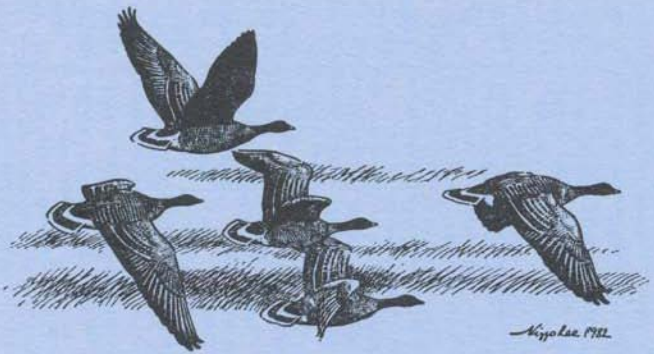
SKRIFTER NR. 181

Current research on Arctic Geese

Proceedings of a symposium at Voksenåsen, Oslo,
24–26 October, 1983



NORSK POLARINSTITUTT
OSLO 1984

DET KONGELIGE MILJØVERNDEPARTEMENT

NORSK POLARINSTITUTT

Rolfstangveien 12, Snarøya, 1330 Oslo Lufthavn, *Norway*

SALG

Bøkene selges gjennom
bokhandlere eller
bestilles direkte fra:

ORDERS

may be placed at your
bookstore or you may
order direct from:

Universitetsforlaget
Boks 2977, Tøyen
Oslo 6
Norway

Global Book Resources Ltd.
109 Great Russell Street
London WC 1B 3NA
England

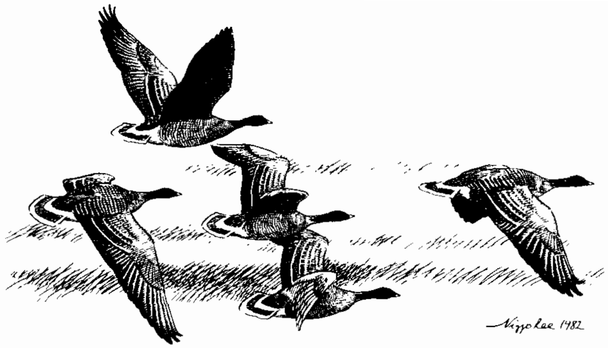
Columbia University Press
136 South Broadway
Irvington-on-Hudson
NY 10533, U.S.A.

SKRIFTER NR. 181

Current research on Arctic Geese

Proceedings of a symposium at Voksenåsen, Oslo, 24–26 October, 1983

Edited by
FRIDTJOF MEHLUM and MALCOLM OGILVIE



NORSK POLARINSTITUTT
OSLO 1984

ISBN 82-90307-33-0
Printed December 1984

Contents

Preface

In 1596 two Dutch skips sailed into the Barents Sea in an attempt to find the northern route to China. Because of difficult sea-ice conditions the Dutchmen chose to sail north of Novaja Zemlja, but they failed in navigation and reached Svalbard. They went ashore on the northwestern coast of Spitsbergen on 21 June. The earliest records of birds in Svalbard originated from this visit. The first bird species they saw was a Brent Goose breeding on a small islet.

The conspicuous arctic geese are still an important part of the bird fauna of Svalbard. Three species breed there, the Pink-footed Goose *Anser brachyrhynchus,* the Barnacle Goose *Branta leucopsis,* and the light-bellied subspecies of the Brent Goose *Branta bernicla hrota.* Today the Pink-footed Goose is the most numerous and the Brent Goose the least abundant species, but this may not always have been the case. Historical data indicate that the Brent Goose may have been the most abundant species in earlier times.

Management of the Svalbard goose populations is an international task, since the birds visit several northwestern European countries during their yearly cycle. It is therefore necessary to focus not only on the situation at the breeding grounds, but also on the migration staging areas and the winter quarters.

The Svalbard geese have been studied by scientists from several countries. Since these goose populations seem to gather in small, discrete staging and wintering areas, they are well suited for population dynamics studies. In this respect the comprehensive individual ringing programme conducted on the Svalbard Barnacle Goose, by the Wildfowl Trust and others, is an excellent example.

Norsk Polarinstitutt is responsible for Norwegian research concerning the management of the wildlife in Svalbard. For management of the Svalbard geese it is essential to have a close cooperation between the research groups and the authorities in the countries visited by the birds during the year. The main purpose of the Arctic Geese symposium in Oslo, 24–26 October 1983, was to consolidate existing knowledge of the biology and population status of the Svalbard geese in order to give priority to future investigations for the best possible management of the populations. We therefore invited goose researchers from Denmark, Great Britain, the Federal Republic of Germany, the Netherlands and Norway to present the results of their studies and discuss the need for future work.

In order to compile the present knowledge of the Svalbard geese and to make it more widely available it was decided to publish the presented papers in the *Norsk Polarinstitutt Skrifter* series. We hope that the Symposium and the proceedings will encourage more research on these arctic goose populations.

Oslo 20 February, 1984
Fridtjof Mehlum

MAGNAR NORDERHAUG:

The Svalbard Geese: an introductory review of research and conservation

Norderhaug, M. 1984: The Svalbard Geese: an introductory review of research and conservation. *Nor. Polarinst. Skr. 181,* 7-10.

This introductory paper summarizes the history of geese research in Svalbard. The present conservation status for the three Svalbard geese species in territories used during various stages of their life cycles are given in Annex. 1.

Magnar Norderhaug, Ministry of the Environment, Oslo-Dep., Norway.

The studies of geese in Svalbard started on 21 June 1596 at the northwestern corner of Spitsbergen. At that time, Gerrit de Veer, pilot on board Willem Barents' ship, landed on Cummingøya or Steggholmen, south of Norskeøyane, and observed nesting geese. He brought about 60 eggs back to the ship and was also able to kill one of the nesting birds with a rock. de Veer called the birds he had found «Rotgansen» because they cried «rot-rot-rot» when flying around (Løvenskiold 1964).

de Veer had most probably seen Brent geese before, coming from a part of the Netherlands where Brents were wintering. In those days people believed that Brent Geese came from trees in Scotland; when fruits from a particular tree fell into the water, small goslings would come out and swim away. If the fruit fell on the ground, it would burst and nothing come out of it. Based on his observation in Svalbard, de Veer concluded that this story was not true, and that it had been believed just because no-one had ever before visited this far away new country and seen the breeding birds.

Studies of geese have definitely not been a very important activity in the history of Svalbard. In fact, through the centuries, most of the interest in Svalbard geese was concentrated on the more profitable art of killing and eating them, as well as stealing their eggs.

For the Light-bellied Brent, the situation gradually became severe, parallel to the decline in the Eider population. From being probably the most numerous goose species in Svalbard, the population reached a critical low level in the beginning of this century and has continued its decline until recently.

Information on the Pink-footed Goose is rather scarce. In fact, this species was first recorded in Svalbard as late as 1837, by Professor Lovén visiting Kongsfjorden. Due to its numbers and different breeding strategy, the Pink-footed Goose has most probably always been less influenced by man in Svalbard than the *Branta* species.

The historical status of the third of the Svalbard goose species, the Barnacle, remains somewhat of a mystery. It was mentioned by Audubon in *The Birds of America* (1843) as a Svalbard bird, without any source of record, and Koenig & le Roi (1911) described this as only guesswork. The first reliable record of Barnacle Geese in Svalbard, is Torell's observation in 1858 when a Barnacle was shot and eggs collected south of Bellsund. There is some confusion about the exact locality of this first record, but both the plains south of Bellsund and Dunøyane have been mentioned in this connection, as described by Løvenskiold (1964). Three other observations of Barnacles in Svalbard have been described in literature from the 19th century. One is from Midterhuken in 1882 (where Barnacles have not been recorded breeding since then, until 1977), one from Van Keulenfjorden, and one from Wijdefjorden, both in 1898.

The most famous old breeding site was Longyeardalen, where at least eight pairs were observed breeding in inaccessible places in 1907. As late as in 1921 the Oxford Expedition to Spitsbergen observed a number of breeding pairs there (Løvenskiold 1964). According to the scanty historical records, the Barnacle must originally have been the least numerous of the Svalbard goose species. Very little is known, however, about its distribution and population size until after 1950. Old records from the wintering grounds in the Solway area, Scotland, may be of interest in clarifying in further detail the original population status of the Barnacle Geese in Svalbard.

Remarkably few papers on the Svalbard geese from the first part of this century are of more specific interest. Most important is probably the impressive work *Avifauna Spitzbergensis* by Koenig & le Roi in 1911, summarizing most available data on the birds of Svalbard at that time. Another important work was the *Contribution a l'ornithologie du Spitsberg* by Mathey-Dupraz (1917). The first specialized paper came in 1921 when F.C.R. Jourdain published his *Remarks on the eggs and nests of Spitsbergen geese.* This paper focused especially on *Branta leucopsis* eggs collected in Spitsbergen. The next year *Ibis* published *The Birds of Spitsbergen and Bear Island* by Jourdain (1922), probably the most important paper on Svalbard birds since Koenig & le Roi's paper in 1911.

In 1922 another valuable description by Jourdain appeared in *The Auk* on «The breeding habits of the Barnacle Goose». In spite of the fact that the Barnacle Goose was the least numerous of the Svalbard geese, it was already in the 1920s the best described species of the three.

During the period 1930--1950 quite a number of ornithological papers from Svalbard were published, but only a few of them gave more than faunistic contributions to our knowledge about the Svalbard geese. The 1950s became a kind of turning point for geese research in this area.

It all started in 1952 when a Sherborne School Expedition consisting of four Englishmen and one Norwegian made preliminary investigations into the possibility of catching geese during their flightless period in Spitsbergen. Upon their arrival in Gipsdalen in August, they found that the adult Pink-footed Geese were already flying, but managed to catch 42 well-developed goslings for ringing. In the autumn that same year, the first two recoveries from Ostfriesland in Germany and Esbjerg in Denmark were reported to Stavanger Museum.

In 1954 another British party, consisting of James Goodhart, Russell Webbe, and Thomas Wright returned to Spitsbergen in July to catch flightless geese. In Reindalen they succeeded in ringing 526 Pink-footed Geese, 23 Barnacles, and 74 Light-bellied Brents. Based on these ringings important material gradually became available on the migration of the Pink-footed Goose and the Brent Goose (cfr. H. Holgersen 1955, 1956 and Salomonsen 1958).

In 1962 came a turning point for the Barnacle studies. This summer a Norwegian expedition consisting of seven students from the University of Oslo visited Hornsund. 1962 had an extremely poor breeding season, but the ringing of moulting adult Barnacles was successful and a total of 685 was ringed during four catches (Bang et al. 1963). Soon after, things started to happen in quite a different place. On 26 October 1962, Hugh Boyd of the Wildfowl Trust saw at least 46 of these ringed birds at the Caerlaverock National Nature Reserve in Dumfries. Four months later came further evidence. On 2 February 1963 a Wildfowl Trust rocket-netting team caught 316 Barnacles at Caerlaverock. These included 94 of the 685 Barnacles ringed in Spitsbergen in the summer of 1962, but none of the 609 birds ringed in East Greenland in 1961 nor any ringed in the Netherlands (Boyd 1964).

From 1962–63, the close and long-lasting cooperation started between British and Norwegian ornithologists interested in the Svalbard Barnacle population. Later, we were also pleased to include our Dutch colleagues in this group. In 1964, joint field work was organized in Svalbard in the area between Sørkapp and Isfjorden, to study the population sizes and breeding success of geese. A Wildfowl Trust expedition worked between Isfjorden and Kapp Borthen, and a team from Norsk Polarinstitutt worked from Kapp Borthen to Stormbukta, south of Hornsund. More Barnacles were also ringed and colourmarked in Hornsund; the following autumn, people from the Wildfowl Trust and Norsk Polarinstitutt made further field studies of the Barnacles at Caerlaverock.

Since the beginning of the 1960s and up to the present time, research and research cooperation on the Svalbard Barnacles have developed remarkably, and today it seems reasonable to claim that this is one of the best studied bird populations in the world. And what is more important: the marked population increase of the Svalbard

Barnacles is one of the best success stories in wildlife conservation in recent decades. In this connection I feel it is also important to underline the close connection between field research, international cooperation, and practical conservation. I think this is an encouraging experience and an example for future international work on migratory species.

Parallel to the studies of the Svalbard Barnacles, we have also seen progress in the studies of the Pink-footed Goose and the Light-bellied Brent. Papers presented at this symposium will clearly show important progress during the last 10–15 years. Finally, if we look upon the conservation status of the three Svalbard goose species, two of them may at present be considered to be in a healthy shape. The third one, the Light-bellied Brent, is still a matter of concern. The conservation history of the Light-bellied Brent in Svalbard quite clearly shows that man may easily lose control of the situation when a serious population decline takes place. In spite of research, international cooperation and various conservation measures implemented, no true recovery has yet been seen in this population. I hope, however, that material presented at this

Annex 1. *Review of the conservation status of the Svalbard geese.*

		Pink-footed Goose	Barnacle Goose	Brent Goose
SVALBARD	Legal status	Satisfactory	Satisfactory	Satisfactory
	Habitat protection	Breeding colonies in need of better protection	Satisfactory	Satisfactory but negative impact from Glaucous Gulls
MAINLAND NORWAY	Legal status	Open season 21.8–23.12	Total protection	Total protection
	Habitat protection	Migratory areas in North Norway in need of better protection	Migratory areas in N.Norway need better protection	?
DENMARK	Legal status	Open season 1.9–31.12	—	Total protection since 1972
	Habitat protection	Need of better habitat protection	—	Need of better habitat protection
W. GERMANY	Legal status	Total protection since 1977	—	Open season for Brent 1.11–15.1. Some may be killed during open season for Dark-bellied Brent
	Habitat protection	Need for geese sanctuaries without hunting on the North Sea coast, and need for better habitat management at Rodenäs	—	As for the Pink-footed Goose
NETHERLANDS	Legal status	Total protection since 1977	—	—
	Habitat protection	Roosting areas protected. No feeding reserves	—	—
UNITED KINGDOM	Legal status	—	Total protection since 1954	Total protection since 1954
	Habitat protection	—	Satisfactory	Satisfactory

symposium may show some positive signs and that time will allow for a more detailed discussion of possible additional measures to improve the population status of this species.

In conclusion, I would like to emphasize the encouraging progress made to increase our knowledge about the ecology and population dynamics of the Svalbard geese during the last twenty years. A very good basis of biological knowledge is now available. However, the need for improved research, continued interest, and international cooperation is still there, and this will never change as the geese continue their migration between Svalbard and their traditional wintering grounds.

It is therefore my sincere hope that this first symposium on the Svalbard geese will not be the last one, but is only the very beginning of an even closer contact between biologists from our countries in the years ahead.

References

Audubon, J.J. 1983: *The Birds of America.* New York.

Bang, C., Gullestad, N., Larsen T. & Norderhaug M. 1963: Norsk Ornitologisk Spitsbergen Ekspedisjon, sommeren 1962. *Norsk Polarinst. Årb. 1962:* 93–119.

Boyd, H. 1964: Barnacle Geese caught in Dumfriesshire in February 1963. *Wildfowl Trust Ann.Rep. 15:* 75–76.

Holgersen, H. 1955: Bird-banding in Norway 1954. *Sterna 21:* 1–40.

Holgersen, H. 1956: Bird-banding in Norway. *Sterna* 26: 1–48.

Jourdain F.C.R. 1921: Remarks on the eggs and nests of Spitsbergen geese. *Bull. Brit. Orn. CL. 42.*

Jourdain, F.C.R. 1922: The Breeding habits of the Barnacle Geese. *The Auk* 39: 116–171

Jourdain, F.C.R. 1922: The Birds of Spitsbergen and Bear Island. *The Ibis (ser. XI) –4:* 159–179.

Koenig, A. & le Roi. O. 1911: *Avifauna Spitzbergensis.* 270 pp. Bonn.

Løvenskiold, H.L. 1964: Avifauna Svalbardensis. *Norsk Polarinst. Skr. 129.* 460 pp.

Mathey-Dupraz, A. 1917: Contribution à l'ornithologie du Spitsberg. *Ornithol. Beobacht.*

Salomonsen, F. 1958: The Present Status of the Brent Goose *(Branta bernicla* (L.) in Western Europe. *IWRD Bull. 4:* 1–80.

BARWOLT S. EBBINGE, HENK T. van der MEULEN and JOHAN J. SMIT:

Changes in winter distribution and population size of Pink-footed Geese breeding in Svalbard

Ebbinge, B.S., van der Meulen, H.T. & Smit, J.J. 1984: Changes in winter distribution and population size of Pink-footed Geese breeding in Svalbard. *Nor. Polarinst. Skr. 181:* 11–17.

Ringing of the Svalbard population of the Pink-footed Goose in its Netherlands wintering grounds has provided 204 recoveries of dead birds. These show changes in winter distribution since the 1950s, with many fewer in Germany than formerly. The population has increased considerably in recent years, but more birds are counted in Denmark in autumn and spring than in the entire winter range in mid-winter. Possible causes of the increase include spring feeding to prevent agricultural damage, cessation of spring shooting in Svalbard, and full protection in the Netherlands. Ringing recoveries reveal a slight interchange with the Iceland-British population of Pinkfeet, but no net immigration or emigration. Recruitment has not changed significantly in the period of study, but mortality has fallen.

Barwolt S. Ebbinge, Henk T. van der Meulen, and Johan J. Smit, Research Institute for Nature Management, P.O.Box 46, 3956 ZR Leersum, Netherlands.

Introduction

Since the severely cold winter of 1955–56, Pink-footed Geese from Svalbard have again become regular winter visitors in The Netherlands (Timmerman 1977). Peak counts in The Netherlands account for about 60% of the peak numbers counted in autumn in Denmark, but in some seasons similar numbers are found in both countries (see Fig. 1). Virtually all Pinkfeet that winter in The Netherlands are concentrated in the southwestern part of the province of Friesland. For a detailed description of their distribution the reader is referred to Timmerman (1977), Rooth et al. (1981), and Schilperoord (1984).

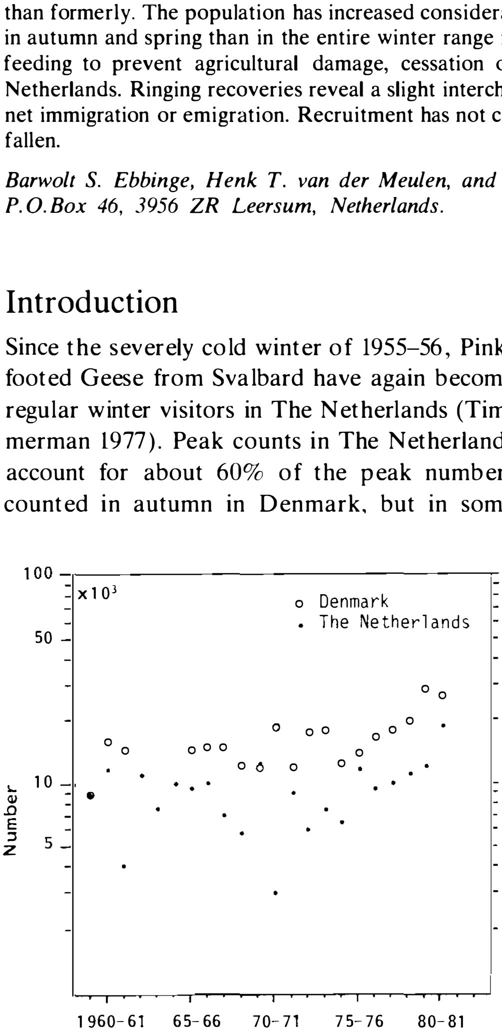


Figure 1. Annual peak numbers of Pink-footed Geese in Denmark (open circles) (after Madsen 1982) and in The Netherlands (dots) (after Timmerman 1977, Rooth et al. 1981, and Timmerman Azn. in annual reports of the Dutch Goose Working Group).

In cooperation with nine old-time goose-netters catching geese with spring operated clap-nets, the Dutch Research Institute for Nature Management (R.I.N.) carries out a ringing programme on White-fronted, Bean, Barnacle and Pink-footed Geese. The goose-netters use carefully selected live decoys to attract the wild geese to their nets. The ringing programme was started in 1955 and is supervised by Mr. J.J. Smit. Under this scheme 1,322 Pinkfeet have so far been ringed, almost all of them in the province of Friesland. Ringing, sexing and ageing of these geese have been carried out almost exclusively by the second author of this paper.

Distribution of ringing recoveries over Western Europe

From these 1,322 ringed Pinkfeet the Dutch Ringing Office 'Vogeltrekstation Arnhem' has received 204 recoveries of dead birds. Table 1 presents the distribution of these recoveries over

Table 1. *Distribution of recoveries of Pink-footed Geese ringed in Svalbard and in The Netherlands over the countries of recovery in five-year periods. Figures refer to total reported dead. Number of birds reported shot is given in parentheses.*

Ringed in:	*Svalbard**		*The Netherlands*				
Recovered in:	*1952/56*	*1956/63*	*1958/63*	*1963/68*	*1968/73*	*1973/78*	*1978/83*
Svalbard	?	?	–	–	4(4)	2(2)	3(–)
Norway	4		–	1(1)	3(2)	3(3)	1(1)
Sweden	–	–	–	–	–	–	2(–)
Denmark	11	18	2(2)	24(24)	43(42)	23(22)	19(19)
FRG	59	–	6(4)	2(2)	6(5)	3(3)	–
Netherlands	18	10	10(2)	6(5)	13(9)	6(2)	9(1)
Belgium	5	4	1(1)	–	–	–	–
France	20	3	1(1)	–	4(4)	–	1(1)
Great Britain	2		2(1)	–	1(1)	–	1(1)
USSR	1		–	–	1(1)	–	–

*From Holgersen (1958) and Bauer & Glutz von Blotzheim (1968).

the various countries. In this table we also included the recoveries of Pinkfeet ringed in Svalbard in the early Fifties (Holgersen 1958; Bauer & Glutz von Blotzheim 1968). Comparing the distribution of recoveries of the birds ringed in Svalbard to that of those ringed in The Netherlands, it is apparent that we are dealing with one and the same population. Only eight recoveries (including the Svalbard ringed birds) are from outside the known range of this population, viz. two from the U.S.S.R. (one from Ostrov Kolgujev 68° 30′ N, 51° 18′ E, and one from Konakovo 56° 40′ N, 36° 50′ E), and six from Great Britain. Half of the latter are from

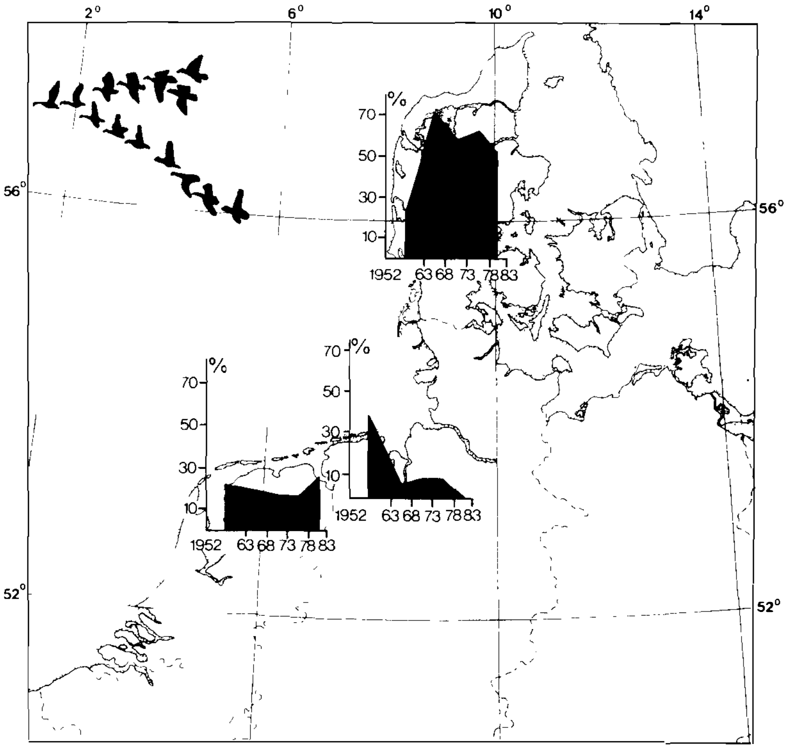


Figure 2. Relative distribution of recoveries of Pink-footed Geese (ringed in Svalbard and The Netherlands) over Denmark, West-Germany and The Netherlands. Recoveries per country expressed as percentage of all recoveries per five-year period (see Table 2).

within the wintering range of the Icelandic-British population of Pinkfeet, whereas the other three were recovered in the very south of Britain in the unusually cold winter of 1962–63. Most of the French recoveries are also from severely cold winters, viz. 1955–56 and 1962–63.

There is a striking difference between the spatial distribution of the recoveries in the Fifties and that of later ones. As illustrated in Fig. 2 there are far fewer recoveries from the Federal Republic of Germany in the Sixties and Seventies, than there used to be in the Fifties. Reports on the occurrence of Pink-footed Geese in this country confirm that all former haunts of this species have been deserted (see Timmerman 1977 and Prokosch 1984). Presumably in recent years most Pinkfeet migrate directly from Denmark to The Netherlands. The total lack of recoveries from the FRG during the last five year period (Table 1) will be due to the full protection recently granted to the species (Lampio 1983).

Though the species is fully protected in The Netherlands since 1976, no similar drop in the relative level of recoveries in The Netherlands is discernible (see Fig. 2). Possibly the majority of the hunters do not distinguish this species from other 'grey geese' that can still be hunted legally. The rings, however, are still reported to the Ringing Office as 'found dead'.

Recent changes in numbers

Since no significant numbers of Pinkfeet winter either in the FRG or in Denmark (Madsen 1982), the discrepancy between the Danish and the Dutch (including Belgian) counts (Fig. 1) is difficult to explain. According to the Danish Game Statistics, about 1,500 Pinkfeet are shot each autumn (P. Jepsen pers.comm.). Subtracting this number and the few hundreds staying in Denmark throughout the winter still leaves on average 6,000 missing birds. To some extent, a number of Pinkfeet may 'disappear' amongst the 200,000 White-fronted Geese *Anser albifrons* that arrive in The Netherlands in the course of December (see Rooth et al. 1981), just like the Ross' Geese *Anser rossi* 'disappear' among the far more numerous Lesser Snow Geese *Anser c. caerulescens* in the United States (McLandress 1979). However, information from the regular goose counts in The Netherlands indicates that the proportion of Pinkfeet among the White-fronts is certainly less than 1 %, and more likely in the order of 0.1 %. Therefore only several hundreds of the 6,000 missing ones can be accounted for in this way. The recent Danish spring counts, when again the entire population is concentrated in that country, are virtually identical with the Dutch peak counts (Madsen 1982). So either the number shot in the autumn before the geese arrive in The Netherlands must be considerably higher, or the size of the early autumn concentration of Pinkfeet in Denmark is somehow systematically overestimated.

