardines.	7	5	2½
CARBOHYDRATE : Potato, Rice, Macaroni	3	3	3
JAM : Jam, Honey, Syrup	3	2	2
CHEESE : Tinned, processed	3	3	2
MILK : Marvel, Ostermilk	3	3	3
SOUP : Powder	1	1	1
CHOCOLATE : Various and sweets	6	6	6
DRIED FRUIT : Dried apple, Prunes, Apricots Dates, Sultanas, Raisins.	4	4	4
DRIED VEGETABLE : Peas, Beans, Carrots.	1	1	1
BUTTER/MARGARINE	1	1	1
SALT	½	½	½
TEA, COFFEE, OVALTINE, LEMONADE	1½	1½	1½
OXO CUBES	1 cube	1 cube	1 cube
MATCHES	1 box	1 box	1 box
Weight of food and packing	12 lbs. (4 man/days)	22¼ lbs. (8 man days)	20½ lbs. (8 man days)

Special Boxes : Dried Egg, Cocoa, Chocolate biscuits, Cake, Flour, Curry powder, Pepper.

This ration provides approximately 4000 calories per day. Vitamins were supplied in 'pill' form.

The separate items of food were measured out where necessary and packed in polythene bags. All the rations were packed in 10" x 10" x 8" moisture resistant cardboard boxes donated by Thames Board Mills. These proved excellent and stood up well to rain and rough treatment.

Comments:

1. Eight man days of food fitted tightly into the box and thus prevented the contents from moving about. This prevented leakage and breakage very successfully. The boxes are a convenient size for pack frames and sledges.

2. The biscuit ration might be slightly increased to advantage.

3. Dried apple and lemonade powder were very popular and oxo cubes very useful.

4. Butter might well be packed with the rest of the food to advantage.

5. The Thames Board Cartons weighed $1\frac{1}{2}$ lbs each.

Foods donated by :

A. Wander Ltd.	:	Ovaltine and Ovaltine Biscuits
Quaker Oats Ltd.	:	Porridge Oats
British Sugar Corporation	:	Sugar
Nestle Company	:	Chocolate
Shippam Ltd.	:	Canned foods
Oxo Ltd.	:	Corned beef
Heinz International Sales	:	Canned foods
Tate and Lyle	:	Golden Syrup
W. Symington & Co.	:	Soups
Glaxo	:	Ostermilk
Cerebos Foods Ltd.	:	Salt and Pepper
British Egg Marketing Board	:	Dried Egg
Venus Easterbrook Ltd.	:	Felt pens
Arthur Bell & Sons	:	Whisky
Duncan MacBeth & Co.	:	Whisky
Thames Board Mills	:	Food boxes
W.D. & H.O. Wills	:	Cigarettes
Dunlop	:	Baseball boots

ACKNOWLEDGEMENTS

The expedition owes debts of gratitude to many people and organisations. We would like particularly to acknowledge the financial help from the D.C. Thompson organisation who were our first benefactors and who rallied round after our return to save the expedition from debt. The Gannochy and Bonar Trusts also gave substantial help. The bulk of support was thus from Dundee and Perth and we are particularly proud of this.

Certain individuals also were keys to our success, among them the Principal of the University and Professor Mair who helped in the realms of high finance and social engineering.

Mr. Carvell of Perth had a map redrawn for us by his architects office which was very useful in the field.

To the Danish Government we are grateful for permission to visit Greenland and to local Danish residents, particularly J.K. Hansen the manager of the Mestersvig airfield, for a great deal of help in the field; also to Mr. Erich Hintsteiner and other members of the Northern Mining Company for numerous civilities.

Elsewhere in the text we have tried to acknowledge other sources of help.

REPORT PRODUCTION

Front Cover design and execution	Murray Johnston, Technician, Anatomy Department.
Back Cover design and execution and Maps.	J. F. Ford, Technician, Geography Department.
Flower drawings	Miss Mary Benstead, Medical Artist.
Typing	Miss Veronica Borland.
Editor	I.H.M. Smart.

The cost of the report was largely met by a grant from the University Court.

EXPEDITION PERSONNEL

Patrons : James Drever F.R.S.E.
Principal, University of Dundee.

Harald Drever, F.R.S.E.
Professor of Geology, University of St. Andrews.

Members :

I.H.M. Smart	Leader and Biologist
R. O'Brien	Deputy Leader and Geomorphologist
C.R. Allen	Climbing Leader
B. Dodson	Surveyor
J. Carvell	Medical Officer
A. Pettit	Dental Officer
B. Heywood	1st Geotomist
A. Runcie	2nd Geotomist