Despite these differences between the Danish and Dutch counts, both series show the same trend. Up to 1974--75 numbers were rather stable, though some wide fluctuations did occur in the Dutch counts. From 1975 onwards, however, both series show a more or less similar rate of increase, on average at a finite rate of 1.14 (or 14%) per year.

Possible causes for the recent increase are: (1) the onset in 1973 of a spring feeding programme in Denmark to prevent agricultural damage (P. Jepsen pers. comm.), (2) stopping of spring hunting in Svalbard (Lampio 1983) (until 1975 Pinkfeet could still be shot upon arrival on their breeding grounds until 10 June (Lampio 1977)), and (3) the full protection granted to the species in The Netherlands in 1976. However, the increasing trend had already started when the species could still be hunted legally in The Netherlands.

Exchange with the Icelandic-British population

Though Ogilvie (1982) stated that the two populations of Pink-footed Geese are completely isolated from one another, we have already seen that three ringed birds from the Svalbard population have been recovered in the usual wintering area of the Icelandic-British population. Large numbers from this latter population have been ringed both in Iceland and in Britain in the Fifties. In Table 2 the recoveries resulting from this ringing programme are compared to the recoveries of birds from the Svalbard population. As can be seen, the majority of the Icelandic

Table 2. *Amount of exchange between the populations of Pink-footed Geese from Iceland/Greenland and from Svalbard.*

Recovered in: / *Ringed in:*	*Iceland/Britain*	*Svalbard/Norway/ Denmark/Germany/ Netherlands*
Iceland/Britain* 1950–1967	5275	5(+ 20**)
Svalbard* 1952–1964	1(+ 1**)	152
Netherlands 1955–1983	2(+ 2**)	200

*From Bauer & Glutz von Blotzheim 1968.
**Extreme weather conditions (see text).

population remains true to its own range, but 25 have been recovered within the range of the Svalbard population. Twenty of them have been shot along the Norwegian coast shortly after westerly gales. It is quite likely that these birds, had they not been shot, would have returned to their British wintering grounds. In five other cases, however, there were no obvious reasons why the birds occurred outside their usual range.

If we assume that the likelihood of recovery does not differ significantly between Britain and continental Europe, and we exclude the recoveries resulting directly from extreme weather conditions, we can estimate the proportion of birds emigrating from the Icelandic population into the Svalbard population at 5/(5275 + 25) = 0.1%. In the same way the proportion of birds emigrating from the Svalbard population into the Icelandic one will be 3/358 = 0.8%. If we include the recoveries after extreme weather conditions the proportions would be 0.5% and 1.7%, respectively. Multiplying these proportions by the respective population sizes (see Figs. 1 and 3) we arrive at an immigration influx from the Icelandic population into the Svalbard population of 100–400 birds annually, whereas a similar number of 150–300 birds emigrates from the Svalbard population to the Icelandic one. So it is unlikely that the recent increase in number of the Svalbard population is caused by immigration from the Icelandic-British population. The pattern might have changed, however, since the above calculation is based on ringing results of some twenty years ago. Because during the last twenty years no further ringing of the Icelandic-British Pinkfeet has been carried out, the possibility of a higher immigration rate from that population than calculated cannot be excluded entirely.

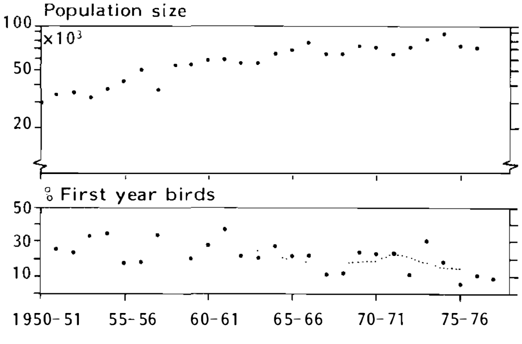


Figure 3. Changes in size and breeding success of the population of Pink-footed Geese wintering in Britain (after Ogilvie 1982). Dotted line follows the five-year running means.

Recruitment

It was not until 1980 that age ratios in the field were collected on a regular basis for the Svalbard population (J. Madsen, L. Schilperoord pers. comm.). The only remaining information on recruitment is from the catches made for the R.I.N.-ringing scheme. Because the number caught is quite small, on average 47 birds per season, we have taken the annual samples together for two periods. During the first period, 1955–1974, the population was stable in number, and the proportion of first-year birds was 29% (n=872). The second period is the one from 1975 till 1983 when the population increased by 14% per year. Then the proportion of first-year birds was 25% (n=450). Thus, we must conclude that the increase in population size cannot have been caused by an increase in the rate of reproduction.

Mortality

Because the number of recoveries is too small to allow the use of timespecific models (Brownie et al. 1978) we have only used Haldane's model (1955) assuming a constant mortality rate throughout the entire 28-year period. We have restricted the analysis to shot birds. Because the ringing season overlaps the hunting season which yields the majority of the recoveries, we have excluded recoveries of birds shot during their winter of ringing. In this way all remaining recoveries were from birds that survived their ringing season and had equal chances to be recovered later on. Since most shooting in Denmark takes place in the autumn before the ringing season in The Netherlands starts, only 17 recoveries of birds shot in the winter of ringing had to be excluded. Birds shot and reported in the first season after ringing numbered 52, those shot in the second season after being ringed 36, in the third 31, and in the fourth season after ringing, 19. Using Haldane's model on this selected sample we found a mean annual mortality rate of 27% (s.e.=3) for those ringed as adults, and 30% (s.e.=4) for those ringed as first-year birds.

From the changes in numbers and age ratios (method described in Ebbinge 1982 and in press) one obtains a value of 29% annual mortality for the stable period 1955–1974, if we accept the clap-netted samples as an unbiased measure for the proportion of first-year birds. For the recent period of increasing numbers the mortality rate must have dropped to 15% per year ($m=0.25-(1.14-1)\ (1-0.25)$), excluding the possibility of net immigration from the Icelandic-British population.

Discussion

The Svalbard population of Pink-footed Geese is an increasing one, and this increase must be the result of a marked reduction in the mortality rate, since neither net immigration, nor an increase in recruitment, occurred. Many goose populations in northwest Europe have shown substantial increases in recent decades (see e.g. Ogilvie 1978). Of particular interest in the context of this study are the Icelandic-British population of the Pink-footed Goose (Fig. 3), breeding in Iceland and Greenland, and wintering in Britain (Ogilvie & Boyd 1975; Ogilvie 1982), and the Baltic-North Sea population of the White-fronted Goose *Anser albifrons albifrons* (Fig. 4), breeding in northern Russia and wintering primarily in The Netherlands (Philippona 1972; Rooth et al. 1981; Philippona in annual reports of the Dutch Goose Working Group).

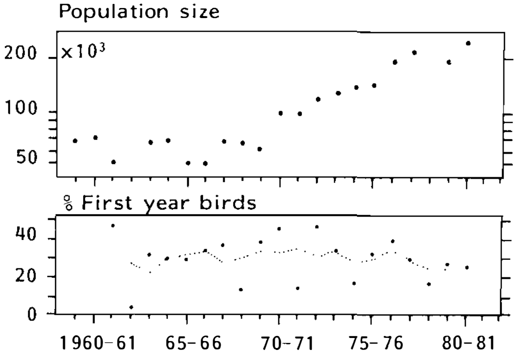


Figure 4. Changes in size and breeding success of the Baltic/North Sea population of White-fronted Geese (after Philippona in annual reports of the Dutch Goose Working Group, and Rooth et al. 1981). Dotted line follows the three-year running means.

The number of Icelandic Pinkfeet has gradually increased since 1950. In the early Sixties the population remained stable for some years, but since then the increasing trend was resumed, although on an ever decreasing rate. The White-fronts, though fluctuating widely, remained more or less stable in numbers in the period 1959–1969. Since 1970, numbers started to increase at a fairly stable rate that seems to be maintained until now.

According to Ogilvie (1982), the increase in number of Icelandic Pinkfeet (Fig. 3) is the result of both a steady reduction in the amount of shooting to which the geese are exposed, and of improved feeding conditions on the British wintering grounds.

In the example of the White-fronted Goose (Fig. 4) the situation is quite different. After an initial period of rather stable numbers the increase starts quite suddenly in 1970. This largely rules out the much more gradual changes in agriculture as a major cause for the observed increase. From the lower panel in Fig. 4 it is apparent that the increase cannot be explained by a change in breeding success either. When numbers were stable Doude van Troostwijk (1974) calculated from ringing recoveries a mean annual mortality rate of 31% for the period 1953–1966. From the counts and age ratios a similar figure is obtained for the period up to 1970, because in a stable population mortality equals recruitment, and mean recruitment (proportion of first-year birds) was on average 30% up to 1970. Mean recruitment has not changed significantly since 1970 (see lower panel Fig. 4), so the mortality rate must have dropped markedly since 1970. The most obvious cause for this drop is the ban on spring hunting in the U.S.S.R. coming into effect in 1970 (Rutschke 1976). We can rule out the possibility of significant immigration from easterly populations as the number of Whitefronts in eastern Europe had already declined tremendously by 1964–65 (Bauer & Glutz von Blotzheim 1968), whereas the increase in size of the Baltic-North Sea population (Fig. 4) did not start until 1970.

The fact that the increase in size of this population started at a different time from in the other two examples, strengthens our view that improved feeding conditions on the wintering grounds are not the cause for the observed increase in goose numbers. Though both the Svalbard Pinkfeet and the Russian Whitefronts share the same wintering area in the southwestern part of the Dutch province of Friesland, the increase in the Whitefronts started five years earlier. Since the Svalbard Pinkfeet do not migrate through the U.S.S.R. the ban on spring hunting coming into effect in 1970 in that country only reduced the mortality rate of the Whitefronts.

As to the discrepancy between the Danish and the Dutch counts (Fig. 1), the explanation by a much higher autumn kill in Denmark is unlikely. Since the mortality rate has dropped recently to 15% per year, the total number of birds dying each year is about 4,000. To make up for the difference between the Dutch and Danish counts, the Danes would have to kill another 6,000 birds, which would raise the annual kill in Denmark alone to 7,500, which is almost twice the number dying per year. So either underestimation in The Netherlands or overestimation of the autumn peak in Denmark is likely to cause the observed difference. Here is a challenge for the coordinators of the regular goose censuses.

Splitting up the recovery data in shorter periods of time resulted in such an increase in the standard error that no meaningful estimates for the mortality over shorter periods than the entire 28-year period of study could be obtained. In order to do so we should have ringed about 500 birds annually. The best opportunities to catch them in big numbers occur in the spring in Denmark, when the geese feed very predictably in dense flocks on barley supplied to them by man, or during the period of wing moult in Svalbard. We hope that both the Danes and the Norwegians will start a full scale ringing scheme for, say, at least five years on this small and interesting population. A colour-ringing scheme enabling repeated sightings of individual birds, like the ones run on Barnacle and Brent Geese, would be the ideal, but the administration of such schemes is quite a task. In this case it will be possible to measure changes in the mortality rate independently. Ringing in spring and during the summer has the additional advantage that those periods do not overlap the hunting season.

Summary

The available data on numbers and ringed birds of the less well-studied Svalbard population on Pink-footed Geese – both population censuses and ringing data – are discussed. This population has increased markedly in recent years. The increase can only be accounted for by a marked reduction in mortality. The recoveries of birds ringed in Svalbard and in The Netherlands show a similar distribution, confirming that we are dealing with one and the same population. They also show that the Federal Republic of Germany used to have very important wintering areas in the early Fifties, but is at present of little significance for this population.

It is hoped that ringing activities will be undertaken both in Denmark and in Svalbard in the near future to enable a much more detailed study of the reduction in mortality.

Acknowledgements

We are very grateful to J. Walinga and M. van der Wal who actually caught most of the geese, to the Dutch Ringing Office for its careful administration of recoveries, and to the many volunteer goose counters. For their critical comments on this paper we gratefully acknowledge prof. Dr. Herman Klomp, prof. Dr. Rudolf H. Drent, and Dr. Arie L. Spaans. We would also like to thank Mr. Arjan Griffioen for his careful preparation of the figures and Mrs. Y. Dammers for typing the manuscript.

References

Bauer, K.M. & Glutz von Blotzheim, U.N. 1968: *Handbuch der Vögel Mitteleuropas Band 2 Anseriformes.* Akad. Verl., Frankfurt am Main. 535 p.

Brownie, C., Anderson, D.R., Burnham K.P. & Robson, D.S. 1978. Statistical inferrence from band recovery data. *U.S. Dept. Int. Fish & Wildl. Serv. Res. Publ. 131.* 212 p.

Doude van Troostwijk, W.J. 1974: Ringing data on White-fronted Geese *Anser a. albifrons* in the Netherlands, 1953–1968. *Ardea 62*:98–110.

Ebbinge, B. 1982: The status of *Branta leucopsis* in 1980–81. *Aquila 89:* 151–161.

Ebbinge, B. in press: Factors determining the population size of arctic-breeding geese, wintering in western Europe. *Ardea 73.*

Haldane, J.B.S. 1955: The calculation of mortality rates from ringing data. *Proc. Int. Orn. Cong. 11*:454-458.

Holgersen, H. 1958: Pinkfeet in Europe. The effect of the cold weather of February 1956 on distribution of the Pink-footed Geese in North-West Europe. *Wildfowl Trust Ann. Rep. 9:*170–174.

Lampio, T. 1983: Waterfowl hunting in Europe, North America and some African and Asian countries in 1980–81. *IWRB spec. Publ. no. 3.*

Madsen, J. 1982: Observations on the Svalbard population of *Anser brachyrhynchus* in Denmark. *Aquila 89:*133–140.

McLandress, M.R. 1979: Status of Ross' Geese in California. *In:* Jarvis, R.L. & Bartonek, J.C. (eds): *Management and Biology of Pacific Flyway Geese.* O.S.U.' Bookstores Inc. Corvallis, Oregon.

Ogilvie, M.A. 1978: *Wild Geese.* Poyser, Berkhamsted. 350 p.

Ogilvie, M.A. 1982: The status of the Pink-footed Goose *Anser brachyrhynchus. Aquila 89:*127–131.

Ogilvie, M.A. & Boyd, H. 1975: The numbers of Pink-footed and Greylag Geese wintering in Britain: observations 1969–1975 and predictions 1976–1980. *Wildfowl 27:*63–76.

Philippona, J. 1972: *Die Blessgans.* Die neue Brehm-Bücherei, Wittenberg Lutherstadt. 135 p.

Prokosch, P. 1984: The wintering sites of Svalbard Pink-footed Geese *Anser brachyrhynchus* in Germany – present situation. *Norsk Polarinstitutt Skr. 181:* (this volume).

Rooth, J., Ebbinge, B., van Haperen, A., Lok, M., Timmerman, A., Philippona, J. & van der Bergh, L. 1981: Numbers and distribution of wild geese in the Netherlands, 1974–1979. *Wildfowl 32:*146–155.

Rutschke, E. 1976: Wasservogelforschung und Wasservogelschutz in der USSR. *Der Falke 23:*365–373.

Timmerman, A. 1977: Het wintervoorkomen van de Kleine Rietgans *Anser brachyrhynchus. Limosa 50:*71–91.

JESPER MADSEN:

Numbers, distribution, and habitat utilization of Pink-footed Geese *Anser brachyrhynchus* in Denmark 1980–1983*

Madsen, J. 1984: Numbers, distribution, and habitat utilization of Pink-footed Geese *Anser brachyrhynchus* in Denmark 1980–1983. *Nor. Polarinst. Skr. 181*:19–23.

Data on population size, breeding success, distribution and habitat utilization of the Svalbard population of Pink-footed Geese wintering and staging in Denmark during the years 1980 to 1983 are presented. Since the peak count of 28, 500 individuals in autumn 1979 the population has apparently stabilized around 25–27,000 individuals, but problems in estimating the annual population level and breeding success exist. The Pink-footed Geese make use of 14 sites in seasonal succession with a close connection to habitat selection. In autumn feeding on stubble predominates, in winter and early spring most feeding takes place on pastures, and in spring most geese feed on new-sown cereal fields. The shift from grassland to new-sown fields has accelerated during the last decades, and conflicts with agriculture will probably increase in the near future. The possible reasons for the population increase since the 1950s are discussed.

Jesper Madsen, Institut for Zoologi og Zoofysiologi, Zoologisk Laboratorium, Universitetsparken, B10 3, DK-8000 Aarhus C, Denmark.

Introduction

In Denmark the Svalbard population of Pink-footed Geese *Anser brachyrhynchus* migrates through a narrow corridor in West Jutland and visits in sequence a total of 14 sites. In autumn the population stops from end September to late October; in mild winters part of the population returns to Denmark in late December from the southern winter range in the Netherlands and Belgium, and from March to mid-May the total population is distributed along the west coast of Denmark.

During the last decades the population has increased from 10–12,000 (1950s) to 25–29,000 (1979–1982) (Madsen 1982). During the same period the population has gradually changed feeding habitats from grassland to arable land. The population increase and the habitat shift have in combination caused a growing conflict with agricultural interests.

The aim of this paper is to document the overall situation of the Pinkfeet in Denmark, and the paper describes (1) the recent development and breeding success of the population, and (2) the distribution pattern and habitat utilization in Denmark 1980–1983. The spring feeding ecology and the damage to crops caused by the Pinkfeet in Western Jutland is currently being investigated, but these results will be reported later.

The information presented here is based on a three-year study of the staging and wintering goose populations in Denmark, organized by the Goose Study Group of the Danish Ornithological Society during the seasons 1980–81 to 1982–83 (the study was terminated in September 1983). The study has been based on midmonthly counts and was carried out in cooperation with the Game Biology Station, Kalø, the National Agency for the Protection of Nature, Monuments and Sites, and the Zoological Museum, Copenhagen. A detailed description of the organization and methods used is given by Madsen & Lund (1982).

Population counts

From the mid-1950s to early 1960s the population increased from 10–12,000 to 15–18,000. In the 1970s the population increased again, and a peak of 28,500 was reached in 1979 (Madsen 1982). During the last three years the population size has been estimated by special counts in October and April when the geese are concentrated in Western Jutland, as well as by compilation of the

---

*Report No. 4 of the Goose Study Group of the Danish Ornithological Society.

Table 1. Population size and population parameters 1980–83 of the Svalbard population of Pink-footed Geese.

Year	*Population estimate*	*Juvenile proportion % (N)*	*Mean brood size (N)*
1980	26900 (Oct.)	24.2 (1114)	2.4 (81)
1981	21000 (Oct.)	5–10 (1264)	2.2 (66)
1982	26700 (Jan.)	21.8 (1318)	2.2 (78)

Danish, Dutch and Belgian mid-monthly counts through the winter. The population seems to have stabilized since the late 1970s (Table 1), although the estimated size in 1981 seems to be too low.

The breeding success assessed by age counts (Table 1) was rather good in 1980 and 1982 while bad in 1981. The spring was delayed in Svalbard in 1981 (A.T. Ekker, pers. comm.). This seems to have affected the breeding success of all three goose populations breeding in Svalbard, although the Pinkfeet were less affected than the Barnacle and Brent Geese (Owen 1984; Madsen 1984).

However, there appears to be a danger of bias when estimating the breeding success by age counts in the wintering areas. Thus in October 1981 a proportion of juveniles as high as 24% was obtained before the peak occurrence of geese in Western Jutland, whereas it was estimated to be only 5–10% during peak occurrence (in accordance with a later estimate achieved in the Netherlands, L. Schilperoord, pers. comm.). This indicates a differential migration between families (arriving early) and non-breeders, as has also been noticed in the Dark-bellied Brent Goose *Branta bernicla bernicla* population (St. Joseph 1979). In order to reach a reliable estimate, the age counts must be carried out when the majority of the population is gathered.

Numbers and distribution in Denmark

The numbers of Pinkfeet counted by the mid-monthly censuses from 1980–81 to 1982–83 are presented in Table 2, and the distribution along the west coast of Jutland in Fig. 1. The population is concentrated in Denmark in October, and in April and May, although as indicated (compare Tables 1 and 2), a complete population count is difficult to obtain. Wintering in Denmark takes place as long as temperatures are above freezing point (0°C) (Madsen 1980), and a northward migration from the Netherlands to Denmark occurs within 1–2 days of a thaw setting in following a period with frost. The movements between the Danish and Dutch wintering grounds are discussed in more detail by Schilperoord (1984) and will not be dealt with here.

The distribution maps (Fig 1) indicate that (1) due to heavy shooting pressure at other sites the population is concentrated at only three sites in autumn (Vest Stadil Fjord, Filsø, Tipperne) (Madsen 1982); (2) in mild winters flocks of geese stay mainly in the Wadden Sea region and on the Tipper peninsula, and a migration to Western Jutland takes place later (March-April) with the population concentrated on a few sites in May; and (3) most of the sites are only used for short periods (1–2 months) and there is much movement between the sites within short intervals.

Habitat utilization

A study of the habitat utilization has been included in the goose count scheme. All flocks within a site have been mapped and related to habitat (noting also the activity of the flocks). For each site the number of goose days per month in each of the three seasons has been calculated for each habitat type (operating with 12 different types; see Madsen & Lund 1982).

In Fig. 2 all sites have been summed to give an overall impression of the habitat distribution of the geese. In autumn, feeding is concentrated on stubble fields (Vest Stadil Fjord and Filsø). The majority of the geese leave Denmark in October probably due to depletion and ploughing of the stubble habitat. In winter the remaining geese and the later arriving wintering flocks feed mainly on pastures, and this is predominant until April when a shift to new sown cereal fields takes place. Included in the new sown cereal habitat type is the feeding of geese with grain which takes place in Vest Stadil Fjord to prevent damage to the surrounding new sown fields (see Fog 1982). However, the utilization of the new sown cereal fields is probably underestimated because the geese often fly from the fields to the roost in the

Table 2. *Mid-monthly totals of Pink-footed Geese in Denmark 1980/81 to 1982/83.*

	Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*
1980/81	17625	2606	344	224	12131	12929	19339	1552
1981/82	15730	28	26	0	14991	11653	17809	15030
1982/83	5613	1	0	15848	2170	13602	21064	3099

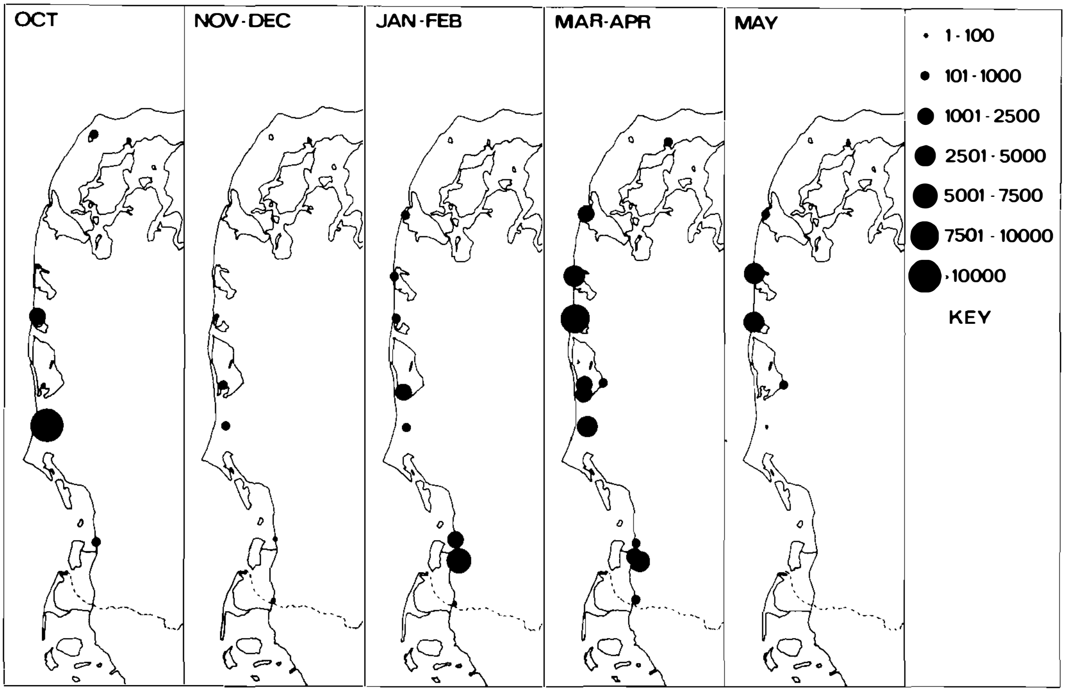


Fig. 1. The distribution of Pink-footed Geese along the Danish west coast from October to May 1980–83. Average numbers per site in the three seasons are shown. Where two months are shown together, the highest average is used.

middle of the day where they might have been counted (M. Hansen, pers. comm.).

Feeding on winter crops (especially winter wheat) is not of major importance to the geese. They do sporadically feed in this habitat however, and on one occasion damage to winter wheat fields has been claimed (Filsø, autumn 1981). The farmer consequently drove off the geese from the area in the following autumn resulting in a mass departure of 10,000 geese on 15 October 1982 (seen in the Netherlands on the same day). An increase in feeding on winter wheat in the Tønder polders has been reported since the diking of the Rodenäs/Højer saltings (I. Gram, pers. comm.). However, most of the staging population here has abandoned the area since the diking in 1979 (Gram 1982).

Because the Pinkfeet now move to the new sown fields, saltings and natural meadows which were previously the most important spring feeding habitats are only of minor importance nowadays. In Tipperne, where a management programme of the meadows increased the carrying capacity of the area (1972–1978) (Madsen 1980), the spring population of Pinkfeet has declined during the last five years, despite the increase of the population in general.

Discussion

The reasons for the population increase since the 1950s are most probably to be found on the wintering grounds, although little is known of

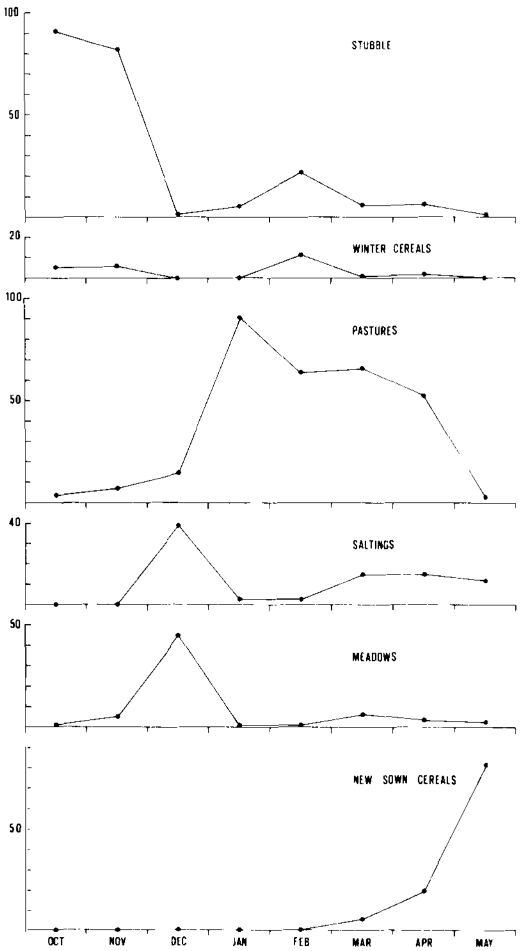


Fig. 2. The habitat distribution of Pink-footed Geese in Denmark 1980–83 (all sites summed). The usage of a habitat type is expressed as the percentage of the total number of goose days per month.

regulating factors on the spring staging areas in Norway and on the breeding grounds. A more effective protection since the 1950s (e.g. ban on spring shooting in Denmark in 1955) has probably been the most important factor (Madsen 1982), but the change from feeding on grassland to new sown fields in the spring may also have contributed significantly to this development.

The shift from grassland to new sown fields in the spring started in the mid 1950s. Due to spring shooting the geese were concentrated on Tipperne before 1955. but since the shooting ban the geese dispersed to other sites, e.g. to the newly reclaimed fields in Vest Stadil Fjord, where the grain feeding started on a larger scale. Until the early 1970s Vest Stadil Fjord was the only place where larger flocks were seen on new sown fields. In the 1970s a massive shift to the new sown fields took place, and flocks of geese were now feeding on grain in several places in Western Jutland. According to several farmers the utilization of the fields has increased dramatically within the last 2–3 years. Flocks are now seen far inland on fields without connection to any of the traditional haunts. Despite the honest motives it cannot be ignored that the feeding of geese in Vest Stadil Fjord since 1973 may have contributed to the acceleration of the habitat shift (and ultimately to the population increase), as a major part of the population has adopted the habit of grain feeding here.

Compared to grass, grain has a much higher digestibility, and the geese only need to spend about 50% of the day feeding on new sown fields, compared to 75–80% on pastures to obtain the same body condition (J. Madsen unpubl.). Feeding on grain may have added significantly to the condition of the geese, enabling them to attain sufficient fat deposits to complete a successful breeding cycle more easily than on grass.

In general the Pinkfeet have a broad spectrum of feeding habitats which shows an adaptation to farming practice, although grain seems to be the preferred food source both autumn and spring (waste grain and new sown grain, respectively). The distribution and movements of geese along the Danish west coast are closely connected to the feeding ecology (available and preferred food sources): (1) in autumn, the geese are restricted to haunts where shooting is regulated or prohibited, and they abandon these sites due to depletion of the habitat; (2) in mild winters the geese exploit pastures. Although there exists some standing crop, no significant primary production takes place until March/April, and the habitats are depleted by the grazing geese (B. Lorentzen, unpubl.); (3) as the sowing starts in Western Jutland the geese leave the grassland and go to the new sown fields.

Within a few years the entire Pinkfoot population will probably have changed to the new sown fields in spring, involving increased conflicts with the farmers. It is reasonable to consider whether attempts should be made now to prevent this development, and discussions and planning of a future management of the spring staging areas and the goose population should be initiated (see also Jepsen 1984).

Acknowledgements

Anders Holm Joensen, Hans Meltofte, Thorkild Lund, and Palle Uhd Jepsen are thanked for fruitful discussions and critical comments on the manuscript. Leo Schilperoord is thanked for the Dutch data.

References

Fog, M. 1982: Vildgæssene søger føde på landmandens marker. *Dansk Vildtforskning 1981,* 15-19.

Gram, I. 1982: Forekomsten af Kortnæbbet Gås *(Anser brachyrhynchus)* i Tøndermarsken. Pp. 50-58 in: Madsen, J. & T. Lund (eds.): *Årsrapport 1981, Gåsegruppen, Dansk Ornithologisk Forening.* National Agency for the Protection of Nature, Monuments and Sites.

Jepsen, P.U. 1984: Protection and managment of arctic goose populations in Denmark. *Nor. Polarinst. Skr. 181* (this volume).

Madsen, J. 1980: Forekomst, habitatvalg og overnatning hos Kortnæbbet Gås *Anser brahyrhynchus* på Tipperne 1972–1978. *Dansk orn. Foren. Tidsskr. 74:* 45–58.

Madsen, J. 1982: Observations on the Svalbard population of *Anser brachyrhynchus* in Denmark: (a) Numbers, distribution and breeding success in 1980/81 and (b) Population trends 1931–1980. *Aquila 89:* 133–140.

Madsen, J. 1984: Status of the Svalbard population of Light-bellied Brent Geese *Branta bernicla hrota* wintering in Denmark 1980–1983. *Nor. Polarinst. Skr. 181* (this volume).

Madsen, J. & Lund, T. (eds.) 1982: *Årsrapport 1981. Gåsegruppen, Dansk Ornithologisk Forening.* National Agency for the Protection of Nature, Monuments and Sites, 62 pp.

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose *Branta leucopsis. Nor. Polarinst. Skr. 181* (this volume).

Schilperoord, L.J. 1984: The status of the Pink-footed Goose *Anser brachyrhynchus* in Southwest Friesland (the Netherlands) and the movements over western Europe. *Nor. Polarinst. Skr. 181* (this volume).

St. Joseph, A.K.M. 1979: The seasonal distribution and movements of *Branta bernicla* in western Europe. *Proceedings of the First Technical Meeting on Western Palearctic Migratory Bird Management, 45–59.*

PETER PROKOSCH:

The wintering sites of Svalbard Pink-footed Geese *Anser brachyrhynchus* in Germany – present situation

Prokosch, P. 1984: The wintering sites of Svalbard Pink-footed Geese *Anser brachyrhynchus* in Germany – present situation. *Nor. Polarinst. Skr. 181:* 25–28.

Short histories of the former important Pink-footed Goose haunts in Germany are given: Emsland (max. figures 2000–3000), Föhr (8000–10000), Jadebusen (10,000), and Rodenäs–Vorland (12,000). After the reclamation of Rodenäs–Vorland (1981/82), the geese have given up the last important site in Germany. Today less than 1000 Pink-footed Geese stay in Germany at any time in winter.

Peter Prokosch, WWF – Wattenmeerstelle Schleswig-Holstein, Olshausenstraße 40-60, D-2300 Kiel, Federal Republic of Germany.

Introduction

The news about the German Pink-footed Goose sites is rather sad: at present not a single important place (holding 1000 or more geese) remains. Although the Federal Republic of Germany is located in the geographic centre of the wintering area of the Svalbard population (Bauer & Glutz von Blotzheim 1968) and has been an important region in the past, the birds today by-pass it and frequent Denmark and the Netherlands on either side almost exclusively. To explain the reasons for this situation, I will give a brief review of the decline in importance of the four important sites since the middle of this century (Fig. 1):

Emsland

The often flooded lowlands of the rivers Ems, Leda, and Jümme were used as a regular wintering site by some 2000–3000 Pink-footed Geese until the Leda-barrage was built in 1954, draining the area (Atkinson-Willes 1961). Since then the geese have left. Not far away part of the Dollart area has remained an important goose haunt, but only for Bean Geese *Anser fabalis*, White-fronted Geese *A. albifrons*, and Greylag Geese *A. anser*. Pink-footed Geese no longer occur in significant numbers (less than 100 birds; Gerdes et al. 1978, Gerdes, in litt., Hummel 1980a).

Föhr

Until 1960, the marshland in the northern part of the island of Föhr was a very important wintering site for the Pinkfeet. The first birds regularly arrived as early as the end of September. The peak occurred in October/November with the arrival of 8000–10000 birds. In some years several thousand stayed there even in midwinter and were observed until April/(May) (Arfsten 1968, in litt.; Busche 1977, 1980; Bauer & Glutz von Blotzheim 1968; unpubl. data of the Ornithologische Arbeitsgemeinschaft Schleswig-Holstein). Inland pastures were used as feeding areas, whereas roosting places were on mudflats outside the seawall. Quite a few recoveries of shot birds, which had been marked by expeditions to Svalbard in the 50s, clearly proved the Svalbard origin of the geese (Holgersen 1958). In two cases Iceland-ringed birds were also on Föhr (Arfsten 1968). Parallel with the settlement of new buildings in the Föhr marshland and the ploughing up of pastures, the geese decreased drastically (Bauer & Glutz von Blotzheim 1968; pers. comm. with the farmers). 2000 geese seen on 1 April 1961 (Brunner, in litt.) was the last available figure of this magnitude. Since 1963–64 this haunt has had absolutely no significance for Pink-footed Geese. Helat (unpubl.) thought that the increasing hunting pressure also played a part in this development.

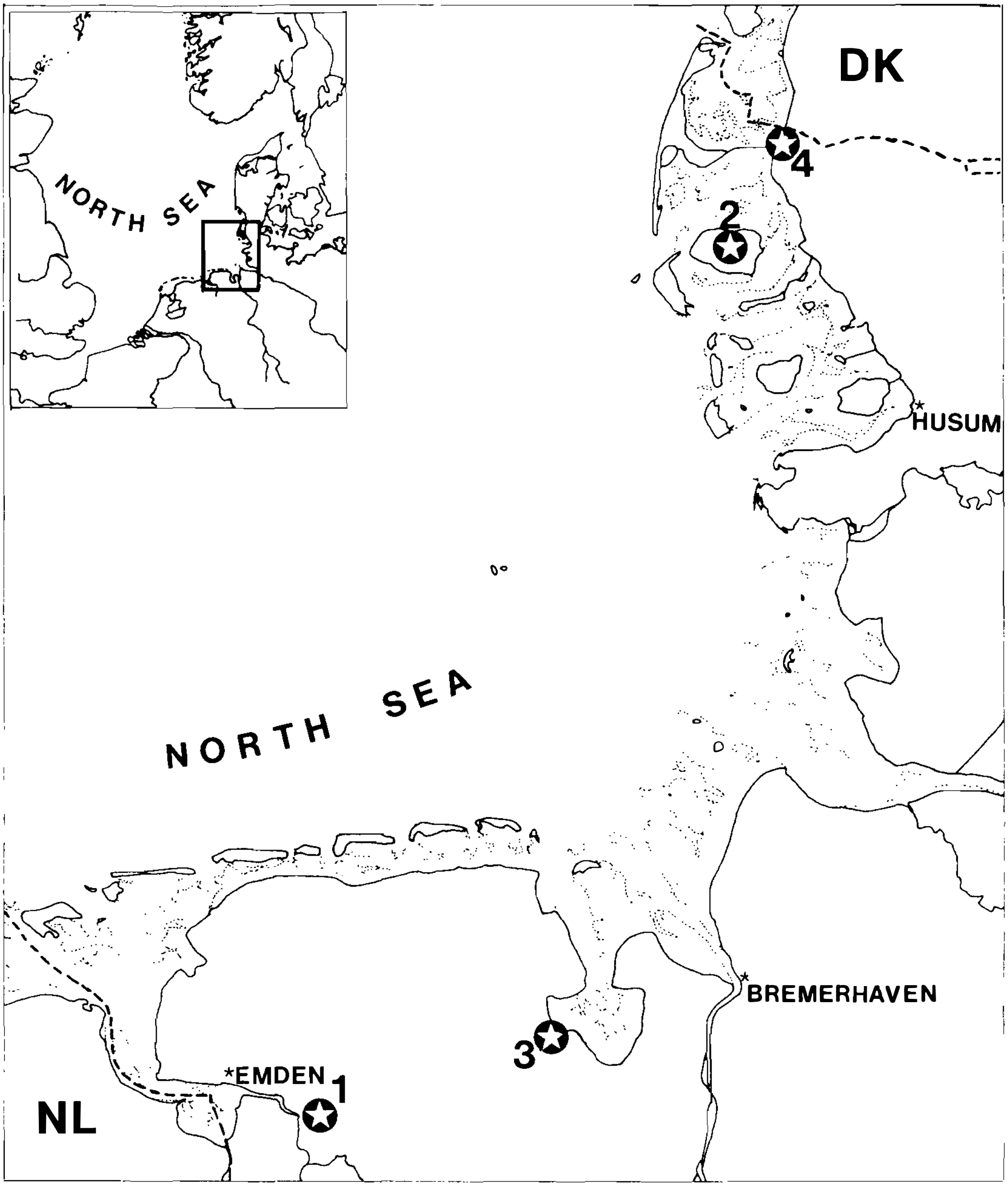


Fig. 1. The former important Pink-footed Goose haunts in Germany: 1) Emsland, 2) Föhr, 3) Jadebusen, 4) Rodenäs-Vorland (see text).

Jadebusen

The marshland around this Wadden Sea bight in Niedersachsen was a traditional wintering site for 3000–4000 Pinkfeet (max. 10,000 during a cold spell in January 1950) until 1955 (Bauer & Glutz von Blotzheim 1968; Großkopf, pers. comm.). Since then, the function of this haunt changed more and more from a long-time wintering to a brief staging area on migration back to Schleswig-Holstein/Denmark from the Netherlands (Bauer

& Glutz von Blotzheim 1968, Hummel 1980a). Relatively high numbers were recorded by Stichmann & Timmermann (1965), 5000 in January 1961, and Hummel (1980b), 4500 in January 1976. 3800 (5 February 1977) was the maximum for the 1976/77 season and then again 4500 (28 December 1977) for the following one (Hummel 1981). In 1978/79 the site was probably not used at all (Hummel 1982) and in 1981/82 for the last time more than 1000 Pink-footed Geese (1008 on 29 January 1982; Heckenroth, in litt.) were present at the Jadebusen. Again the winter 1982/83 no birds arrived at all (Henneberg, in litt.). Increasing tourist and hunting activities may have caused this decline (Hummel, pers. comm.; H.R. Henneberg, in litt.).

Rodenäs-Vorland

In 1964 this site – formerly an extensive saltmarsh area – was recognized as a major spring staging area for Pink-footed Geese (Busche 1977). For nearly twenty years it was the most important Pink-footed Goose haunt we had at that time in Germany (Fig. 2). At the peak 12,000 geese were seen on 17 April 1977 (Busche 1980). This site – used mainly from February to April – always had a close relationship to Danish haunts across the nearby border (I. Gram, pers. comm.; Hummel 1980a). Starting in 1979 in Denmark and finished in 1982 on the German side, a new seawall was built in the Wadden Sea on both sides of the Danish/German border reclaiming almost totally the Rodenäs-Vorland area (550 ha) and about 1200 ha littoral habitat in Denmark (MELF 1980; Prokosch 1978). Although the reclaimed area in Germany has kept its status as a nature protection zone, the Pink-footed Goose numbers dropped sharply after 1979. In the last two years a maximum of only some 500 birds were present (Fig. 2). Perhaps this change was also influenced partly by the increasing human activities in the area (the building of the seawall, roads, and other things, and spectators visiting the former quiet place). In any case the change in the goose habitat is obvious: a reduction of feeding space to central parts of the marsh due to enclosed seawall surroundings and an increase in sheep and cattle grazing. Nevertheless it may not be impossible to get some of the Pink-footed Geese back to Rodenäs, if the farming management can be more accommodated to the demands of the geese (e.g. limitation of the sheep and cattle grazing to the months June–September only; probable mowing of some fields).

Other sites in Germany

Danish and Dutch colleagues (e.g. Ebbinge 1984, Madsen 1984, Schilperoord 1984) have asked us several times whether there might possibly be other – so far undiscovered – sites with some 10,000 Pinkfeet staying in Germany for a period in the winter when this number of birds is missing between Denmark and the Netherlands. Discussing this problem with other geese experts in northern Germany (R.K. Berndt, G. Busche, K. Gerdes, H.R. Henneberg, D. Hummel, W. Knief) it seems unlikely that major haunts should still be undiscovered. Outside the four mentioned sites, roosting numbers of more than 100 Pink-footed Geese occur only irregularly (Berndt & Busche 1981; Busche 1980; Großkopf pers. comm.; Hummel 1980b, 1981, 1982). Even if we include the figures of our former important haunts (see above), a present total of more than 1000 geese in Germany at any time of the winter would be surprising. The Pink-footed Goose seems to by-pass Germany using a direct flyway across the North Sea between Denmark and the Netherlands as already assumed by Hummel (1980a).

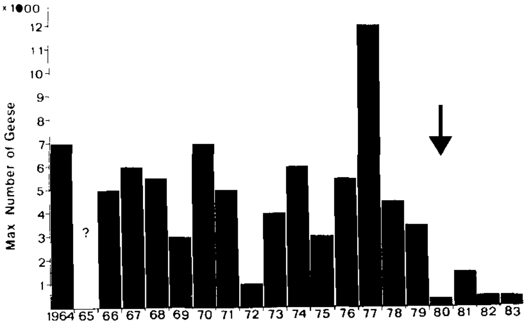


Fig. 2. The development of Pink-footed Goose spring maxima at Rodenäs-Vorland 1964–1983 (after Busche 1980; I. Gram pers. com.; unpubl. data of the Ornithologische Arbeitsgemeinschaft Schleswig-Holstein). The arrow marks the first winter/spring with dike-building activities (beginning in Denmark; new seawall completed by 1982).

References

Arfsten, R. 1968: Wildgänse auf der Insel Föhr. *Jordsand Mitt. 2:* 11–13.

Atkinson-Willes 1960: Emsland without wildfowl. *Wildfowl Trust Ann. Rep. 12:* 34–39.

Bauer, R.K. & Glutz von Blotzheim U.N. 1968: *Handbuch der Vögel Mitteleuropas. Vol. 2.* Akademische Verlagsgesellschaft, Frankfurt a.M.

Berndt, R.K. & Busche G. 1981: Ornithologischer Jahresbericht für Schleswig-Holstein 1979, mit besonderer Berücksichtigung des Kältewinters 1978/79. *Corax 8:* 226–265.

Busche, G. 1977: Gänse im Westen Schleswig-Holstein. *Die Heimat 84:* 340–349.

Busche, G. 1980: *Vogelbestände des Wattenmeeres von Schleswig-Holstein.* Kilda Verlag, Greven.

Ebbinge, B.S., Meulen, H.T. van der & Smit, J.J. 1984: Changes in winter distribution and population size of Pink-footed Geese breeding in Svalbard. *Nor. Polarinst. Skr. 181* (this volume).

Gerdes, K., Heß, D. & Reepmeyer, H. 1978: Räumliche und zeitliche Verteilungsmuster der Gänse *(Anser fabalis, A. albifrons* und *A. anser)* im Bereich des Dollart (1971–1977). *Vogelwelt 99:* 81–116.

Holgersen, H. 1958: Wanderungen und Winterquartiere der Spitzbergen–Kurzschnabelgänse. *Proc. XIIth Intern. Orn. Congress, Helsinki 1958:* 310–316.

Hummel, D. 1980a: Durchzug und Überwinterung der Kurzschnabelgans *(Anser brachyrhynchus)* im Bereich der Nordseeküste (1974–1977). *Vogelwelt 101:* 121–131.

Hummel, D. 1980b, 1981, 1982: Das Auftreten von Wildgänsen in der Bundesrepublik Deutschland vom 1.9.1976 bis 31.8.1977 (77–78, 78–79). *Ber. Int. Rat. Vogelschutz 20, 21, 22.*

Madsen, J. 1984: Numbers, distribution, and habitat utilization of Pink-footed Geese *Anser brachyrhynchus* in Denmark 1980–1983. *Nor. Polarinst. Skr. 181* (this volume).

MELF (Minister für Ernährung, Landwirtschaft und Forsten Schleswig-Holstein) (1981): *Vordeichung Tonderner Marsch. Faltblatt.* Kiel.

Prokosch, P. 1978: Pläne zur Eindeichung von Nahrungshabitaten der Dunkelbäuchigen Ringelgans *(Branta b. bernicla)* in Schleswig-Holstein. *Orn. Mitt. 30:* 3–12.

Schilperoord, L.J. 1984: The status of the Pink-footed Goose *Anser brachyrhynchus* in Southwest Friesland (the Netherlands) and the movements over western Europe. *Nor. Polarinst. Skr. 181* (this volume).

Stichmann, W. & Timmermann, A. 1965: Durchzug und Überwinterung der Gänse in Norddeutschland, den Niederlanden und Belgien 1960/61, 1961/62 und 1962/63. *Vogelwarte 23:* 140–148.

LEO J. SCHILPEROORD:

The status of the Pink-footed Goose *Anser brachyrhynchus* in Southwest Friesland (the Netherlands) and the movements over western Europe.

Schilperoord, L.J. 1984: The status of the Pink-footed Goose *Anser brachyrhynchus* in Southwest Friesland (the Netherlands) and the movements over western Europe. *Nor. Polarinst. Skr. 181:* 29–36.

From autumn 1979 to spring 1983 regular counts were made of the Pink-footed Geese, wintering in Southwest Friesland. Compared with the period before 1976 some local shifts in the distribution were noted and described. In the four seasons considered here most geese arrived in Friesland by the end of October or the beginning of November, except in 1982 when they arrived about two weeks earlier. The autumn maximum was reached during the first half of November and the numbers remained almost constant until December, when several thousands of Pinkfeet flew southwards to Belgium. The migration back to northerly feeding grounds started as early as January and it seems to be normal that nearly all geese have left Friesland after the first week of February. However, in three of the four seasons they returned under the influence of frost and snow in the second half of February. They moved northward for the second time in late February or early March. Southwest Friesland held 23 to 28% of the total number of Pink-footed Goose-days spent in Western Europe in 1980/81 to 1982/83 (Table 2). From the information of the occurrence in Denmark, Friesland, and Belgium it appears that during the whole winter period considerable numbers of Pinkfeet must be in unknown places. The missing numbers are much higher than those found in Germany.

Leo J. Schilperoord, Department of Zoology, State University at Groningen, P.O. Box 14, 9750 AA Haren, The Netherlands.

Introduction

Since October 1979 more regular counts than previously have been made of the Svalbard Pink-footed Geese *Anser brachyrhynchus* in Southwest Friesland, the most important wintering ground in the Netherlands. The geese were also counted in Denmark and Belgium. This means that we received a good picture of the occurrence of geese in these areas and their movements over Western Europe.

This report presents details of the occurrence of Pink-footed Geese in Southwest Friesland from 1979/80 to 1982/83 and makes a comparison with the occurrence in other countries. The distribution within Southwest Friesland during the last four seasons will be compared with the period before 1976, as described by Timmerman (1977). Finally, a summary will be given of the movements over Western Europe and the total numbers found in autumn, winter, and spring during the last four seasons.

Occurrence in Southwest Friesland

Distribution

The area of the Netherlands where the Pink-footed Geese winter is the southwestern part of Friesland, one of the most northern districts of the country. This area has been used as a wintering ground by thousands of Pink-footed Geese since the season of 1956/57 (Timmerman 1977). Fig. 1 shows the most important feeding grounds and roosts from 1979/80 to 1982/83. Outside this area Pinkfeet were seen very rarely and in very small numbers.

The area consists of grassland with scattered farms and villages. The grasslands are quite wet, mainly highly fertilized, and intensively used for cattle grazing or hay. Several lakes provide potential roosts; the most important of these from 1979 to 1983 were (see Fig. 1):

A. Flooded islands in the Zwarte en Witte Brekken.

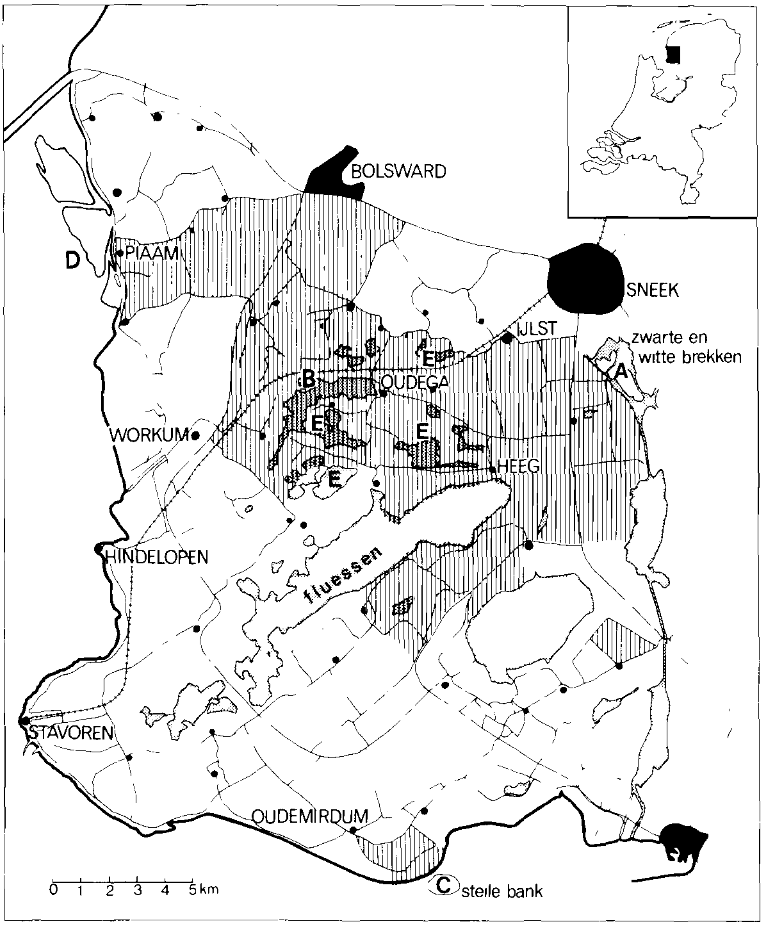


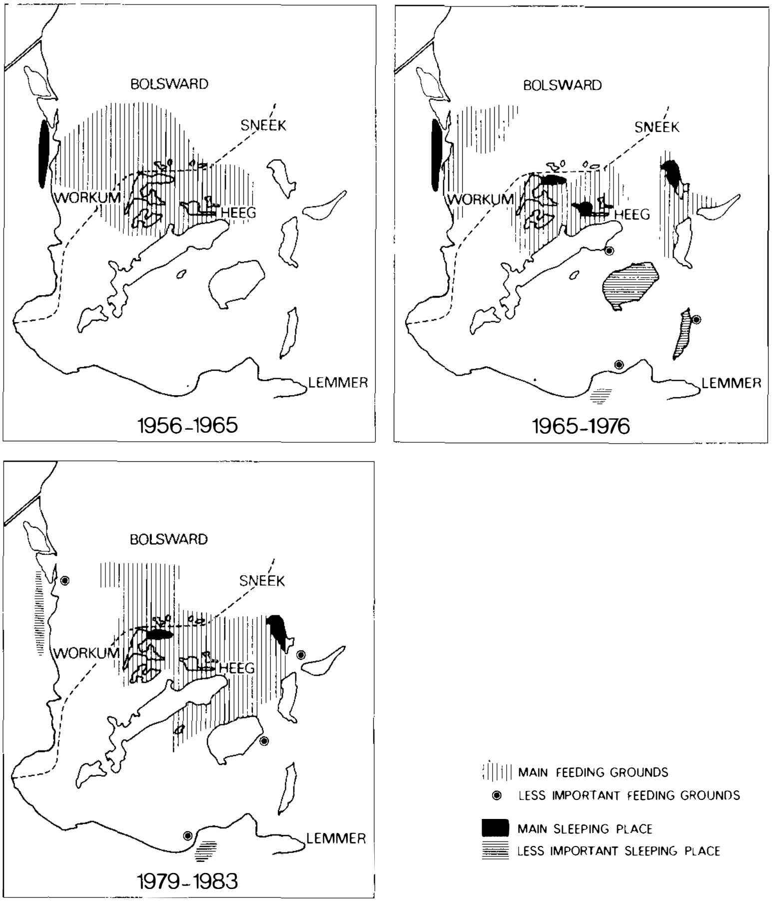
Fig. 1. Distribution of Pink-footed Geese in Southwest Friesland from 1979/80 to 1982/83. A, B, C, D and E refer to the roosts described in the text.

B. The Oudegaster Brekken, where the geese roost along the northern shore, swimming on the water.
C. The Steile Bank near Oudemirdum, a sand-bank in the IJsselmeer.
D. A sand-bank in the IJsselmeer near Piaam.
E. Some small lakes very close to the feeding grounds were used.

Compared with the distribution in Southwest Friesland from 1956 to 1976 (Timmerman 1977), local shifts have been noted as follows (see Fig. 2):

- The feeding grounds near Piaam and the roost there are now less important. Timmerman (1977) and Philippona (1978) claimed that the roost in the IJsselmeer was very important in the period before 1977, but now it is mainly used by a few tens or hundreds of Pink-footed Geese, though sometimes by 1000 to 1500 for only two or three days. The Workumerwaard is completely deserted as a feeding area.
- The feeding grounds around the Oudegaster Brekken (B) are now the most important area in December and January, when nearly all Pinkfeet are concentrated on this roost. On the other hand, the use of the Idzegaster Poel near Heeg as a roost was never determined for certain between 1979 and 1983, while this was one of the most important roosting places from 1961/62 to 1974/75 (Timmerman 1977; Philippona 1978). The Idzegaster Poel was probably used for the last time in 1974/75 (Philippona 1978).
- The area around the Zwarte en Witte Brekken (A) is still very important, although the grasslands east of this roost have been irregularly used.

Fig. 2. Distribution of Pink-footed Geese in Southwest Friesland 1956–1965, 1965–1976, and 1979–1983. Information about 1956–1976 after Timmerman (1977).



- The importance of the area southeast of the Fluessen has increased, especially in October and November, when most Pinkfeet foraged in that area.
- The use of the Steile Bank (C) and adjacent grassland is still irregular, but has been annual since 1972 (Philippona 1978) and probably more important than before 1976.

Numbers

The first few Pink-footed Geese probably arrived in the Netherlands at the end of September or during the first days of October. However, those very early observations concerned only individual birds and it was not until mid-October that the first hundreds were seen. There was a slow increase during the last two weeks of October, leading to a mass-arrival by the end of the month or the beginning of November (Fig. 3 and Table 1). An exception to this rule was 1982, when the mass-migration took place on 15 October. The early departure from Denmark on this date was most probably caused by a very high hunting pressure on their feeding grounds (Madsen 1984). On that day about 10,000 geese were seen leaving Denmark and flying directly to the Netherlands. This is confirmed by the observations of many migrating flocks of Pinkfeet, both in Germany and the northern part of the Netherlands, as described by Hulscher (1983). On 16 October, 10,600 Pinkfeet were counted in Southwest Friesland (Table 1 and Fig. 3).

In all four seasons, the numbers had nearly reached the autumn maximum during the first half of November. The peak number itself varied from year to year, but the numbers stayed about constant for several weeks in November and December.

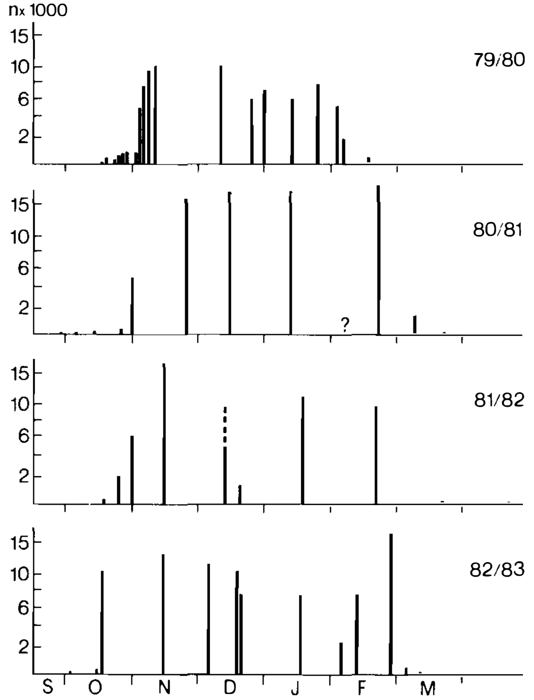


Fig. 3. Numbers of Pink-footed Geese in Southwest Friesland from 1979/80 to 1982/83.

By the end of November or the beginning of December some thousands of Pinkfeet flew southwards to Damme in Belgium. In most winters this led to a decrease of the numbers in Southwest Friesland, and in the very mild winter of 1979/80 the total numbers of Friesland and Belgium were quite constant until early February. This indicates that normally no more geese would arrive from the north after the mass-arrival in October or November.

This was not the case in 1980/81, when the numbers in Friesland showed a slight increase from November to December, in spite of the arrival of thousands in Belgium. This means that the departure of geese from Friesland was masked by the arrival of geese from the north, or that the geese in Belgium came directly from Denmark or Germany. This last possibility seems unlikely, in view of the fact that in the previous year they clearly came from Friesland.

In the winter of 1981/82, frost and snow from 7 to 29 December drove the geese away from Friesland to the southern parts of the Netherlands and to Belgium. No more than 1500 Pink-footed Geese remained in Friesland on 19 December, while in Belgium the exceptionally high number of 10,825 was reached on 2 January (Kuyken 1983). After this date the geese came back to Friesland and on 17 January a complete count resulted in a total of 11,500 Pinkfeet.

In three of the four seasons the January numbers were lower than those for November. This indicates that the migration back to the northerly feeding grounds must have already started in January, before the last geese departed from Belgium.

In spite of this early onset of the northerly migration, the Pink-footed Geese stayed in quite large numbers in Friesland until the end of January. However, as reported by others (Timmerman 1977; Rooth et al. 1981), it seems to be normal that nearly all geese have left the country by mid-February.

In 1979/80 the numbers dropped drastically from the first days of February onwards and nearly all geese were gone by the middle of the month (Fig. 3). The same probably happened in 1980/81, but this is not confirmed by counts which could not take place in the beginning of February because of thick fog. However, around mid-February, many Pinkfeet were back in Denmark, but a period of frost from 11 to 25 February drove the geese away as soon as the temperature fell below zero (J. Madsen, pers. comm.). This indicates that the geese counted in Friesland on 22 February had most probably returned from Denmark between 15 and 22 February. In that season nearly all geese definitely left the Netherlands during the first days of March, when there was a strong migration of geese (both Pinkfeet and Whitefronts *Anser albifrons)* to the north. They were seen above Groningen, and the Danish television reported the arrival of very many geese (M. Fog, in litt.). On 8 March only 1560 Pinkfeet were left in Southwest Friesland.

Table 1. *First observations of Pink-footed Geese in Southwest Friesland in the seasons 1979/80 – 1982/83.*

	First birds	*First hundreds*	*First thousands*
1979/80	16 Oct.: 80	18 Oct.: 380	3 Nov.: 5000
1980/81	27 Sept.: 2	15 Oct.: 250	1 Nov.: 5032
1981/82	(17 Oct.: 200)	17 Oct.: 200	24 Oct.: 2265 31 Oct.: 6150
1982/83	3 Oct.: 3	15 Oct.: 250	16 Oct.: 10600

The season of 1981/82 was strongly influenced by the period of severe winter weather in December. After returning to Friesland in January, the Pinkfeet seem to have stayed there in relatively high numbers until the last week of February or the first days of March (Fig. 3). However, an incomplete visit to Southwest Friesland on 13 February gave the impression that there were not very many Pinkfeet left. This impression agrees with the occurrence of 15,000 geese in Denmark on 12/13 February (Madsen 1984), which left the area again after the count and might have been back in Friesland on 21 February.

In the season of 1982/83, finally, most of the geese had disappeared from Friesland in the beginning of February, with only 2400–2500 left on 5 February (Fig. 3). Again a period of frost from 7 to 24 February drove them back to the Netherlands, resulting in the season peak on 25 February. They stayed there until the first days of March, as in 1980/81 and 1981/82. Only 500 were left on 5 March.

Importance of Southwest Friesland

The significance of Southwest Friesland for wintering Pink-footed Geese can be expressed as the number of goose-days spent in the area in relation to the total number of goose-days spent in Western Europe. Madsen (1982) sets the season from 1 October to 15 May. The number of goose-days spent in Friesland can be calculated as the total number of geese counted and the multiple of the average of two successive counts and the number of days between those counts. The total number of goose-days spent in Western Europe is calculated by the number of days between 1 October and 15 May (227) and the population estimate in each year by Madsen (1982, 1984). According to this, Southwest Friesland held 12.4% of the goose-days in 1979/80 and an average of 25.9% in 1980/81 to 1982/83 (Table 2).

Table 2. *The number of Pink-footed Goose-days spent in Southwest Friesland in relation to the number of goose-days spent in Western Europe from 1 October to 15 May. Population estimate after Madsen (1984).*

	Population estimate	*Number of g.d. spent in W.-Eur.*	*Number of g.d. spent in SW Fr.*	*Percentage spent in SW Fr.*
1979/80	28,500	6.5×10^6	0.8×10^6	12.4%
1980/81	26,875	6.1×10^6	1.7×10^6	28.4%
1981/82	21,000	4.8×10^6	1.2×10^6	25.9%
1982/83	26,600	6.0×10^6	1.4×10^6	23.3%

In the future some changes can be expected in Southwest Friesland. Within 4–5 years the reclamation in the area IJlst – Oudega – Heeg – IJlst will be finished. This includes lowering of the water-table by about one metre, construction of new roads, building of new farms, and changes in the farming of the area. All together these developments will make the area more accessible and thus less quiet. Fortunately 450 ha will be a protected area.

Besides this, the town of Sneek is expanding in the direction of the goose roost on the Zwarte en Witte Brekken. Plans for a new motorway right across this roost, to replace the present road around Sneek, are off for the time being, but not definitely dead and buried.

Movements over Western Europe

Distribution during the season

Fig. 4 shows the most important wintering haunts for Pink-footed Geese in Western Europe. Fig. 5 gives a summary of the occurrence in Denmark, Friesland, and Belgium.

The Pinkfeet arrive in Denmark by the end of September and normally stay there in large numbers until the end of October (Madsen 1982). Around this time they leave the country and move mainly to Southwest Friesland. Only in 1982 had they already left Denmark in mid-October. In November and December (mainly in the last ten days of November and the first ten days of December), several thousands of them fly southwards to Belgium. Here the peak number is usually reached around the turn of the year (Kuyken 1981, 1983), and most Pinkfeet return to Friesland as early as January. In mild winters, the migration from Friesland to the northeast has already started around mid-January, and in 1980/81 even much earlier; on 27 and 28 December, 2500 Pinkfeet were seen flying eastwards over Ostfriesland (Germany) and 400 northwards over Sylt (D. Hummel, in litt.). In spite of this early onset of the migration, in three of the four seasons the geese reappeared in Friesland for two

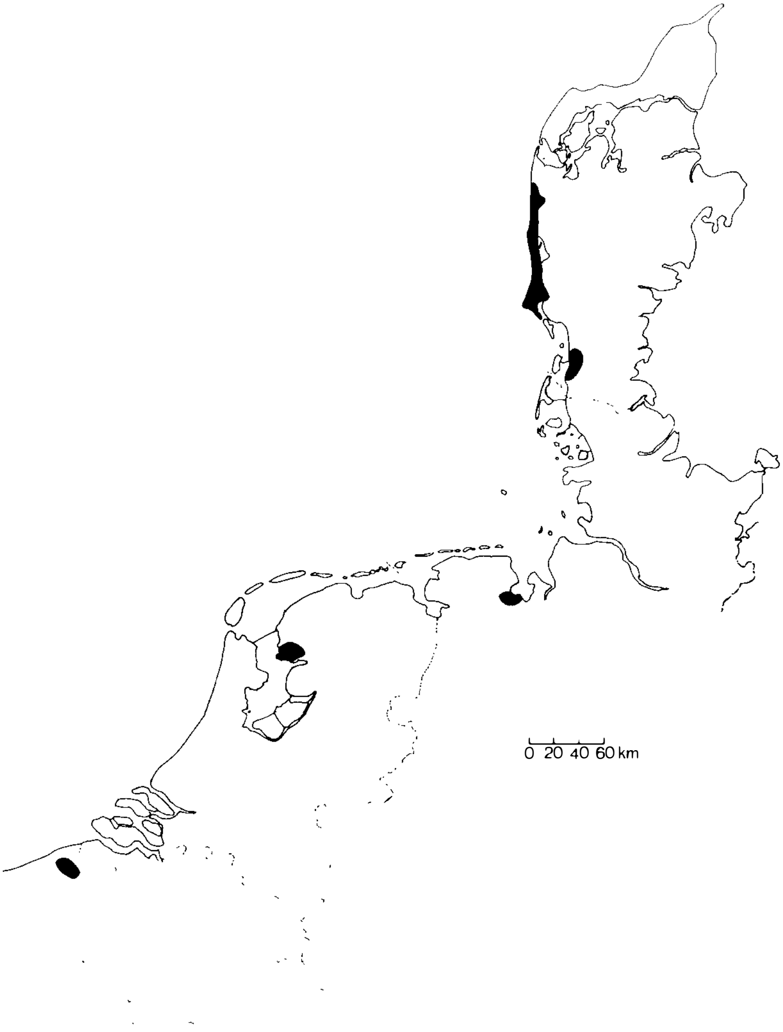


Fig. 4. The position of the most important wintering haunts for Pink-footed Geese in Western Europe.

or three weeks in February, under the influence of severe weather conditions. During the periodical decrease of the numbers in Friesland the Pink-footed Geese may appear in Denmark. If they return to Friesland again in February, they definitely leave this area in the first days of March. They reappear on the Danish haunts, but spring peak numbers there are usually reached in April.

Numbers

The information about the occurrence of the Pink-footed Geese in Denmark, the Netherlands and Belgium is quite detailed especially for the last three or four seasons. The peak numbers in Denmark are always strikingly much higher than those in the Netherlands and Belgium (Table 3).

In the season of 1979/80 a maximum number of 28,500 was counted at Filsø in autumn 1979 (Madsen 1982, 1984). After the departure by the end of October/beginning of November (J. Madsen, pers. comm.) no Pinkfeet were left in Denmark by mid-November (Fog 1980), but only 10,000 arrived in the Netherlands during the first ten days of November. During the whole season no more than 10,570 geese were found in Friesland and Belgium (Table 3, Fig. 5), which means that about 18,000 Pinkfeet must have been somewhere between Filsø and Friesland.

In 1980/81, Madsen (1982) estimated the pop-

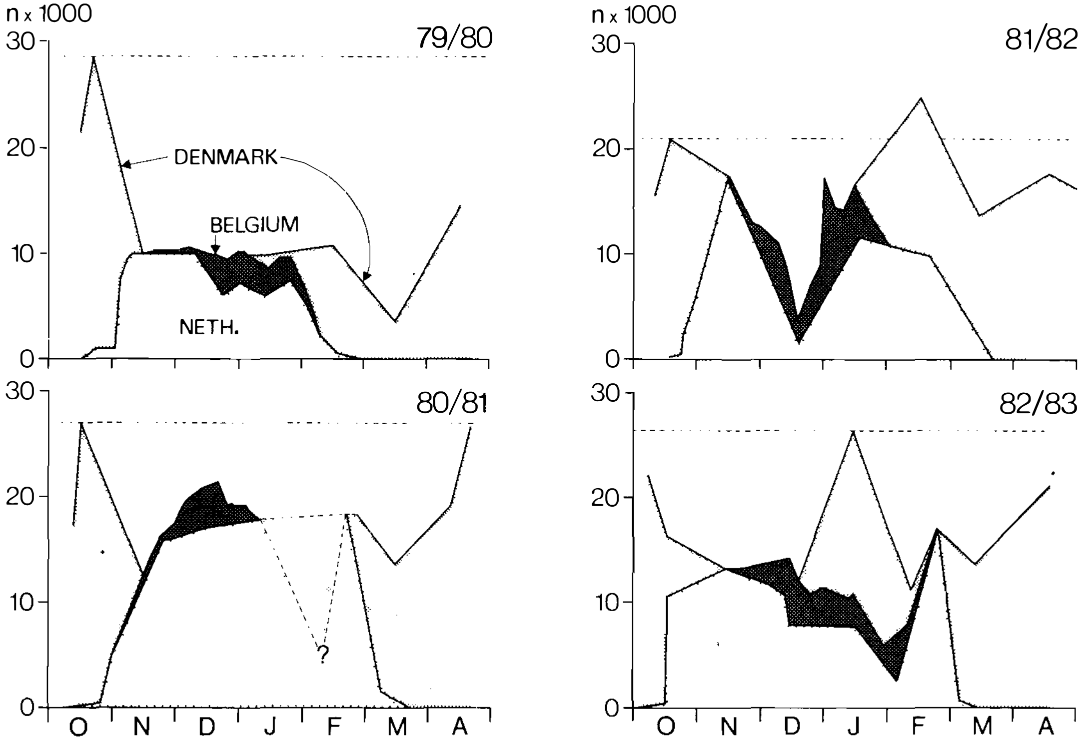


Fig. 5. The occurrence of Pink-footed Geese in Denmark, Friesland, and Belgium. Data from Denmark, 1979/80 after Fog (1980); 1980/81-1982/83 after Madsen (1984 and pers. comm.). Data from Belgium after Kuyken (1983, in litt. and pers. comm.).

ulation at nearly 27,000 in October 1980. Only 17,625 were counted in Denmark on 11–12 October (Madsen 1984) while in Friesland there were less than 100 on 12 October. The mid-monthly counts in November, December, January, and February resulted in a total of no more than 18–21,000 in the three countries together (Fig. 5), and it was not until 10 April that the number of 27,000 was counted for the second time in Denmark (Madsen 1981).

In 1981/82 the most striking period is that around mid-December (Fig. 5), a period of frost and snow. The 1500 geese counted in Friesland on 19 December (Fig. 2) were feeding in the same area as the 5000 of 12 December, but the local farmers informed us that there had been no geese for several days during the week between the two counts. This indicates that the 1500 geese might possibly be «new» geese from the east and that all 18,000 Pinkfeet staying in Friesland in November may have moved southwards in December. Many of them must have been spread over the southern part of the Netherlands, Belgium, and perhaps France. If this is the case, nearly the whole population must have visited Southwest Friesland, passed to southerly wintering haunts, and not very many geese had really disappeared during this season.

In 1982/83 the population was estimated at 26,600 (Madsen 1984). On 15–16 October there were only 5600 in Denmark and 10,600 in

Table 3. *Peak number in Denmark in October (1979/80, 1980/81, 1981/82) and/or April (1980/81, 1982/83) and in Friesland, Belgium, and Friesland + Belgium between 1 November and 15 January. Information from Denmark after Madsen (1981, 1982, 1984); data from Belgium after Kuyken (1983, in litt. and pers. comm.).*

	1979/80	*1980/81*	*1981/82*	*1982/83*
Denmark	28,500	26,875	21,000	21,000
Friesland + Belgium	10,570	21,470	17,575	14,265
Friesland	10,000	17,000	17,375	13,170
Belgium	3,450	3,700	10,825	4,410

Table 4. *Percentage of the total number of Pink-footed Goose-days in Western Europe, spent in Southwest Friesland and Belgium in 1979/80, 1980/81, and 1982/83. Belgium calculated from data after Kuyken (1983, in litt. and pers. comm.).*

	1979/80	*1980/81*	*1982/83*
Friesland	12.4	28.4	23.3
Belgium	2.2	1.6	3.5
	14.6	30.0	26.8

Friesland, leaving over 10,000 missing birds. In November 13,000 geese are lacking from our counts, a number that remains stable until mid-January, when the total seasonal peak number is reached. In February and March again large numbers have disappeared (Fig. 5).

Obviously, from what is described above, considerable numbers of Pink-footed Geese must be in unknown places during the whole winter period. The percentage of Pink-footed Goose-days spent in Friesland and Belgium in 1979/80, 1980/81, and 1982/83 is given in Table 4. Madsen (1982) estimates the percentage for Denmark in 1980/81 at 36%. If this is about the average, the total number of goose-days found back in the counts will not be more than 70% of the expected number in these seasons.

Although the available information from Germany is lacking in detail, it is obvious that the difference in the peak-numbers can never be explained by the numbers found there. Between 1974 and 1978 large numbers of Pink-footed Geese were never seen in Germany (Hummel 1980, 1981) and the numbers during the seasons considered in this report gave a peak of only 2000 (Prokosch 1984).

Recommendations

More information is needed about the occurrence of Pink-footed Geese in all Western Europe. The regular counts in Denmark, the Netherlands, and Belgium should be continued, and special attention given to areas in Germany and perhaps southern Denmark during the winter months. In this way it should be possible to find the missing geese.

In Friesland early arrivals of the geese may cause damage for the local farmers, which will lead to many disturbances, with or without hunting. International management and further observations within Southwest Friesland should be carried out, to prevent damage and give the Pink-footed Goose better protection.

Acknowledgements

The author is very grateful to Piet Bouma, Rob Cuijpers, Wiggele de Haas, Trinus Haitjema, Yde Kuipers, Jappie Muizelaar, Jules Philippona, Mirjam Schilperoord-Huisman, Dirk Tanger, and Arend Timmerman who helped in gathering information. Data from other countries were kindly given by M. Fog and J. Madsen (Denmark), D. Hummel and P. Prokosch (Germany), and E. Kuyken (Belgium). I thank Dr. R.H. Drent for his comments on an earlier draft of this report and his presentation to the Symposium in Oslo. Finally I wish to thank mr. D. Visser, who drew most of the pictures, and mrs. J. Poelstra-Hiddinga who typed the final version of this article.

References

Fog, M. 1980: Gåsetællinger 1979–80. *Dansk Vildtforskning* 56–57.

Hulscher, J.B. 1983: Massale doortrek van Kleine Rietgans bij Groningen op 15 oktober 1982. *De Grauwe Gors 11:* 6–9.

Hummel, D. 1980: Durchzug und Überwinterung der Kurzschnabelgans *(Anser brachyrhynchus)* im Bereich der Nordseeküste (1974–1977). *Die Vogelwelt 101:* 121–131.

Hummel, D. 1981: Das Auftreten von Wildgänsen in der Bundesrepublik Deutschland vom 1.9.1977 bis 31.8.1978. *Ber.Dtsch.Sekt.Int.Rat Vogelschutz 21.* 53–76.

Kuyken, E. 1981. Overwinterende ganzen in de kustpolders van NW-Vlaanderen. *De Wielewall 47:* 467–476'

Kuyken, E. 1983: Aantallen en verspreiding van overwinterende ganzen in de Oostkustpolders: seizoen 1981/82. *Veldornithologisch Jaarboek van Noord-West-Vlaanderen 1981–1982:* 41–46. Uitgave JNM Brugge.

Madsen, J. 1981: Census of geese in Denmark 1980/81. *Proc. of the second Nordic Congress of Ornithology, 1979:* 150–153.

Madsen, J. 1982: Observations on the Svalbard Population of *Anser brachyrhynchus* in Denmark. *Aquila 89:* 133–140.

Madsen, J. 1984: Numbers, distribution, and habitat utilization of Pink-footed Geese *Anser brachyrhynchus* in Denmark 1980–1983. *Nor. Polarinst. Skr. 181* (this volume).

Philippona, J. 1978: De slaapplaats van de Kleine Rietgans *(Anser brachyrhynchus)* in Friesland. *Watervogels 3:* 33–38.

Prokosch, P. 1984: The wintering sites of Svalbard Pink-footed Geese *Anser brachyrhynchus* in Germany - present stituation. *Nor. Polarinst. Skr. 181* (this volume).

Rooth, J., Ebbinge, B., Haperen, A., van, Lok, M., Timmerman, A., Philippona, J. & Bergh, L. van der 1981: Numbers and distribution of wild geese in the Netherlands, 1974–1979. *Wildfowl 32:* 146–155.

Timmerman, A. 1977: Het wintervoorkomen van de Kleine Rietgans *Anser brachyrhynchus. Limosa 50:* 71–91

MYRFYN OWEN:

Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose *Branta leucopsis*

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose *Branta leucopsis*. *Nor. Polarinst. Skr. 181:* 37–47.

This paper describes the dynamics of the Svalbard-Solway population of Barnacle Geese from 1970 to 1983 and examines influences on mortality and breeding performance which explain the observed changes in numbers. Despite a period of stability in the 1960s, the population grew steadily from just over 3000 in 1970 to 8000–9000 in the 1980s. The increase was due to a lowering of the mortality rate rather than better breeding. It was concluded that this decrease in death rate was enabled by the extension of a winter refuge which made geese less accessible to illegal shooting. Mortality rate of adults varied from 8.7% to 13.7% annually. Juveniles had a higher mortality rate only in some years. Birds in their second year of life had consistently lower mortality rates than older birds. The recruitment rate, expressed as the proportion of mature geese that bred, fell as the population grew, from 40–50% at 2–3000 potential breeders, to 10–20% at 6–7000. Young geese bred significantly less well than adults and the difference did not disappear until the birds were in their 6th year of life. At present population levels breeding success was limited by factors operating on the breeding grounds. The low birth rate and death rate led to an increasing surplus of unproductive mature geese and an increase in the average age, from 2.5 years in 1972 to 5.9 years in 1983. The density-dependent depression of recruitment rate would set a limit on future population growth. Given average weather conditions and continued low mortality the population is likely to stabilise at about 12000 birds.

Myrfyn Owen, Wildfowl Trust, Slimbridge, Gloucester GL2 7BT, United Kingdom.

Introduction

The small population of Barnacle Geese *Branta leucopsis* breeding in Svalbard and wintering on the Solway Firth in northern Britain is one of the most intensively studied geese populations in the world. Changes in numbers, mortality, and breeding success from 1948 to 1976 were described by Owen & Norderhaug (1977). This paper updates that analysis and a more recent treatment of mortality (Owen 1982), and provides more detailed information on age structure and recruitment based on the resighting of individually marked birds.

In 1948 the population probably reached its lowest level ever, only 300 being counted on the wintering grounds. Following full protection from shooting throughout its range, the population grew to fluctuate from 3000 to 4000 in the 1960s. Intensive studies followed the establishment of a Wildfowl Trust Refuge at Caerlaverock on the north shore of the Solway Firth, in 1970. This refuge included part of the National Nature Reserve created in 1957 but also included a 100 ha undisturbed area of farmland. The marking programme began in 1973 with an expedition to Hornsund, Spitsbergen, and by autumn 1983 a total of 3300 geese had been marked with individually coded plastic rings. The period discussed here is from 1970–1983.

Methods

Counts of the total population were made in early October each year, when nearly all the birds are usually on the Caerlaverock refuge. Totals are accurate to ± 2% and in most years ± 1%. Estimates of percentage young were based on many thousands of birds aged in samples, after the population was known to have completed its autumn migration. Brood sizes were based on ringed birds seen several times and on scan samples of both ringed and unringed birds from the whole population. There is no significant difference between the two samples so that brood size estimates before ringing became widespread can be considered reliable. In 1978 and 1980, which were good breeding seasons and when migrating conditions were unfavourable, substantial numbers of young were outside families so brood sizes in winter would not reflect the true number of young reared. In these two years the brood size estimate was based on a large sample of broods on the Nordenskiöldkysten in late August (J. Prop, pers. comm.), corrected for the fall in the percentage young between there and Caerlaverock. This assumes that young are lost at the same rate from broods of all sizes. The number of young divided by mean brood size represented the number of pairs which were successful in bringing young to the wintering grounds.

Since the population is closed, the mortality can be calculated as those birds not returning the following year (N in year t – young(t))/N(t–1). Mortality was also calculated from the disappearance rate of ringed birds, assuming that birds not seen for two seasons had died in the season when last seen (Owen 1982). With ring loss very small and resighting rate high this is a reliable method. The number of birds carrying rings and the resighting rate in each year are shown in Fig. 1. When large numbers of birds were ringed in 1977 the effort was stepped up so that the resighting rate remained high, at around 95%. With about 2000 birds carrying rings in recent years, mortality estimates and data on breeding success are available from very large samples of birds.

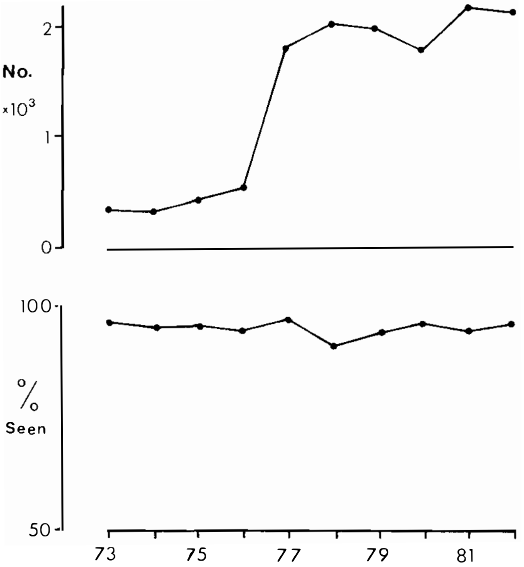


Fig. 1. The number of geese estimated to be carrying individually coded plastic rings in the population (upper line) and the percentage of these which were seen in that year. Overall annual resighting rate is 94.43%.

Pairing was determined by association, and as some pairs are rather loosely associated and there may be temporary partners, each observation is not entirely reliable. Birds were not considered to be paired unless they were recorded with the same mates repeatedly. Birds of the same sex recorded as pairs were assumed to be family associations. Success in breeding was defined as having at least one gosling on the wintering grounds. Thus 'non-breeders' include birds which have nested unsuccessfully, and those which have lost their goslings at any stage up to the first record. Since in most years 80% of the pairs were seen within six weeks of arrival, the proportion of pairs which have brought young to the Solway and lost them before being seen is likely to be negligible. Since families begin to break up in late winter, only records before February were considered to be a true indication of failure, though birds were classified as successful if they were seen with goslings at any time.

Results

Changes in numbers

The October population and breeding success each year since 1970 are shown in Fig. 2. Following the period of stability in the 1960s the linear increase in numbers was rather surprising. This was not caused by an improvement in breeding success, but a reduction in apparent mortality from a level of 25% in the 1960s. Calculations from the early ringing (Ogilvie & Owen 1984) confirm that there has been a change in mortality although the number of recoveries is rather small. There are still questions, however, about the real situation prior to the start of this study (see Owen & Campbell 1973).

Since there had been a period of relative stability in the 1960s, the trebling of numbers in the 1970s was surprising. Three measures were taken which could have affected the death rate in the population and so caused this rise:

a) In 1970 the Wildfowl Trust established a refuge at Eastpark, Caerlaverock. This included the most important part of the Nation-

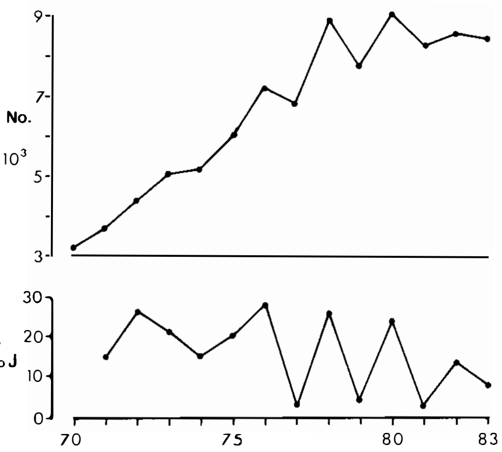


Fig. 2. The population total (upper line) and the percentage young, both estimated on arrival in the Solway in late September/early October, 1970–1983.

al Nature Reserve but also provided additional undisturbed feeding on farmland.

b) The species was completely protected from shooting in Norway in 1971.

c) Most of the breeding islands in Svalbard became sanctuaries in 1973.

The creation of the breeding sanctuaries was intended to reduce disturbance of nesting birds and the resultant egg predation. It has not been possible to measure their effectiveness in this respect, though the number of breeding pairs in many of the sanctuaries has increased (Prestrud & Børset 1984). As there was no suggestion that adult mortality would be affected, their real benefit to the population would come through increasing the recruitment rate, rather than just the absolute recruitment; but this did not happen (see below).

Protection from shooting in Norway (the open season was in the autumn) would also have had a negligible effect since the geese do not stop there on migration and rarely overfly the mainland in autumn (Owen & Gullestad 1984). This is borne out by the fact that despite the ringing of nearly 1000 birds in the 1960s, only eight of these were recovered from shooting in Norway, a very small proportion of the recoveries during the period. Thus this measure can be considered a mere formalisation of the species' protection rather than making an important contribution to its conservation.

Many losses occur on autumn migration and these may well be linked to late breeding seasons (Owen 1982). There were no very late seasons in the early 1970s so the migration losses could have been lower then. The effect is, however, likely to have been a minor one in the context of overall adult mortality. The three disastrous seasons, 1977, 1979, and 1981, had only a small effect on losses during that period.

This leaves the extension of the winter refuge at Caerlaverock as a possible cause. But could this have brought about such a marked reduction in mortality? Following the extension of the refuge, the proportion of the total wintering time that the geese spent there rose from about 20% to over 50% in two years (Owen 1980). If only the shooting season were considered, the effect would be more marked since the refuge use was chiefly in autumn and early winter. Effectively the geese were held on the refuge for most of the shooting season. As numbers increased and the capacity of the refuge was exceeded, the proportion using it dropped again, to 20% in the late 1970s (Owen 1980).

Even though the birds have been protected in Britain since 1954 the vast majority of winter mortality of Barnacle Geese is due to shooting, either deliberate, or accidental in mistake for other goose species also found on the Solway. Even today, following intensive educational efforts and prosecutions in the last 20 years, 300–400 geese annually are estimated to die from this illegal shooting (Owen 1982). In the 1960s the annual number shot was probably higher than this, possibly amounting to 10–20% of the population. Adding natural mortality this could well bring the average up to the observed 25%. A kill of 300–400 geese represents less than 5% of the present population which is not sufficient to stabilise numbers again. Thus the refuge appears to have given the population 'breathing space', allowing a trebling of numbers. Even though the birds dispersed again, the larger population was better able to withstand the existing shooting pressure.

Variations in mortality

Variations due to year, season, age, and sex have been discussed in detail elsewhere (Owen 1982), so only those aspects pertinent to understanding

Table 1. *The mortality rate of juvenile, yearling and adult birds from 1975–1982, calculated from the disappearance rates of ringed birds (Owen 1982).*

Years	*Juveniles*		*Yearlings*		*Adults*	
	n	%	*n*	%	*n*	%
1975–6	44	11.4	–	–	374	12.6
1976–7	56	23.6	39	10.3	336	13.7
1977–8	65	9.3	303	7.3	733	8.7
1978–9	148	17.6	57	10.5	1140	11.3
1979–80	33	9.1	146	6.9	1607	9.7
1980–1	–	–	30	10.0	1451	11.6
1981–2	–	–	245	10.2	783	12.6

Note: To minimize the effect of ring loss, birds which have been ringed five or more years previously are excluded.

population dynamics or where more data are available will be presented here. Mortality is always calculated from one October to the next, for juveniles between ages 3 and 15 months, yearlings 15 and 27 months, etc.

We must have reasonable estimates of age-specific mortality rates if we are to understand the age composition of the population. The mortality rates of juveniles, yearlings, and older birds in the years when sufficient data are available, are given in Table 1. In three of the five years when juvenile data are available their death rate is very similar to that of adults and in two it is significantly higher, though the 1976 sample is rather small. Information from counts and age ratio estimates of mortality suggest that the estimate from rings is much too high in that season. Lumping all years together, first year mortality is only slightly higher than that of adults but the difference might show annual variation.

In no single year was the mortality rate of yearlings significantly different from that of adults. Yearlings did, however, have a consistently slightly lower mortality rate than older birds when all years are considered (sign test P=0.016). Yearlings moult earlier than most adults and are at an advantage since they can feed on lush bird slopes for a longer time. They reach adult weight by their second autumn (Owen & Ogilvie 1979). They might thus suffer lower mortality on autumn migration and at breeding time than adults, at least those that attempted to breed.

It is unusual to demonstrate an increase in death rate with age in wild animals but Owen (1982) produced some evidence for an 'old age' mortality in this population. Although there was a significant old age effect the sample was small. A large sample of yearlings was caught in 1977 and the disappearance rate of these, together with older birds caught at the same time, is shown in Fig. 3. The analysis is restricted to females because some males may have died because of problems with the marking itself. There is a lower mortality during the yearling year (see above) but thereafter the slope of the line is identical for both groups. If there is an increase in mortality in old age, this is not manifested until the birds are of considerable age, perhaps as old as 20 years. By that stage so few birds remain that the increased death rate has a negligible effect on that of adults as a whole.

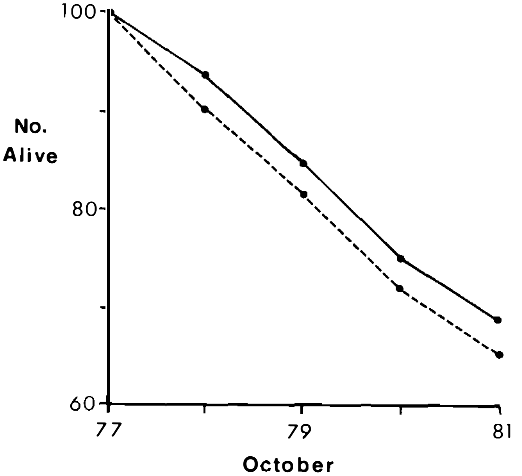


Fig. 3. The percentage of female geese hatched in 1976 (yearlings when caught in 1977) – N = 185, seen alive in future years (solid line). The dashed line shows the survival of adult females caught at the same time (N = 298).

There is a surplus of males in the adult population, but not in that of yearlings or juveniles (Owen et al. 1978). There is, therefore, a sex specific mortality at some stage in the life cycle. There is no significant difference between the mortality rate of juvenile or yearling males and females in any year. This differential mortality must therefore affect the population in adult life. This was borne out by the fact that females ringed in 1973 were significantly less likely to survive until 1981 than males (Owen 1982). Both sexes had higher mortalities in poor breeding years and the hypothesis was put forward that birds, especially females, emerging from the breeding cycle in poor condition, suffered high mortality on autumn migration.

Annual variation in mortality of adults as estimated from ringing is not great, varying only between 8.7 an 13.7% in seven years (Table 1). This method is much more reliable than that of age ratio and population counts (Owen 1982), and it is likely that estimates using counts of other populations have overestimated annual variations in mortality.

Variations in recruitment

There were indications in the mid 1970s that the recruitment rate was slowing down as the population increased in size (Owen & Norderhaug 1977). Even disregarding the three disastrous years, 1977, 1979, and 1981, there is an apparent downward trend in the percentage young in recent years (Fig. 2), and levels in the 1970s are, on average, lower than those in the 1960s. Breeding success is better examined as the proportion of potential breeding adults which manage to raise young, rather than the proportion or number of young produced.

Practically all two-year-old Barnacle Geese breed in captivity (own unpublished data), so that two-year-olds are physiologically capable of breeding. In the wild, however, few breed successfully and not all are paired in their second winter. Two-thirds of geese are paired when on migration in their second spring, so these can be considered the maximum proportion that are potential breeders. All geese older than two years can confidently be classified in the 'potential breeding' group. The number of potential breeders in year was therefore the Total population – (Juveniles–Yearlings) – (2 Year-olds/3) in year (t-1). The relationship between the potential number and the percentage which were parents on arrival in Scotland is shown in Fig. 4.

Clearly three years, 1977, 1979 and 1981, lie well outside the range of other points and we know that those three springs were very late in Svalbard. A very close correlation between breeding success as measured in Scotland and the extent of snow cover at Isfjord Radio in the laying period had already been demonstrated (Owen & Norderhaug 1977). Two regression lines are drawn on Fig. 4, one including the three years (correlation coefficient, r = 0.687 P < 0.05) and one excluding them (r = 0.801 P < 0.02). Either way, breeding performance is lower when numbers are high.

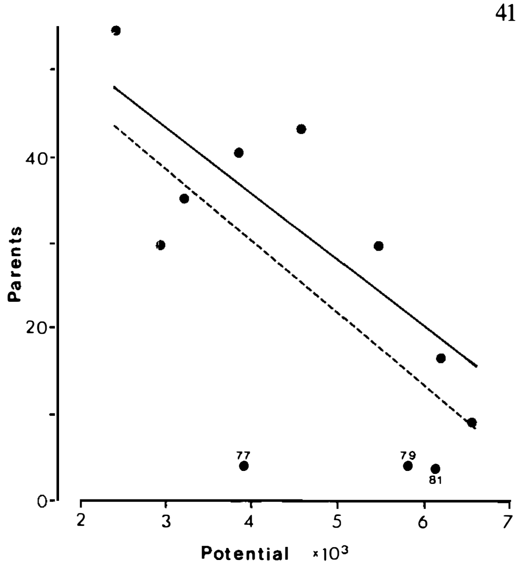


Fig. 4. The percentage of potential breeders (see text for definition) which were successful in bringing young to the wintering grounds (Parents), in relation to the number of potential breeders in the population in the previous winter. Correlation coefficient including the three 'non-breeding years' (dashed line) r = 0.687 P < 0.05, excluding their solid line r = 0.801 P < 0.02.

Since we can regard the three disastrous seasons as 'non-breeding' years, there are good grounds for excluding them, but we cannot discount the possibility of an effect of population density even in these years, in that there may be an interaction between late springs and high numbers in bringing about breeding failure. Only twice between 1958 and 1976 did the proportion of juveniles fall below 10%–to 5.3% in 1962 and 9.6% in 1964. Would the recent poor seasons have been so disastrous at lower population levels? Detailed examination of this question awaits analysis of weather data from the breeding grounds in recent years in comparison with previous records.

The effect of age on breeding

As indicated above about two-thirds of two-year-old geese are paired before the breeding season, but most of these pairs are formed in the spring.

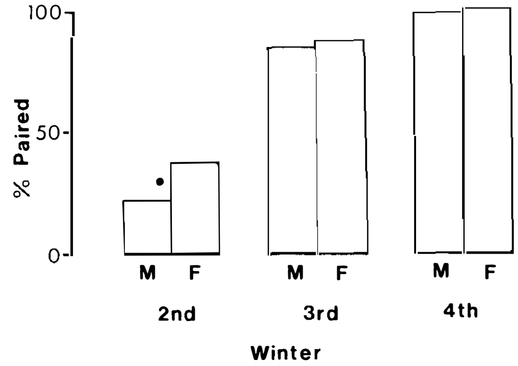


Fig. 5. The percentage of geese marked as juveniles and yearlings which were paired in their second, third and fourth winter on the Solway, males (left) and females (right). The solid dot indicates significance between the sexes P < 0.05.

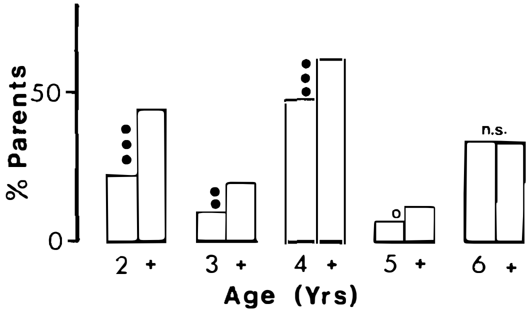


Fig. 6. The proportion of 1976-hatched geese which bred in the years 1978–82 (left histogram of each pair), compared with the proportion of adults from the same catches on the Nordenskiöldkysten which did so. Three solid dots indicate significance between age classes P < 0.001, two dots P < 0.01, and the open dot 0.05 < P < 0.10.

The proportion of two, three-year-old and older geese which are paired in winter (most observations before March) is shown in Fig. 5. The sample is restricted to birds caught on the Nordenskiöldkysten, Spitsbergen, in 1977, so that all ages are comparable.

On average 30% of geese are paired during their second winter but a significantly higher proportion of females (38%) are paired than of males (22%). This is an effect of the surplus of males in the mature population rather than a true differential maturity between the sexes. A high proportion of yearling females caught in 1977 subsequently paired with adult males from the same catches, and some of these were paired on arrival in Scotland (i.e. 15 months old). Thus the surplus unpaired males were pairing in summer with the yearling females producing the difference between the sexes. Similarly Brakhage (1965), studying a population of Canada Geese *Branta canadensis* with a surplus of females, found that 64% of two-year-old males nested, compared with only 33% of females.

More than 80% of geese are paired in their third winter and by the fourth practically all females and 98% of males have mates. The slight difference between mature males and females again reflects the disparity in the adult sex ratio.

The breeding success of paired birds with conclusive information on breeding in their second to sixth year is compared with that of older birds in Fig. 6. Again the comparable Nordenskiöldkysten sample is used. Both males and females are included although some are paired to each other (i.e. some pairs are represented twice). The sample is large enough, however, so that this would make a negligible difference to the result. The age of the mate is not taken into account (in most cases this is unknown). Since some young birds pair with older geese the average age of the pair is often older than that shown.

Even in the good season of 1978, the proportion of two-year-olds that bred was only half that of older geese. The following year was a 'non-breeding' year when the then three-year-olds performed only half as well as adults. The gap narrowed in the fourth year, which was good for breeding but even in the fifth the difference only just failed to reach significance (0.05 < p < 0.10). It is not until they are six years old, in their fifth potential breeding season, that the age disparity in breeding success disappeares. Presumably this extreme deferred breeding is a new phenomenon but unfortunately too few geese of known young age were caught during the early years of the study. In more recent years, however, young birds have apparently been even less able to compete with older ones. In 1980 only 22% of 54 two-year-olds bred successfully compared to 50% of older geese, while in the early season of 1982 only 6.5% of 93 1980-hatched birds bred compared with 28% of adults.

Unfortunately it is difficult fully to examine age effects in recent years, when coincidence of weather conditions has brought about an alternating pattern of breeding. Thus since 1976 two-year-olds have been abundant in early years and almost non-existent in non-breeding years. Similarly the preponderance of three-year-olds has coincided with disastrous breeding conditions.

There are, as yet, no indications that breeding performance declines in old age. Birds which were adult in 1973 had very similar performance to that of younger adults, and the same was true of birds ringed in the early 1960s, although the sample was very small.

Individual performance

There is a substantial difference between individuals in feeding and aggressive performance (Nugent & Owen unpublished data), and in some cases these differences are reflected in breeding success. Scott (1980) found that the dominance rank of individual Bewick's Swans *Cygnus columbianus bewickii* was consistent from year to year and breeding success did vary a great deal between pairs. One dominant pair with highly cohesive family ties bred successfully in each of ten successive seasons, producing 40 young (D.K. Scott, pers. comm.). The average expectation of successful breeding for mature birds in that population is once in every three years and the mean brood size is two, giving an expectation of only 6–7 young in ten years.

The frequency of breeding in ringed Barnacle Geese for birds having 5, 6, 7, 8 and 9 years with reliable records was examined against the random (Poisson) distribution. The hypothesis of individual difference would predict a bimodal frequency distribution, with a larger than expected number of birds both breeding more regularly and less regularly than expected, and with fewer showing intermediate performance. The results for five years and nine years breeding groups are shown in Fig. 7.

With five years' data the distribution almost exactly matches that of the Poisson, but there is a suggestion of bimodality in the group with nine years' records. Neither of these, nor any other samples, proved significantly different from the Poisson distribution. One of the problems with this analysis is that it is important which group of years is being analysed, whether it includes 1, 2, or more 'non-breeding' years. Ideally only the years of good breeding should be used, but this would reduce the sample drastically, and in any case 'good' birds ought to breed even in bad seasons.

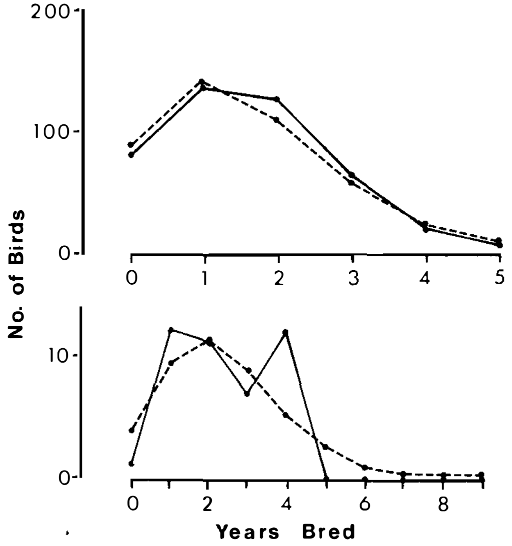


Fig. 7. The number of paired birds with five years of conclusive breeding data (N = 442) which bred from 0 to 5 times during those 5 years (upper figure), and a similar plot (lower figure) of breeding frequency for birds with 9 years data (N = 42). None of these bred successfully on more than 5 occasions. The dashed line in each case follows the expected frequency if success in any individual in any year were random (Poisson distribution).

This analysis does not disprove the hypothesis that the population consists of a predominance of 'good' and 'bad' birds; indeed it provides some weak support for it. Conclusive evidence cannot, however, be expected until data on the larger samples of birds are available for a considerably longer period.

Population structure

The data on mortality and breeding success collected since 1970 allow us to describe the age and status of the population from 1972 onwards and this is shown in Fig. 8. Because of rather constant annual mortalities after the first year, the age classes tend to represent a constant fraction of the previous year's cohort, i.e. a large cohort of young in 1976 produces a large number of two-year-olds in 1977, three-year-olds in 1978,

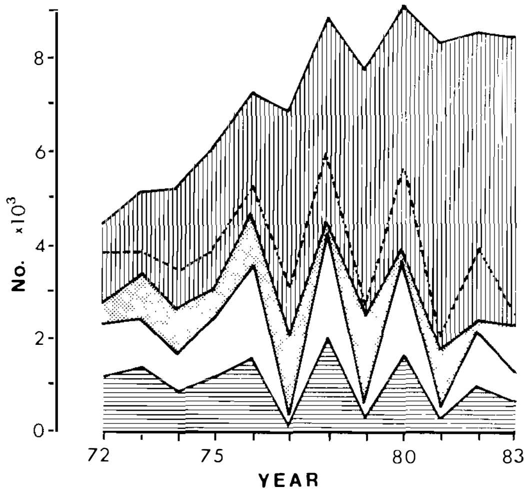


Fig. 8. The structure of the Barnacle Goose population from 1972 to 1983. Horizontal lines – parents, unshaded – juveniles, stippled – yearlings and vertical lines – mature non-breeders. The dashed line breaks non-breeders into two-year olds (below) and older geese (above the line). Data are for October each year.

etc. Because of the breeding failures, there are gaps in the age distribution, e.g. there are virtually no juveniles or two-year-olds in 1979 or in 1981.

The most striking feature is, however, that whereas the numbers in the productive part of the population (parents and their young) have fluctuated around a constant level, the number of mature geese which fail to breed has increased from about 2000 in the early 1970s to more than 5000 in the 1980s. The combination of the low proportion of young and the low mortality has caused the average age to increase from just over 2.5 years in 1972 to nearly 6 years in 1983, as shown in Fig. 9.

The population has thus become older and less productive as numbers have increased. There is greater competition between individuals and this favours old, experienced geese. The effects of age and breeding experience have not been separated in this study, but this should be possible in the future, with longer runs of data.

Discussion

After reaching a low of about 300 in the late 1940s, the fate of the Solway/Svalbard Barnacle Goose population has been a spectacular conservation success story. Early protection from shooting did not bring about substantial increase in numbers until the establishment of the National Nature Reserve at Caerlaverock in 1957. The population then trebled from around 1000 in 1957 to 3500 in the mid 1960s. The stability through the 1960s occurred despite virtual complete protection and good average recruitment rate, in excess of 20% young annually. It was again the creation of a feeding refuge, the extension of the existing reserve, that apparently provided the opportunity for further growth, to 8000–9000 birds in the early 1980s. Although the provision of protected feeding grounds may have lessened natural winter mortality, it was through reducing illegal shooting by making the geese inaccessible to hunters that most of the effect was brought about.

The proportional recruitment rate has certainly fallen with increasing population size, and the fact that the late years, 1977, 1979 and 1981, have proved disastrous for breeding is probably not independent of density. The density dependent effect on birth rate could be brought about at various stages in the breeding cycle.

The spring fattening period is vital to the breeding potential of individuals and of the population as a whole, and competition during this period could well reduce potential. Most fattening occurs on the Solway in March and April, when the geese are allowed to feed undisturbed on the large areas of saltmarsh pasture. The geese are heaviest on departure from the Solway, and reserves used on migration are 'topped up', both on the staging area on

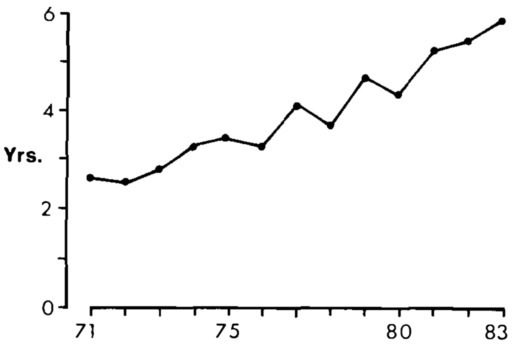


Fig. 9. The average age of geese in the population each autumn from 1971 to 1983.

Helgeland and in Svalbard prior to nesting. The condition of geese in spring has been estimated using a field index since 1977, both on the Solway and in Norway. Whereas there are good relationships between the build-up of reserves and the earliness of the spring, there are no indications of any density effects. All classes of geese are together in spring and any relationship would be expected to be with total population size. The fact that a closer correlation exists between breeding success and the number of potential breeders points to the breeding areas as the likely location of competition.

Since nesting is restricted to small offshore islands and a few hillsides and cliffs, competition for nest sites could be an important factor. This could operate not only through the physical shortage of suitable sites, through competition for territories, which may include more than one nest site, but also through density effects on nesting success. There are numerous examples where nesting success declines with increasing density in Canada Geese. For example, Ewaschuk & Boag (1972) found that while 60% of nests resulted in hatched young at normal densities, fewer than 30% were successful at high density. Most nest losses were the result of territorial competition between males. Nest desertion is also influenced by the feeding success of incubating females and their mates (Prop et al. 1984), so that increased competition for tundra feeding sites could well result in lower nest success.

The time between hatching and departure on autumn migration for these geese is 8–10 weeks. In this time the young birds must not only grow to fledging (6 weeks) but also lay down sufficient reserves to complete the autumn migration. It has already been suggested that failure of late broods to achieve this leads to high losses between the breeding and the wintering area (Owen 1982). Feeding competition among families could have the same result by lengthening the fledging period, resulting in many young failing to build up sufficient reserves for migration.

There is some evidence that both nesting and gosling losses have increased with density. In the early year, 1975, when the potential breeders numbered 3200, Ebbinge & Ebbinge (1976) estimated that 55% of established nests resulted in broods and that mortality of goslings to fledging was negligible. Using these data and figures from Scotland, Owen & Norderhaug (1977) estimated gosling losses between one week and arrival on the wintering grounds at less than 15%.

In 1982, also an early year, when there were 6200 potential breeders, Prestrud & Børset (1984) estimated that there were about 2000 pairs at the nest during the early part of incubation. Only 500 pairs arrived on the wintering grounds with young and the total number of goslings amounted to 1150. This is 0.58 young in winter per initiated nest compared with 1.02 young per nest in 1975. Nothing is known of nest success in 1982, but in 1983 brood counts of M. A. Ogilvie and P. Prestrud indicated a mean brood size of 3.4 young at 1–3 weeks of age. Brood size at arrival in Scotland, when all the young were in families, was down to 2.0. This is a gosling mortality of 41%, even assuming that no broods were lost altogether, which is unlikely at this loss rate.

It appears, therefore, that both nest losses and loss of young have increased substantially since 1975, with a doubling of the number of potential breeders. So much so that more young were produced in 1975 than from twice the number of nests in 1982.

A similar pattern of lower fecundity with increasing population size has been demonstrated for Pink-footed Geese *Anser brachyrhynchus* (Boyd & Ogilvie 1969), Greylag Geese *Anser anser* (Boyd & Ogilvie 1972), and the population of Barnacle Geese breeding in Greenland (Ogilvie 1978). By contrast White-fronted Geese *A. albifrons* of western Siberia show breeding success undiminished despite quadrupling of numbers (Rooth et al. 1981). The north Atlantic species breed in rather small patches of suitable habitats on islands or coastal plains, whereas the Whitefront breeds over the vast expanses of West Siberian tundra. This adds more circumstantial evidence to support the hypothesis that density-dependent mechanisms operate on the breeding rather than the wintering grounds.

Future population levels

Owen & Norderhaug (1977) predicted that the level of recruitment would level out as competition increased on the breeding grounds and that if it did so at the level of the mid 1970s an equilibrium population of 10,000–12,000 might be expected. This was presuming mortality remained relatively constant as a proportion, an assumption which has been justified at least up to the present. It seems unlikely that mortality from shooting on the wintering grounds will increase, with better education and control likely to reduce illegal shooting. Natural (starvation) mortality in winter is almost unknown in European geese since the very severe winter of 1962–63. Losses of Barnacles on the Solway in that season were no higher than usual and no starving birds were seen. The future size of the population therefore depends on what happens to the level of recruitment.

The number of young produced, in relation to the number of potential breeders, is shown in Fig. 10. In good years in the 1970s the number increased but decreased in 1982 and 1983; whether this decrease is really significant is unknown. It seems safer to consider the recruitment in good years to be stable at the average of the eight points, with recruitment in bad years being negligible. The average production is 1400 young per good year; the average over all years depends on the ratio of early to late seasons. Accepting 5% young or less as the criterion for a late year, this ratio has been 5.5:1 since 1958, i. e. two out of every thirteen years is a failure. This reduces the average recruitment, including 200 young for each of the poor years, to around 1200 per annum – very close to the level used by Owen & Norderhaug (1977).

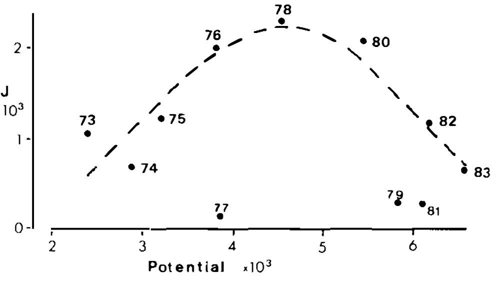


Fig. 10. The number of juveniles arriving at the wintering grounds in autumn in relation to the number of potential breeders in the population the previous winter. The dashed line is drawn by eye to link the points excluding the 'non-breeding' years of 1977, 79 and 81.

Thus, although the population shows signs of levelling out at around 8500, this low level is largely the result of the coincidence of three non-breeding years in the last seven. Provided arctic conditions return to the average for the last 25 years, further growth can be envisaged. The population will fluctuate around a stable level when 10% mortality counterbalances the recruitment of 1200 geese – i.e. a population size of 12,000 birds.

All this is, of course, based on predictions outside the range of density encountered to date, and if density-dependent effects are severe, as suggested by Fig. 10, this will lead to overcompensation, whereby there would be a reduction in population size. The events of the next decade should provide at least some of the answers. It is intended that this population study will continue and the ringing programme carried on at its present intensity. As well as enabling better predictions to be made of future numbers, it will also provide information on age-related breeding success, mortality, and lifetime performance of individuals, rarely obtained in wild migratory animals.

Acknowledgements

This study would not have been possible without the continued help and cooperation of many people, especially in marking activities and in resighting ringed birds in the field. Our Dutch colleagues R.H. Drent, B. Ebbinge, S. Dirksen, T. van Spanje, J. Prop, and M. van Eerden participated in the ringing expeditions of 1977 and 1981 and supplied many observations of geese in Svalbard. The cooperation of N. Gullestad has been invaluable in studies of migrating geese both in spring and autumn.

The following have also made major contributions: S. Berrow, J.M. Black, R. Bridson, M.J. Brown, C.R.G. Campbell, S. Carter, C. Clunies-Ross, N. Davies, A. Dekker, S. Ellis, R. Goater, M.J. Holloway, E.E. Jackson, J. Kirk, H. Liber, C. Miller, S. Montgomery, M.J. Nugent, M.A.

Ogilvie, M. Ounsted, C. Prentice, P. Reynolds, B. Sears, P. Vaux, P. Webb, R.L. Wells, R. White-Robinson, G. Williams, and B. Wojtowych. Many others have contributed observations from time to time.

The Wildfowl Trust provided basic office and field work facilities as well as core financial support. Its Director, Sir Peter Scott, and Director of Research, Professor G.V.T. Matthews, have been constant sources of encouragement and advice.

The project has also been supported by major financial contributions from Macmillan (London) Ltd, The North Atlantic Treaty Organisation, The Natural Environment Research Council, and Shell (UK) Ltd, and many other individuals and organisations have given donations or helped in a practical way.

References

Boyd, H. & Ogilvie, M.A. 1969: Changes in the British-wintering population of the Pink-footed Goose from 1950 to 1975. *Wildfowl 20:* 33–46.

Boyd, H. & Ogilvie, M.A. 1972: Icelandic Greylag Geese wintering in Britain in 1960–71. *Wildfowl 23:* 64–82.

Brakhage, G.K. 1965: Biology and behaviour of tub-nesting Canada Geese, *J. Wildl. Mgmt. 29:* 751–771.

Ebbinge, B. & Ebbinge-Dallmeijer, D. 1976: Barnacle Geese *(Branta leucopsis)* in the Arctic summer – a reconnaissance trip to Svalbard. *Norsk Polarinst. Årbok 1975:* 119–138.

Ewaschuk, E. & Boag, D.A. 1972: Factors affecting hatching success of densely nesting Canada Geese. *J. Wildl. Mgmt. 36:* 1097–1106.

Ogilvie, M.A. 1978: Wild Geese. Berkhamsted, T. and A.D. Poyser.

Ogilvie, M.A. & Owen, M. 1984: Some results from the ringing of Barnacle Geese *Branta leucopsis* in Svalbard and Britain. *Nor. Polarinst. Skr. 181* (this volume).

Owen, M. 1980: The role of refuges in wildfowl management. Pp. 44–61 in *Brit. Crop Prot. Council Sump. Royal Holloway College, London. 4–5 April 1979.*

Owen, M. 1982: Population dynamics of Svalbard Barnacle Geese, 1970–1980. The rate, pattern and causes of mortality as determined by individual marking. *Aquila 89:* 229–247.

Owen, M. & Campbell, C.R.G. 1973: Recent studies of Barnacle Geese at Caerlaverock. *Scot. Birds 8:* 181–193.

Owen, M., Drent. R.H., Ogilvie, M.A. & van Spanje, T.M. 1978: Numbers, distribution and catching of Barnacle Geese *(Branta leucopsis)* on the Nordenskiöldkysten, Svalbard. in 1977. *Norsk Polarinstitutt Årbok 1977:* 247–258.

Owen, M. & Gullestad, N. 1984: Migration routes of Svalbard Barnacle Geese *Branta leucopsis* with a preliminary report on the importance of the Bjørnøya staging area. *Nor. Polarinst. Skr. 181* (this volume).

Owen, M. & Norderhaug, M. 1977: Population dynamics of Barnacle Geese breeding in Svalbard, 1948–1976. *Ornis Scand. 8:* 161–174.

Owen, M. & Ogilvie, M.A. 1979: Wing moult and weights of Barnacle Geese in Spitsbergen. *Condor 81:* 42–52.

Prestrud, P. & Børset, A. 1984: Status of the goose population in the bird sanctuaries in Svalbard. *Nor. Polarinst. Skr. 181* (this volume).

Prop, J., Eerden, M.R. van & Drent, R.H. 1984: Reproductive success of the Barnacle Goose *Branta leucopsis* in relation to food exploitation on the breeding grounds, western Spitsbergen. *Nor. Polarinst. Skr. 181* (this volume).

Rooth, J., Ebbinge, B., van Haaperen, A., Lok, M., Timmerman, A., Philippona, J. & van den Bergh, L. 1981: Numbers and distribution of wild geese in the Netherlands, 1974–1979. *Wildfowl 32:* 146–155.

Scott, D.K. 1980: Functional aspects of prolonged parental care in Bewick's Swans. *Anim. Behav. 28:* 938–952.

MALCOLM A. OGILVIE and MYRFYN OWEN:

Some results from the ringing of Barnacle Geese *Branta leucopsis* in Svalbard and Britain

Ogilvie, M.A. & Owen, M. 1984: Some results from the ringing of Barnacle Geese *Branta leucopsis* in Svalbard and Britain. *Nor. Polarinst. Skr. 181:* 49–55.

A total of 4,522 different Barnacle Geese *Branta leucopsis* of the Svalbard breeding population has been ringed since 1954, and another 1,732 recaptured. Details are given of the number and location of all the different catches. Nearly all the birds have been rounded up while flightless on the breeding grounds, or caught with rocket nets on the wintering grounds. Brief details are given of the different types of rings put on the geese. The use of individually coded plastic rings has brought great advances in the study of this population. Losses of these rings are shown to be negligible. The majority of the recoveries of dead birds have come from within the known range of the population. Those from outside the range are probably mostly drifted or over-shooting migrants. Shooting is the single major cause of death, and this still continues despite total protection throughout the range. Mortality calculations based on the recoveries suggest a higher mortality in the 1960s than since, fitting with estimates from counts and sightings of individually ringed birds.

Malcolm A. Ogilvie and Myrfyn Owen, Wilfowl Trust, Slimbridge, Gloucester GL2 7BT, United Kingdom.

Introduction

The catching and ringing of Barnacle Geese *Branta leucopsis* belonging to the Svalbard-breeding population began almost accidentally, during work on the Pink-footed Goose *Anser brachyrhynchus*, and has developed into a major tool in the long-term and detailed studies now being carried out. In particular, the introduction of large plastic leg rings, with individual codes able to be read in the field, has revolutionised the amount and the quality of the data which can be obtained. Owen (1984) and Owen & Gullestad (1984) report on just some of the results garnered in this way.

The paper gives details of when, where, and how the geese were caught, and what rings were used. It also examines what information has accrued from the recoveries of dead birds, including the causes of their deaths, and calculations of annual mortality.

Numbers of Barnacle Geese ringed

A total of 6,254 Barnacle Geese has been caught between July 1954 and October 1982 (Table 1). This includes 780 repeats, birds which were recaught during the same period of ringing, and 952 retraps, birds recaught during subsequent periods. Thus 4,522 different Barnacle Geese have been ringed.

The first goose to be caught was a single moulting adult in Reindalen, Spitsbergen, on 15 July 1954. It was in a catch of over 200 Pinkfeet, which were the principal target of the catchers (Goodhart et al. 1955). The next day they caught a further 22, also adults, this time with 115 Pinkfeet and 63 Light-bellied Brent Geese *Branta bernicla hrota.*

In July 1962, the Norwegian Ornithological Spitsbergen Expedition made four catches on the Dunöyane, off Hornsund, ringing 685 birds (Larsen & Norderhaug 1963). This was clearly a major effort which has subsequently contributed much to our knowledge of the population; yet ironically the expedition had as one of its aims the ringing of Pinkfeet, not Barnacles. Fortunately these aims were fully adaptable to the circumstances which the expedition members found on their arrival in Svalbard.

As a direct result of the July 1962 ringing, a catch of geese was made on the wintering grounds on the Scottish side of the Solway on 2 February 1963. Of the 316 birds caught no less than 94 had been marked on Dunöyane (Boyd 1964). This catch made virtually certain the previous supposition that the Solway was the sole wintering place for the Svalbard Barnacle Geese and that there was no overlap with the population breeding in East Greenland and wintering in western Scotland and Ireland.

Further catches were made on Dunöyane in July 1963 and July 1964 (Norderhaug 1964), and a small one on the Solway in February 1966. In summer 1968 a British expedition visited Reindalen and caught 53 birds (Vaughton & Hancock 1969).

In 1973, the Wildfowl Trust mounted an expedition to the Hornsund region and made six catches of Barnacle Geese, ringing a total of 393, some on Dunöyane, others on the coast to the north (Jackson et al. 1974). This marked the start of an intensive period of study which has included catches in six winters on the Solway and three major summer ringing expeditions, two to Nordenskiöldkysten, in 1977 (Owen et al. 1978) and in 1981, and one to Daudmannsöyra in 1979 (Needham 1982). The 1977 expedition achieved 12 catches within three weeks for a total of 1180 new-ringed birds and 59 retraps. In 1979, 114 birds were caught in four catches, while in 1981, 535 new birds were ringed and 343 retraps handled, also in four catches. The locations of all Spitsbergen ringing are shown in Fig. 1.

In all the catches since 1973 the geese have not just been ringed, but have been aged and sexed, weighed and measured. In addition samples have been X-rayed to check for shot pellets.

Fig. 2 compares the annual peak population count, made on the Solway wintering grounds each October, with the number of geese estimated to be wearing rings at the time. The latter are calculated by applying a mean annual mortality of 13.8% (estimated from an updated version of Table 1 in Owen & Norderhaug 1977). The upper part of the figure expresses this comparison as a percentage. It can be seen that the initial major ringing effort in 1962–1964 took the percentage ringed to over 20%, from which it declined steadily until the very successful ringing

Table 1. *Numbers of Barnacle Geese* Branta leucopsis *ringed in Spitsbergen, Norway and Scotland, 1954–1962.*

Year	*Month*	*Locality*	*No.of catches*	*New ringed*	*Retraps*[1]	*Repeats*[1]	*Total*
1954	July	Reindalen	2	23	–	–	23
1962	July	Dunøyane	4	685	–	145	919
1963	Feb	Solway	1	222	94	–	316
	July	Dunøyane	1	21	15	–	36
1964	July	Dunøyane	1	102	116	–	218
1966	Feb	Solway	1	15	7	–	22
1968	July	Reindalen	2	49	3	1	53
1973	July	Dunøyane	2	189	15	16	220
		Strandtjørnene	4	204	8	11	223
1975	Oct	Solway	1	113	8	–	121
1976	Oct	Solway	1	138	13	–	151
1977	July	Nordenskiöldkysten	12	1180	59	275	1514
	Oct	Solway	1	154	39	–	193
1978	Jan	Solway	1	166	59	–	225
	Apr	Solway	1	36	15	–	51
	May	Lånan, Helgeland	1	1	1	–	1
	Oct	Solway	1	311	60	–	371
1979	July	Daudmannsøyra	4	92	22	–	114
	Nov	Solway	1	64	19	–	83
1980	Jan	Solway	1	125	35	–	160
1981	Feb	Solway	1	1	–	–	1
	May	Lånan, Helgeland	3	3	–	–	3
	June	Nordenskiöldkysten	5	1	4	–	5
	July	Nordenskiöldkysten	4	535	343	332	1210
1982	May	Lånan, Helgeland	1	–	1	–	1
	Oct	Solway	1	92	16	–	108
Total			58	4522	952	780	6254

[1] For definition see text.

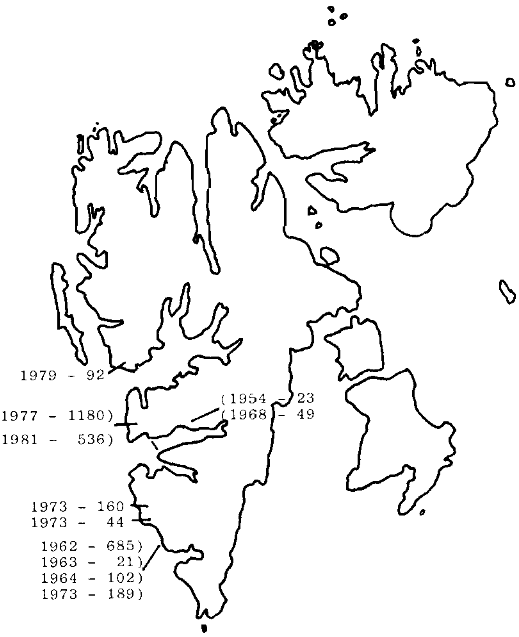


Fig. 1. Map of Svalbard showing locations of Barnacle Goose ringing.

in 1977. This brought it over 20% again where it has remained ever since, a substantial proportion of any population of birds to be ringed, with the great majority able to be identified individually in the field (see below).

Methods of capture

Virtually all the geese caught in Spitsbergen in the summer months were rounded up while flightless. The techniques and any special variations used are well described in the references given in the previous section. There is no doubt that this is a particularly successful catching method for Barnacle Geese, which on being disturbed from a feeding area will bunch together and seek refuge on any water in the vicinity. The shallow coastal lagoons on the west coast of Spitsbergen serve this purpose well, with the additional benefit from the catchers' point of view that they are mostly sufficiently small and shallow to make driving the flock off the water and into the catching pen a fairly straightforward task. The main problem has always been to prevent the birds reaching the sea across the narrow divide between the lagoons and the beach. The catching success in 1963 and 1964, and again in 1981, owed much to the previous catches, in 1962 and 1977 respectively, in precisely the same areas, sometimes even the same lagoons. This is an instance of the catchers learning faster than the geese.

The catching in the winter months has, with the single exception of a goose which hit some wires, recovered, and was ringed on its release, been by rocket or cannon nets (see Ogilvie 1978 for a brief description). Since 1975, the aim has been to make at least one catch each October, soon after the arrival of the birds in the winter quarters, with selected catches later in some winters. This has not always been achieved, principally through lack of cooperation from the weather, and sometimes the geese. Ideally, though, the requirement is to mark a sample of each year's young birds to give an annual addition of marked known-age birds in the population.

A set of compressed-air propelled nets have been taken in recent years to the spring staging islands in Helgeland, Norway, but only five birds

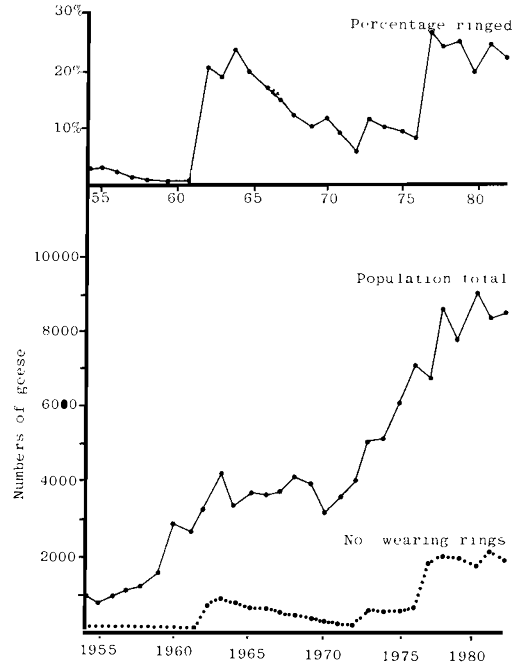


Fig. 2. Comparison of Barnacle Goose population size with number of birds wearing rings. Upper part shows comparison as annual percentage.

have been caught in this way. They were also used in 1981 on a breeding island off the Nordenskiöldkysten, resulting in the capture of a further five birds.

Rings used

Throughout the period of catching, the great majority of the geese have been marked with standard metal leg rings as issued by the relevant national ringing schemes. The only exceptions have occurred on occasions when there were insufficient rings available to mark all the birds in a very large catch. In 1954, and again in 1963 and 1964, the geese were additionally marked with a white spiral plastic ring. These enabled distinction to be made between the Svalbard population of Barnacle Geese and the Greenland population, which were being marked in the early 1960s with differently coloured spiral rings.

From 1973 almost all the geese caught have been marked with large rings made of a coloured plastic laminate. Individual codes of two or three letters are engraved into the laminate producing black letters on a coloured background (Ogilvie 1973). The principal colour used has been yellow. Different year-classes of goslings, and also some adults, have been marked in recent years with other colours, including white, orange, and blue, and also with yellow rings bearing contrasting stripes of blue or orange. Some of the detailed field studies have depended upon being able to make repeated observations on a fairly small number of geese, hence the need to make some birds more conspicuous than the remainder. To this end, yellow dye on the white tail coverts has also been used in some winter catches.

Resighting rates of plastic-ringed birds have been very high, with consistently over 94% of ringed birds being seen in the year after ringing, and, for specially marked groups, reaching 98% or even 99%. The position has now been reached whereby if an individual is not seen over a period of two winters it can be assumed to be dead (Owen 1982). The resightings of the geese have been used by Owen to estimate very accurate annual mortality and to make other precise calculations. The only qualification that could be made to these would be if there was a marked loss of rings by the geese. Table 2 (taken from Owen 1982, with corrections) demonstrates that such loss has thus far been negligible. It is based on the recapture of 499 ringed birds and includes details of worn and broken rings, with pieces chipped out, as well as those which have come off completely. Taking into account the period which the rings had been on the geese, a mean of 2.35 years between capture and last recapture, the loss rate of 0.4% represents no more than 0.14% per annum, or only two or three individuals in the whole population.

Table 2. *The status of 499 plastic leg rings examined on recapture (last recapture in cases of birds recaught more than once). Only birds also wearing metal rings included. After Owen (1982).*

Status of ring	*No.*	*%*	*Total days*	*Days/ring*
Undamaged	476	95.4	488,082	1025.4
Worn or broken	21	4.2	29,115	1386.4
Lost	2	0.4	2,580	1290.0
Total	499		519,777	1041.6

Recoveries of ringed birds

Distribution

Table 3 sets out the country of recovery of the 215 dead birds notified to mid-1983, and also distinguishes between those which had been shot and those which had died from other causes, or had just been reported as found dead. The great

Table 3. *Recoveries of ringed Barnacle Geese* Branta leucopsis *by country.*

Country of recovery	*No. shot*	*No. not shot*	*Total*
Svalbard	4	12	16
Norway	13	9	22
Denmark	1	1	2
Netherlands		1	1
Britain (excl. Solway)	23	22	45
Solway	30	87	117
Ireland		3	3
France	1		1
Spain		1	1
Iceland	1		1
East Greenland	1		1
Newfoundland	1		1
Total	75	140	215

Table 4. *Distribution of shot Barnacle Geese* Branta leucopsis *in five-year periods from 1964. Recoveries before 1963 not split.*

Country of recovery	*Periods of recovery* *1955–63*	*1964–68*	*1969–73*	*1974–78*	*1979–83*	*Total*
Svalbard	3	1				4
Norway	2	7		1	3	13
Britain (excl. Solway)	1	6	2	8	6	23
Solway	1	5	10	5	9	30
Elsewhere		2			3	5
Total	7	21	12	14	21	75

majority of the recoveries are from within the known range, but there are eleven from eight countries which indicate some degree of wandering.

The two recoveries in Denmark can be explained either by assuming that they had got caught up in the flocks of Pinkfeet or Brent, both of which migrate from Svalbard to Denmark, or through drifting off-course on their way between Norway and Scotland.

The single recovery in the Netherlands may have involved similar movement. Here, though, there is a large wintering population of Russian-breeding Barnacle Geese with which it might be possible for a lost Svalbard goose to link up. Owen & Gullestad (1984) report on sightings of Svalbard Barnacle Geese in the Netherlands flocks.

Recoveries in Ireland, France, and Spain can be regarded as over-shooting by migrating birds. Four of the five were in the autumn, October or November. None of the Irish birds, though, had moved into areas frequented by the Greenland Barnacle Geese.

Linking with Greenland Barnacles would explain the recoveries in Iceland and Greenland, however. The principal wintering area for this population is on the island of Islay in western Scotland, only 160 kilometres from the Solway. A few colour-ringed Svalbard Barnacle Geese have been seen on Islay, just as the occasional ringed Greenland Barnacle has reached the Solway (Owen & Gullestad 1984). A lone goose moving out of its traditional winter range and finding itself in a flock of Barnacle Geese with a different migratory pattern might find the pull of gregariousness stronger than its own migratory instinct, though there is a case of a bird so lost finding its way back into the right population (Owen & Gullestad 1984).

The final recovery, that in Newfoundland, is the most extraordinary, geographically, of them all. The Barnacle Goose is a scarce vagrant to North America (Palmer 1976). It could be supposed that the majority of occurrences might have their origin in the much nearer East Greenland Barnacle population. The Newfoundland recovery was in October and so presumably involved a bird which went badly astray during its southward autumn migration.

Causes of death

Shooting has already been seen from Table 3 as a most significant cause of death, especially in Britain and Norway. It is almost certainly much more important, particularly in Britain, where many birds are reported as being found dead on the Solway tideline, within a few kilometres of the wintering area. Undoubtedly a high proportion of these will have been shot.

Table 4 shows the distribution of shot birds in the different countries, for five-year periods from 1964. Recoveries before 1964 are too few to separate. The Barnacle Goose was given full protection within its British range in 1954, in Svalbard in 1955, and in Norway in 1971. These measures would appear to have been much more successful in Svalbard and in Norway than in Britain. However the population has the misfortune to winter in an area of very high shooting pressure, particiularly for Pink-footed Geese as well as for ducks. There is no doubt that this is the main reason for the continuing shooting deaths in the Solway.

Table 5. *Causes of death of recovered Barnacle Geese* Branta leucopsis.

Cause of death	*No.*
Found dead	114
Shot	75
Hit wires	7
Killed by rocket net	7
Found injured	5
Caught in line	2
Hit by traffic	1
Hit by train	1
Caught in net	1
Struck by lightning	1
Killed by fox	1
Total	215

Table 5 lists the causes of death for all the recovered birds. «Found dead», as already mentioned, will certainly include many shot birds. Otherwise other forms of death are mostly accidental and make a negligible contribution to overall mortality.

Mortality

Owen & Norderhaug (1977) calculated annual mortality of the population using counts for the period 1959 to 1976. They found that from a mean 13.1% in the early 1960s it rose to 25.5% in the late 1960s before dropping to only 10% in the 1970s. Owen (1982) was able to compare the mortality as shown by the counts with that shown by the non-return of ringed birds. The mortality calculated from the counts continued at about 10% through to 1980, while from the ringed birds it was rather higher, at about 13%. Owen suggested that the latter was the more accurate figure.

It is also possible to calculate mortality from the recoveries of ringed birds. Their distribution with time is set out in Table 6. Using the formula of Haldane (1955), the overall mortality for the period 1954 to 1982 is 9.9%. Sub-dividing the data is probably rather risky as the ringing effort has been so variable over a period of years, with much of the large-scale ringing very recent. Nevertheless, separating the recoveries into those from ringing in 1962–1964 and later does suggest that mortality has declined in recent years. The mean mortality for the first ten years of recoveries from ringing in 1962–1964 is 20.1%, but this drops sharply to 12.3% if all recoveries are included. Mortality from ringing since 1973 is just below 8%. This decline is probably associated with the extension of the refuge at Caerlaverock on the Solway in 1970 which gave the geese more space in which to live safely by increasing the area free of wildfowling.

Conclusions

The initial ringing of the Svalbard Barnacle Geese was of vital importance in separating the three populations of this species which winter in such close proximity in north-west Europe and equally vital in establishing the very circumscribed winter range of this particular population.

Table 6. *Recoveries of ringed Barnacle Geese* Branta leucopsis *by year of ringing and year of recovery.*

Year of	*Year of recovery*																				
ringing	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
1954		2		1				1													
1962	3	9	5	1	5	2	3	3	4	1	4	2	1	3	2	2		1	1		1
1963	3	8	1	3	3	1	1	2	1	3	1						1	2			
1964	2		1				1				1										
1966	1												1								
1968	1	2		2	1		1	1			1										
1973	1	1	2	1	3	2		3	4	2											
1975		3		1	1	1	1		1												
1976		1		1	2	2															
1977	3	13	9	9	4	2	4														
1978	1	4	5	3	1	1															
1979		2		1	2																
1980	1	3	2																		
1981		1																			

The subsequent use of individually coded rings and the ability to achieve and then maintain such a high proportion of marked birds in the population has enabled a study of unrivalled detail and depth to be pursued. The knowledge so gained is not only of immediate value in increasing our understanding of, and capability of looking after, the Svalbard Barnacle Geese but has direct applications in the setting up of studies of other wildfowl.

References

Boyd, H. 1964: Barnacle Geese caught in Dumfriesshire in February 1963. *Wildfowl Trust Ann.Rep. 15:* 75–76.

Goodhart, J., Webbe, R. & Wright, T. 1955: Goose ringing in Vest-Spitsbergen. *Wildfowl Trust Ann.Rep. 7:* 170–6.

Haldane, J.B.S. 1955: The calculation of mortality rates from ringing data. *Proc. Int. Orn. Cong. 11:* 454–8.

Jackson, E.E., Ogilvie, M.A. & Owen, M. 1974: The Wildfowl Trust expedition to Svalbard (Spitsbergen) 1973. *Wildfowl 25:* 102–16.

Larsen, T. & Norderhaug, M. 1963: The ringing of Barnacle Geese in Spitsbergen, 1962. *Wildfowl Trust Ann.Rep. 14:* 98–104.

Needham, B. (Ed.) 1982: *Oakham School Exploration Society Svalbard Expedition 1979.* OSES, Oakham. 162pp.

Norderhaug, M. 1964: Ornitologiske feltarbeider på Vestspitsbergen 1963–64. *Sterna 6:* 185–94.

Ogilvie, M.A. 1973: Large numbered leg bands for individual identification of swans. *J. Wildl. Manage. 36:* 1621–5.

Ogilvie, M.A. 1978: *Wild Geese.* Poyser, Berkhamsted. 350 pp.

Owen, M. 1982: Population dynamics of Svalbard Barnacle Geese 1970–1980. *Aquila 89:* 229–47.

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose. *Norsk Polarinst. Skr. 181* (this volume).

Owen, M., Drent, R.H., Ogilvie, M.A. & van Spanje, T.M. 1978: Numbers, distribution and catching of Barnacle Geese *(Branta leucopsis)* on the Nordenskiöldkysten, Svalbard, in 1977. *Norsk Polarinstitutt Årbok 1977:* 247–58.

Owen, M. & Gullestad, N. 1984: Migration routes of Svalbard Barnacle Geese with a preliminary report on the importance of the Bjørnøya staging area. *Norsk Polarinst. Skr. 181* (this volume).

Owen, M. & Norderhaug, M. 1977: Population dynamics of Barnacle Geese breeding in Svalbard 1948–1976. *Ornis Scand. 8:* 161–74.

Palmer, R.S. (Ed.) 1976: *Handbook of North American Birds. Vol.2.* Yale Univ.Press, New Haven. 521 pp.

Vaughton, K.C. & Hancock, N.J. 1978: Expedition report: Svalbard (Spitsbergen) 1968. *Bull. Oxford Univ. Exploration Club 17(5):* 71–94.

NILS GULLESTAD, MYRFYN OWEN and M.J. NUGENT:

Numbers and distribution of Barnacle Geese *Branta leucopsis* on Norwegian staging islands and the importance of the staging area to the Svalbard population

Gullestad, N., Owen, M. & Nugent, M.J. 1984: Numbers and distribution of Barnacle Geese *Branta leucopsis* on Norwegian staging islands and the importance of the staging area to the Svalbard population. *Nor. Polarinst. Skr. 181:* 57–65.

Barnacle Geese breeding in Svalbard and wintering in northern Britain perform a non-stop migration in late April and early May to a staging area in Helgeland (65° 40′ N, 11° 40′ E), Norway. This paper describes the area and studies carried out between 1975 and 1982. Counts from the staging area, together with information from Britain, other parts of Norway, and from Svalbard, indicate that the whole of the Svalbard population can be found in Helgeland in the first half of May. Departure from the Solway depends on wind conditions but mass movements are usually between 20 April and 7 May. The length of the staging period is 2–3 weeks depending on arrival time in Helgeland. Departure from Helgeland during the years of study has been largely between 15 and 20 May. Individual geese are loyal to their staging archipelago and the majority of adults return to the same part of the area year after year. A decline in numbers of geese on Lånan-Flovær in recent years, traditionally the most important archipelago for geese, has coincided with the absence of grazing animals and other changes in the forms of traditional management of the area. In considering the status and future management of the Helgeland archipelagos, it is stressed that

(a) the area is of vital importance to the Svalbard population,
(b) depopulation and cessation of stock grazing and traditional management practices is deleterious to the geese,
(c) steps should be taken to give the main areas protection and to encourage the continuation or reintroduction of traditional management practices.

Nils Gullestad, Nordland Regional College, P.O. Box 309, 8001 Bodø, Norway; Myrfyn Owen and M.J. Nugent, Wildfowl Trust, Slimbridge, Gloucester GL2 7BT, United Kingdom.

Introduction

The population of Barnacle Geese breeding in the Svalbard (Spitsbergen) archipelago winters in a restricted area in the Solway Firth, in south-west Scotland and north-west England. The population is closed, having negligible interchange of individuals with that breeding in western Siberia and wintering in the Netherlands or with the population which breeds in east Greenland and winters in north-west Scotland and western Ireland (Boyd 1961; Owen & Norderhaug 1977). The geese have been counted regularly in winter since 1948 and their numerical breeding distribution was fairly well known by the late 1960s (Løvenskiold 1964; Norderhaug 1970).

Following ringing activities in Svalbard and Scotland in the early 1960s, about 1000 geese were marked. Since the population was protected over most of its range recoveries were few, only 22 from Norway, 15 in autumn, and seven in spring. Of the seven spring recoveries, six were concentrated in Helgeland, in an area between 65°30′N and 66°N. It was not until 1975, however, that it was discovered that offshore islands in this region were important as staging areas for Barnacle Geese in late April and early May.

Further catching in the breeding area (Jackson et al. 1974; Owen et al. 1978) and in the wintering grounds in the late 1970s enabled large numbers of geese to be marked with individually-coded plastic rings readable with a telescope at up to 200 m. Since summer 1977 there have been over 2000 individually marked geese in the population, 20–25% of the total (Owen 1984).

This paper briefly describes the area and considers its importance to the Barnacle Goose population. At least one of us has visited the islands each spring between 1975 and 1983 and

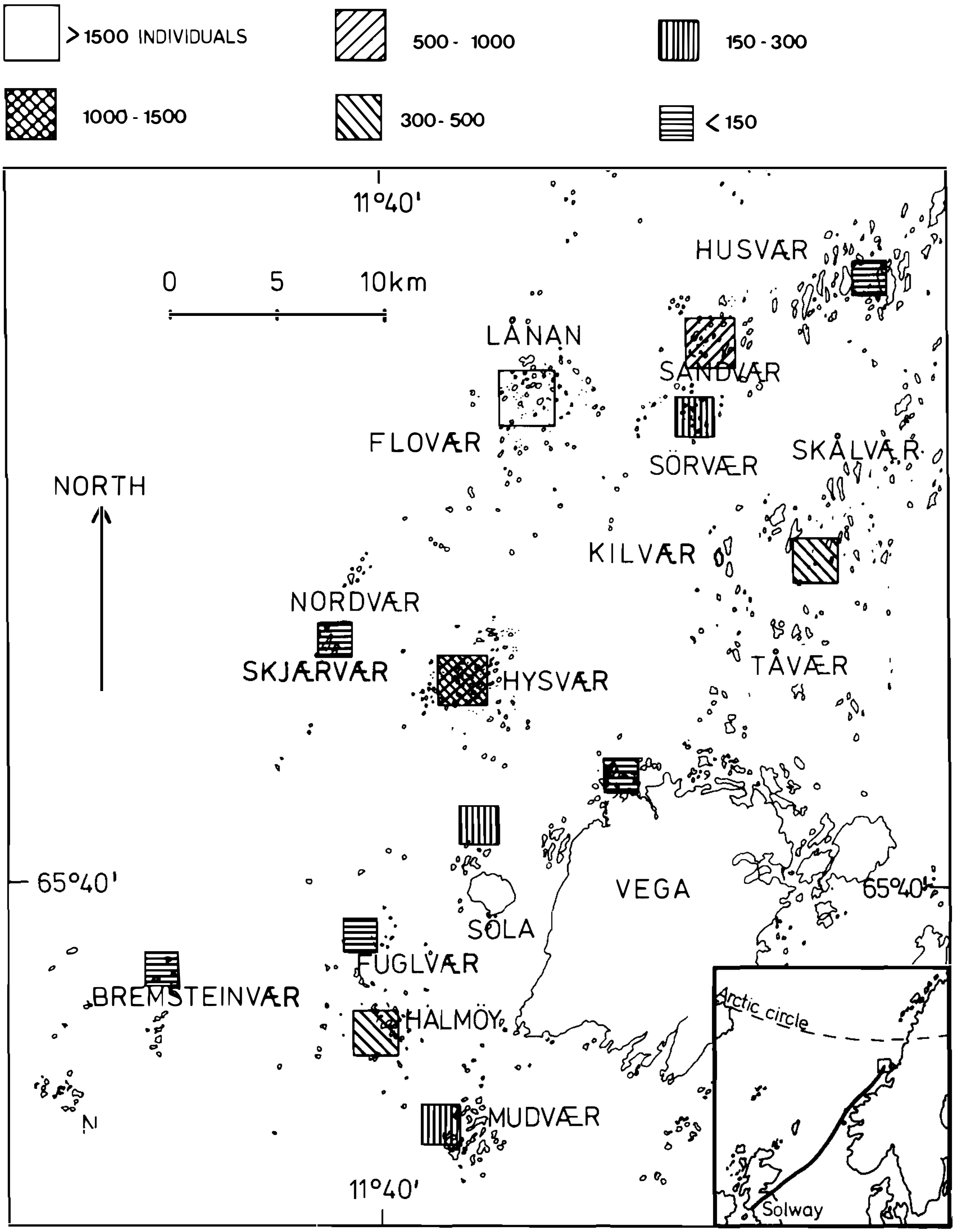


Fig. 1. The Helgeland area, showing the locations of the main archipelagos used by Barnacle Geese in spring. The symbols (top left) indicate the regular number of geese using the various island groups from 1975 to 1982. The spring migration route from the Solway Firth is shown in the inset (bottom right).

made observations on numbers and distribution. We have also collected information from observers throughout Helgeland on goose numbers. More detailed ecological work was carried out in 1977, 1978, 1980, 1981, 1982 and 1983, when additional observers stayed on the islands. Much of the ecological work will be reported on elsewhere.

The study area

The Helgeland region (Fig. 1) has tens of thousands of islands of varying size extending up to 40 km from the mainland. Many of the islands are very small, remote, and sparsely populated and there is little boat traffic during the stay of the geese. The islands are all rocky, and many, especially on the inland side, are 10–20 m high and covered with heather *Calluna vulgaris*. These are unsuitable for geese, but many smaller, flat-topped islands are less than 5 m above sea level and grass-covered. The extreme exposure precludes tree growth except on the sheltered slopes of the higher islands.

The main study area was the small Lånan/Flovær archipelago consisting of about 300 small flat islands, visible at high tide and vegetated, within a radius of 5 km (Fig. 2). The islands vary in area from a few square metres to 12 ha and the total area is about 120 ha, probably 100 ha of which is grass covered. The 'home' island, of about 10 ha in area, is near the centre of the archipelago and most of the outer islands can be viewed from there.

A complete vegetation survey has not been carried out but the main sward component over most of the outer islands is *Festuca rubra* which grows as pure stands in many areas. *Poa pratensis* is also abundant and on the lower parts of each island are small patches of *Puccinellia maritima,* sometimes mixed with *Armeria maritima.* In sheltered parts of the larger islands the vegetation is taller, with coarse grasses and also *Filipendula ulmaria, Rumex* spp. and sedges. *Juniperus communis* commonly covered the rocks in these sheltered sites. On the home island the sward was shorter and more mixed. *Poa pratensis* was abundant and *P. annua, P. trivialis,* and *Anthoxanthum odoratum* were locally common especially near buildings. There were also numerous other herbs such as *Alchemilla vulgaris, Trifolium repens,* and *Luzula campestris.*

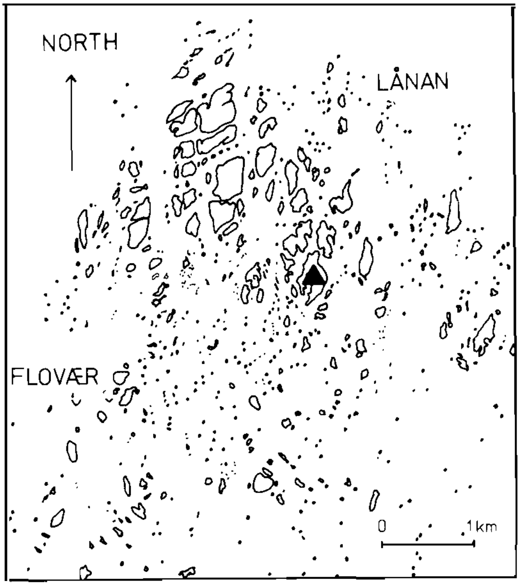


Fig. 2. The Lånan/Flovær archipelago, with the triangle marking the position of the home island from which most of the observations were made.

A small number of sheep were traditionally kept inwintered in barns and ferried to the outer islands to graze in May. Hay for winter feeding was cut on the home island and dried on racks. Sheep were present up to 1979 but the practice had ceased by 1980. There is a progressive decline in the stock kept on the Helgeland islands as the area becomes depopulated and houses are used only in spring and summer. Dung from inwintering sheep was spread on the home island. No other attemps at fertilising were made, but seaweed, sometimes in large quantities, was washed onto the islands (even the interior of the larger ones) by winter gales, and gradually became incorporated into the peaty soil.

This management produced a shorter and better sward on the home island, especially in the vicinity of barns where dung was spread. Here growth was evident much sooner, since the ground was relatively clear of dead vegetation. On the outer islands young shoots grew through substantial tussocks of dead material, especially in the sheltered sites. Even in mid-May the outlying islands looked brown from a distance.

The only other grazing animals were Greylag

Geese *Anser anser,* although their density was low, perhaps 30-40 pairs on the study area. In early May they were incubating or on territory and did not associate with the Barnacle Geese. There was a large population of voles *Arvicola terrestris,* but they largely fed on underground plant parts, and all had disappeared from the island by 1982.

Human disturbance was largely confined to the home island but islanders made a few boat trips to outlying islands to collect seaweed or eggs. Because of the importance of the area for Eider *Somateria mollissima* farming (the ducks were prospecting for nests in early May), the whole area was completely undisturbed before 0800 GMT.

Methods

Phenology, numbers and distribution

Each year observers in Britain regularly counted the number of geese there during April and May. The Lånan/Flovær archipelago was visited and attempts were made to count the number of geese there at regular intervals. This information was supplemented by counts made on periodical visits to neighbouring archipelagos and from reports from observers there. Repeat sightings of marked individuals provided some information on length of stay.

Sightings of ringed birds

Ringed individuals were identified in each season and their location in the study area recorded. Sightings were compared between years to estimate the fidelity of individual geese to particular staging areas, and sightings in Helgeland were compared with capture data to discover whether groups of geese caught together were likely to be found together on migration. Chi-square tests were used to test for non-random mixing.

Results

Phenology, numbers and distribution

Counts of geese on the whole staging range was difficult because of the remoteness of the area and the travelling difficulties, but counts from neighbouring archipelagos have been possible occasionally, and the range of numbers believed to be staging in each group is shown in Fig. 1. Table 1 gives the counts on Lånan/Flovær since 1976, plus occasional counts from the other two main areas.

In 1978 counts and estimates from the main haunts totalled 4800 geese out of the 6300 believed to be alive at the time. Since small numbers are scattered over a wide area, we believe that the whole Svalbard stock stays in Helgeland in the spring. Numbers on Lånan have clearly declined recently, especially if expressed as a percentage of the estimated population (autumn count less 5% overwinter mortality (Owen 1982)), from above 20% in the mid-1970s to about 10% at present. Numbers have increased in the other main haunts and there has been a rapid dispersal into other areas, of which many are more disturbed and not previously visited by geese.

The pattern of departure from the Solway and changes in numbers on the study area in Helgeland are shown in Fig. 3. The pattern is broadly similar in all three years although the timing of large-scale movements is slightly different. Although we have no accurate estimates of the time it takes for geese to migrate to Helgeland from Britain, observations on other goose species (e.g. Blokpoel 1974) suggest air speeds of around 60 km p.h. during migration. Butler & Woakes (1980) found that the lowest flight speed of captive Barnacle Geese was 54 km p.h., the mean for five flights being 67 km p.h. It seems likely, therefore, that a non-stop flight between Britain

Table 1. *The number of geese counted or estimated on the three main staging areas since 1976.*

	Year							
Archipelago	*1976*	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*	*1983*
Lånan/Flovær	1100	1800	1500	1200	1500	870	590	900
% of population	19.2	26.0	23.4	14.3	20.3	10.2	7.6	11.3
Hysvær			1200		1500			
Sandvær			700		900+			

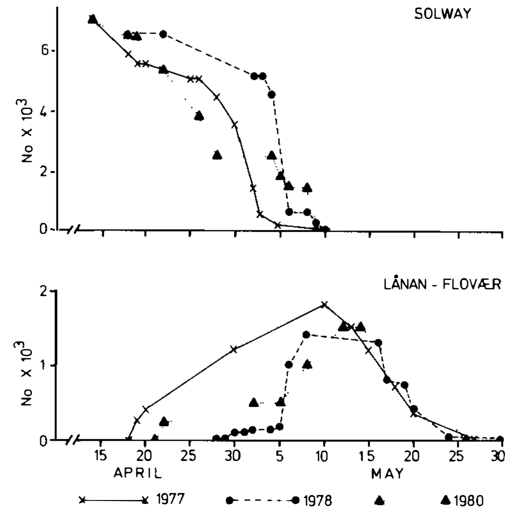


Fig. 3. Counts of Barnacle Geese on the Solway and on the main study area in Helgeland in the second half of April and in May 1977, 1978, and 1980.

and Helgeland (1600 km) would take 24 hours without wind assistance. The pattern shown in Fig. 3 is consistent with the flight being non-stop. The best coordination of observations was in 1978 when about 800 geese were seen to arrive on the study area, most before 0700, on 6 May. 4200 geese left the Solway between 0900 on 4 May and the morning of 6 May – a maximum period of 46 hours. In 1982 four birds were identified at Caerlaverock (on the Solway) and later seen on Lånan within only 30 hours, confirming that the flight is probably non-stop. No other stopping places, other than a few hundred birds on islands just north and just south of that shown in Fig. 1, are known elsewhere on the Norwegian coast although we have made exhaustive efforts to locate any through local contacts, a procedure which has successfully located stopping places for other goose species.

Departures from the Solway usually begin in the second half of April and a few birds are seen on Lånan in most years from 15 April onwards. The mass of geese, however, do not leave the Solway until the end of April or early May, the exact timing depending on local weather conditions. It is rare to find any geese remaining in Britain beyond 9 May.

The length of time spent by geese on the archipelago varied from year to year since arrival time was different while departure time remained the same. The average number of days spent can be calculated by measuring the interval between mid-arrival (when 50% of the maximum has arrived) and mid-departure. This was 20 days in 1977, 13 days in 1978, and 14 days in 1980. This will, of course, be different for different individuals and since late counts include birds from southerly areas which stop for a time (see below), this figure gives a slight overestimate of the staging period. In 1977 the average length of time between the first and last sighting of individual geese was 8.6 days (discounting individuals seen only once), but 24 of 109 birds (22%) were seen over a period of 15 or more days during the observers' 19–day stay. Observers were present on the islands for 22 days in 1978 and the average length of stay was 6.0 days, only 2 of 239 birds (1%) being seen 15 or more days apart. Clearly this gives an underestimate of the average since not all the geese present are sighted.

The first method probably gives a reasonably reliable estimate of length of stay and in 1975, 1976 and 1979, when counts were less frequent, average stay was about 16, 25 and 16 days, respectively. The duration of the staging period, therefore, is usually between two and three weeks, but the average can be as much as ten days longer in some years than in others. The reason for the variability is mainly delay in migration from Britain because of unfavourable weather.

The use of the staging area by individual birds. Each year between 20 and 25% of the Svalbard population used the study area at peak, and in each of the three main seasons 20–25% of geese estimated to be alive and carrying rings were sighted there. To test for non-randomness in the distribution of ringed birds, sightings of particular groups of geese were compared. In 1980 geese were available which had originally been caught in six more or less separate parts of the breeding area. In the analysis 'bird units' were used rather than individuals, pairs of geese being treated as one unit. Using the whole of the data, there was no significant difference (Chi-square) between the proportion of geese from different breeding groups which were staging in the study area. However, birds from a small breeding area at the south end of Nordenskiöldkysten were significantly more likely to be seen in the study area than others.

On another archipelago nine units were seen in 1978 on two small, adjoining islands (each 150 × 75 m). Eight of these came from the northern part of Nordenskiöldkysten. The proportion was significantly different ($P < 0.05$) from that expected on the basis of the proportion of geese ringed in that and other areas (Kolmogorov-Smirnoff one-sample test). In 1977 there was a significant difference in the sighting rate of birds originating from two different areas between Hornsund and Bellsund. These examples suggest that the distribution of geese in the staging area is not random with respect to breeding place but that the overall analysis is not sensitive enough to pick out differences, which may be on a very small scale.

In 1975 and 1976 catches were made in Scotland immediately after the arrival of the geese. If spring and autumn migrating groups are similar it might be expected that sightings of these birds in Norway would not be random. Thirty-eight out of 109 (35%) of 1975-caught geese were seen in the study area compared with only 21 out of 142 (15%) of those caught in 1976 (Chi-square, $P < 0.001$), and the difference was even greater when bird units were compared. The 1975 group was significantly more likely to be seen in the area than any other sample of birds caught together. It seems likely, therefore, that sub-groups in the population consistently migrate together and the most likely reason is that they are part of the same breeding unit.

Sightings of individuals seen in different years were used to determine how loyal geese were to their staging area. Since about one-fifth of available geese were sighted in the three main study seasons, the likelihood of seeing an individual in two successive years by chance is about $0.2 \times 0.2 = 0.04$ – a 4% loyalty by chance. In 1975 and 1976 many fewer birds were seen and the probability of sighting an individual by chance was even lower. From sightings in winter (c. 90% of individuals seen each year) it was possible to identify those birds which were dead or had lost their rings. Individual sightings in 1975, 1976, and 1977 were compared with those in 1979 and 1980 to determine area loyalty. Birds were considered loyal if they were seen in the first and last years or had regularly attended until their death. Those which were alive and were not seen for two or more seasons were not loyal. Units which were seen only once before they died or were missed only once could not be reliably classified. A pair of geese was considered as one unit and the results are presented in Table 2.

Most geese turned out to be loyal to their staging area; the figure of 61% for adults

Table 2. *The loyalty of individual bird units (pairs considered as one unit) to their staging area. For explanation of loyalty criteria, see text.*

		Loyal	*Not loyal*	*Not known*	*% loyal*
First seen as Adults	1975	8	5	4	
	1976	8	7	4	
	1977	17	9	13	
	All years	33	21		61
Yearlings*	1977	7	10	3	41
Goslings+	1976	3	3	1	
	1977	1	6	2	
	All years	4	9		31

* Yearlings are in their second spring
\+ Goslings are in their first spring

Significance between classes

	Chi Square	P
Adults/Yearlings	6.8	< 0.01
Adults/Goslings	7.46	< 0.01
Yearlings/Goslings	0.19	NS

underestimates loyalty because birds may be seen while in transit. For example two units were seen in the study area once in the beginning of the staging period in 1978 and later identified on another archipelago, suggesting there is some redistribution after first arrival. At the end of the staging period there is a high turnover of individuals on the study area as birds in transit from more southerly sites stop on the way north. For example, in 1978 91 individuals were seen on 16–17 May of which 9 had not been seen previously in the archipelago. The northerly migration occurred mainly between 17 and 20 May when 41 of 110 birds were 'new' (Chi-square, $P < 0.001$). Occasional sightings of such birds must substantially depress the estimate of area loyalty. It seems likely, therefore, that adult birds, once they have chosen their staging area, generally return there year after year. In fact out of ten units identified in 1975 which survived for three or more years afterwards, six were seen in the study area in all or five of the six seasons.

Birds which are seen as yearlings (about two-thirds of which are paired) are less loyal than adults, as would be expected either if they had not selected their staging area or if they accompanied their eventual mate to its staging haunt. Birds staging as goslings are even less likely to return although the difference between them and yearlings is not significant.

The distribution of geese within the study area was not random. Individuals were repeatedly seen in the same part of the area, both on different days in the same year and in different years. As an example Fig. 4 shows the locations of three pairs of geese on different days in 1977, and there are many similar cases. API, with APF and later with another mate, and ALA, with AKG and subsequently a new mate, both returned to the same part of the area as in 1977 in four other years. ADZ lost its mate in 1977 but returned in 1978. It subsequently re-paired but, although alive in 1980, was not seen again in the study area.

In 1980 the part of the archipelago under regular observation was divided into twenty sectors, nine of which were on the home island. The sector boundaries did not present effective barriers to goose movement and birds regularly moved across those boundaries. Each time a bird unit was sighted the sector was recorded. Over a 16-day period 94 bird units were sighted on three or more days and the total number of unit days was 512 (mean of 5.4 days/unit). In 34% of the cases sightings were recorded in the same sector on different days and 77% of the units were seen in the same or contiguous sectors. This might be expected if birds moved among many sectors in the same day but the mean sighting rate per unit day was only 1.29, i.e. five sightings per four days.

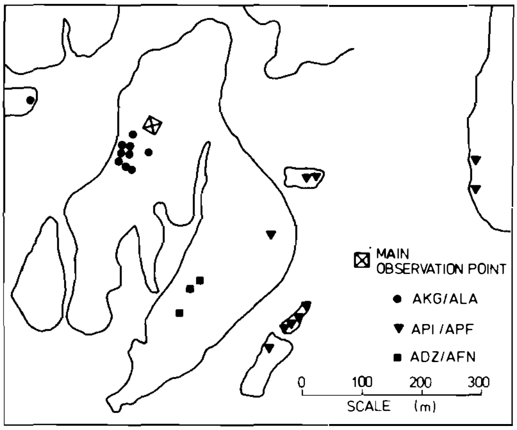


Fig. 4. The locations of three marked pairs of geese on different days in the central part of the study area in 1977. The large island is the home island.

Considering, therefore, that many of the sectors are extremely small and that their boundaries in many cases do not present barriers to goose movements, this provides conclusive evidence that the majority of birds are not only loyal to the staging place but also to the same part of the area within, and to a large extent between, seasons. There is some competition between individuals for feeding areas (see below) and one pair was seen to defend vigorously a small (a few square metres) patch to which they returned each day in at least two seasons, i.e. they were defending a fixed feeding territory.

Daily activities

The geese sometimes roosted (usually sitting with head in feathers) on the rocky margins of feeding islands but more often flew a short distance to bare rocky islets. Roosting groups were small, usually between 2 and 20 individuals. In the morning, geese flew onto the home island from all directions and often all the geese in the archipelago were feeding there between 0200 and 0800. Later in the day the birds were disturbed by human activity and moved to the outer islands. The morning flight was usually about 30 minutes before sunrise and the evening flight 30 minutes after sunset.

Because the islands are relatively undisturbed the birds move little during the day and spent a very small proportion of the time flying. The only regular disturbance was caused by overflying White-tailed Eagles *Haliaeetus albicilla* and this varied from year to year according to the weather, from once every few days to several times daily.

Discussion

The Helgeland area is probably used as a staging place by the whole of the Svalbard stock of Barnacle Geese, and their stay lasts 2–3 weeks. This time, immediately pre-breeding, is a crucial one for all geese (reviews in Newton 1977, Owen 1980, Prop et al. 1984) and the birds accumulate substantial body reserves during their stay (M. Nugent & M. Owen unpubl.). It is vital, therefore, for the well-being of the population that these islands should be safeguarded.

Individual geese remain loyal to their staging areas although a number must have abandoned Lånan since the mid-1970s as the importance of the area declined. The significance of this loyalty is probably related to the ability to find suitable feeding places and we know that some individuals, at least, defend an area which might be termed a feeding territory. Since assemblages of geese on the staging grounds bear some relationship to those at other times of the year, the loyalty may also serve a function related to the cohesion of breeding units, pairs, or families.

The decline in importance of Lånan coincided with important changes in the management of the islands. The lack of grazing animals, which were inwintered on the home island and ferried to outer areas to graze in summer, has had several deleterious effects:

(a) The outer islands are now completely ungrazed in summer, allowing the vegetation to grow rank. This delays the appearance of new growth above the dead vegetation and also means that it is older and less nutritious.

(b) No hay is cut on the home island as was traditional, again leading to rank vegetation there.

(c) No dung is spread on the home island, which means the nutritive value of the vegetation there declines.

The importance of the better feeding conditions on the home island is clear; wherever there is habitation and stocking the geese flock in the early morning. The areas where numbers have increased in recent years are those which are inhabited and stocked.

Future management.

A very important characteristic of the Helgeland islands is their relative freedom from disturbance, and any future management regime must maintain this characteristic. The restriction of boat traffic is most important since powered boats create substantial disturbance. The level of traffic at present, even in the more populated islands, is disruptive but not seriously so, since geese always have access to undisturbed islands.

Another important aspect in the habitated areas is the freedom from morning disturbance by humans, anxious to preserve the Eider farming industry. This is likely to continue since (sale of) down makes up a substantial contribution to the income of the inhabitants.

The effects of depopulation through lack of stocking with cattle and sheep continue to increase, as fewer and fewer animals are now kept. Simulating the effect of their grazing is difficult, although autumn burning would eliminate much of the dead vegetation and make low levels of grazing more effective. This is not practicable on inhabited islands, however, because of the hazard to buildings which are largely constructed of wood. The introduction of burning as a regular management, coupled with a small subsidy on stock, would help to maintain the vegetation of the islands in a suitable state for the geese.

The importance of the area for this goose population, coupled with the unfavourable management trends, we believe, calls for rather urgent attention by conservation organisations. Substantial refuges should be created in the more important areas, and the inhabitants encouraged and helped to continue traditional land management practices which have proved so favourable to the geese.

Acknowledgements

We are extremely grateful to Petter Ingolf Johnsen and his family for providing accommodation and a great deal of practical help in the work on Lånan/Flovær. We also thank other residents of Helgeland archipelagos for cooperation in our goose work. We are grateful to the following observers who assisted with observations in Norway and Britain: Colin Campbell, Arie Dekker, Andrew St. Joseph, and Beth Woijtowych.

The work was financed by donations from The Ministery of the Environment, Oslo, The Natural Environment Research Council, Shell (UK) Ltd., The Wildfowl Trust, and World Wildlife Fund (Norway).

References

Blokpoel, H. 1974: Migration of Lesser Snow and Blue Geese in spring across southern Manitoba. Part I. Distribution, chronology, directions, numbers, heights and speeds. *Can. Wildl. Serv. Rep. Ser. No. 28,* 30pp.

Boyd, H. 1961: The number of Barnacle Geese in Europe in 1959–60. *Wildfowl Trust Ann. Rep. 12:* 116–124.

Butler, P.J. & Woakes, A.J. 1980: Heart rate, respiratory frequency and wing beat frequency of free flying Barnacle Geese *Branta leucopsis. J. Exp. Biol. 85:* 213–226.

Jackson, E.E., Ogilvie, M.A. & Owen, M. 1974: The Wildfowl Trust expedition to Spitsbergen 1973. *Wildfowl 25:* 102–116.

Løvenskiold, H.L. 1964: Avifauna Svalbardensis. *Norsk Polarinst. Skr. 129.*

Newton, I. 1977: Timing and success of breeding in tundra resting geese. Pp. 113–126 *in* Stonehouse, B. & Perrins, C.M. (eds.): *Evolutionary Ecology.* London, Macmillan.

Norderhaug, M. 1970: The present status of the Barnacle Goose *Branta leucopsis* in Svalbard. *Norsk Polarinst. Årbok 1968:* 24–35.

Owen, M. 1980: *Wild Geese of the World.* London, Batsford.

Owen, M. 1982: Population dynamics of Svalbard Barnacle Geese 1979–80. The rate, pattern and causes of mortality as determined by individual marking. *Aquila 89:* 229–247.

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard. Barnacle Goose *Branta leucopsis. Nor. Polarinst. Skr. 181* (this wolume).

Owen, M. & Norderhaug, M. 1977: Population dynamics of Barnacle Geese *Branta leucopsis* breeding in Svalbard, 1948–1976. *Ornis. Scand. 8:* 161–174.

Owen, M., Drent, R.H., Ogilvie, M.A. & Spanje, T.M. Van. 1978: Numbers, distribution and catching of Barnacle Geese *(Branta leucopsis)* on the Nordenskiöldkysten, Svalbard, in 1977. *Norsk Polarinst. Årbok 1977:* 247–258.

Prop, J., Eerden, M.R. van & Drent, R.H. 1984: Reproductive success of the Barnacle Goose *Branta leucopsis* in relation to food exploitation on the breeding grounds, western Spitsbergen. *Nor. Polarinst. Skr. 181* (this volume).

MYRFYN OWEN and NILS GULLESTAD:

Migration routes of Svalbard Barnacle Geese *Branta leucopsis* with a preliminary report on the importance of the Bjørnøya staging area

Owen, M. & Gullestad, N. 1984: Migration routes of Svalbard Barnacle Geese *Branta leucopsis* with a preliminary report on the importance of the Bjørnøya staging area. *Nor. Polarinst. Skr. 181:* 67–77.

The paper describes the migration routes of Barnacle Geese between their Svalbard breeding area and their wintering grounds on the Solway Firth in northern Britain, established from observations of migrating birds and from the sighting and recovery of ringed individuals. The geese keep to well defined routes which differ slightly in autumn and spring. Lateral drifting causes a scatter of observations in Britain in autumn, but most displaced birds eventually reach the wintering grounds. Movements occur over a very narrow time span, especially in spring. Mass movements both in autumn and spring are almost always on strong following winds and periods without such conditions can cause delays in migration. Preliminary observations from the newly-discovered autumn staging area Bjørnøya are presented. The geese travel non-stop from there, taking 36–48 hours for the journey. The area of suitable vegetation for geese is small but provides a vital extension to the pre-migratory fattening period, especially in years of early snowfall in the Spitsbergen breeding and staging areas.

Myrfyn Owen, Wildfowl Trust, Slimbridge, Gloucester GL2 7BT, United Kingdom; Nils Gullestad, Nordland Regional College, P.O. Box 309, 8001 Bodø, Norway.

Introduction

Following intensive ringing in the early 1960s it was discovered that the Svalbard stock of Barnacle Geese was a separate population, migrating across the Norwegian and North Sea to winter in the Solway Firth, in northern Britain (Boyd 1961). While recoveries from this early ringing indicated that some of the geese moved along the coast of Norway, both in autumn and spring, it was not until recently that the routes and timing of movements were known in any detail.

More intensive ringing in the 1970s meant that there was a better chance of recovering and resighting migrating birds. The discovery, in 1975, of the spring staging area in Helgeland and the regular studies in spring (Gullestad et al. 1984) coupled with intensive studies on Spitsbergen (Prop et al. 1984) meant that movements in spring became well known. In 1980 N.G. discovered an autumn staging area on Bjørnøya and in following years work was concentrated on obtaining information on autumn migration.

This paper describes the migration routes and the timing of migration in autumn and spring and presents a preliminary report on the Bjørnøya staging area following prolonged visits there in September 1982 and 1983.

Methods

Arrival and departure from the Solway are routinely monitored. Observations of migrating geese were obtained from observers in Britain and from reports of local bird clubs, including the annual Scottish Bird Report, covering the whole of Scotland. Norwegian observations were gathered from contacts along the coast and from regional faunistic reports published in *Vår Fuglefauna.*

Weather data were obtained from meteorological stations at Carlisle (Solway), Skålvær, Helgeland, and from Bjørnøya Radio.

Visits to Bjørnøya to conduct surveys of the area and to record numbers, distribution, and behaviour of the geese were made by N.G. in 1982 and by a four-man team in 1983 (Owen et al. 1983).

Results

Migration routes

There are regular records of migratory movements along the Norwegian coast in autumn, as shown in Fig. 1a, and the majority are on the extreme western part. Most commonly flocks are seen flying past the Helgeland islands used in

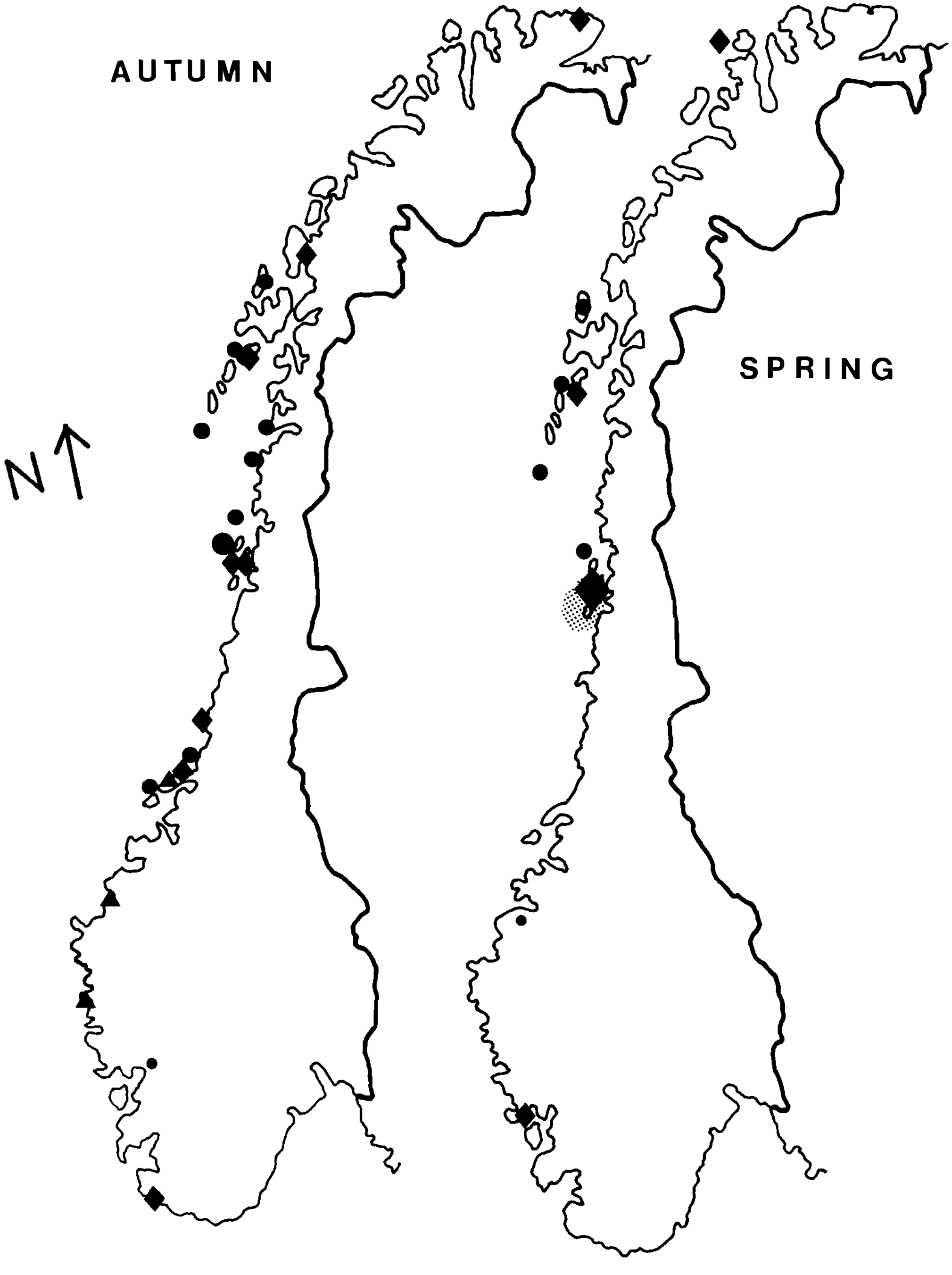


Fig. 1. Records of Barnacle Geese seen or recovered along the coast of Norway (a) in autumn and (b) in spring. Large dots indicate regular sightings of migrating flocks, smaller dots isolated records.
Squares represent places where ringed birds have been seen more than twice, triangles one or two ring sightings. Diamonds mark the recovery locations of dead birds.

Fig. 2 Records of Barnacle Geese in Britain during autumn migration – late September/October, from 1970–82. Symbols as in Fig. 1. Arrows indicate directions from which migrating geese are seen to arrive at Caerlaverock, on the Solway.

spring and just west of Ålesund (62° 30′N) in the south. Although the birds are occasionally seen to land on outlying islands they rarely stop for more than a few hours. Most of the recoveries refer to birds shot before the species was protected in Norway in 1961.

Observations of geese in Scotland during migration time (20 September – end October) come from a wide area (Fig. 2), and geese are seen to arrive at Caerlaverock on the Solway from the west and east as well as from the north. The pattern of observations indicate two regular routes, one almost directly north/south through Shetland, Orkney, and north-east Scotland, and the other from ENE, passing over northern England, with birds regularly seen on the ground on the coast east or north-east of the Solway.

Birds are frequently displaced to the south and west, particularly when the weather during migration is unfavourable, and most of those individually identified from their rings are later seen on the Solway. There have even been cases of geese joining flocks of Russian Barnacles in the Netherlands, and Greenland birds in west Scotland, which have eventually returned to the Solway flock, although there are a few birds which clearly remained with the other population.

It seems likely that there are two main migration routes in autumn, one from Spitsbergen or Bjørnøya to northern Norway and down the west coast, crossing the North Sea to Northumberland. The other probably involves a nonstop flight from the autumn staging area to the Northern Isles, with most birds flying direct to the Solway, while a few stop in north-east Scotland, sometimes for a few days.

In spring, there are very few observations in Britain (Fig. 3), indicating that the migration is along much narrower corridors and that there are no regular stopping places. The sparsity of spring observations in Norway (Fig. 1b) also suggests that the flight to the Helgeland islands is directly over northern Scotland in most cases. This is corroborated by the timing of spring departure and arrival in Norway, as well as observations of ringed birds (Gullestad et al. 1984).

The route from Helgeland is due north and a regular passage is seen at Røst, the southernmost island of the Lofoten group. From there the route passes over Bjørnøya, and Radio Station personnel there frequently observe geese passing over in the latter half of May. A visit by N.G in the spring of 1980 confirmed that the island is not a spring staging area. Even in that very early year the island was almost completely snow-covered in late May. Barnacle Geese were seen passing overhead but only a few stopped, and then only for a few hours.

Autumn and spring migration routes are summarised in Fig. 4.

The timing of movements

The first snow covers the breeding area sometime in September. This is usually accompanied by northerly winds and the geese move southwards. Nordenskiöldkysten in some years is devoid of geese by mid-September (J. Prop, pers. comm.). Whether there are stopping places in southern Spitsbergen is unknown, though it seems likely that some geese may stop at Sørkapp. Most probably they fly direct to Bjørnøya, where the first geese are present in August and large numbers arrive by mid-September (see below).

The earliest date when geese have arrived in the Solway is 22 September and the latest 1 October. In the 13 years since 1971 there has been a maximum of 30 days and a minimum of 17 days between the first and the last arrival. The migration was complete by 7 October in the earliest year and by the 20th in the latest.

To examine the effect of weather on Bjørnøya on the timing of movement, five wind and temperature variables at Bjørnøya were correlated with 13 different arrival measures (1st arrival, time from 1st to 50% arrival, mid-arrival, etc.). There were no consistent relationships between temperature variables and the timing of arrival, whereas negative relationships between the preponderance of southerly winds and positive ones with northerlies were found. Few of these were significant. Looking only at the timing of mass movements, however, the pattern is much clearer, as shown in Table 1. Most years had only one distinct mass movement, with numbers building up steadily thereafter, but in 1976 and 1978 two distinct influxes were noted.

Clearly most of the wind directions are northerly or easterly, especially 48 hours before mass arrival, when 10 out of 14 times the wind was

Fig. 3 Spring migration (late April/early May) records of Barnacle Geese in Britain. Conventions as Figs. 1 and 2.

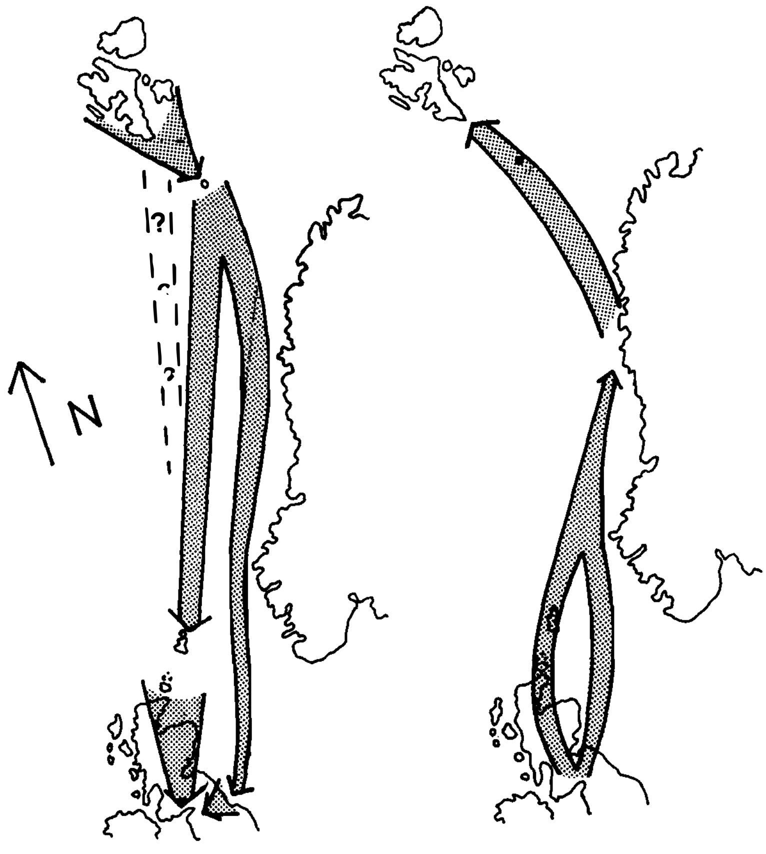


Fig. 4. Summary map of Svalbard Barnacle Goose migration routes (a) in autumn and (b) in spring.

from a northerly quarter, 3 from the east, and only one from the south and west together. Testing the frequency of northerly winds in this sample with that expected by chance (distribution of quarters in Table 1) gave the following results:

Hrs. before 0700 on arrival day	Chi-square	P
24	3.56	$0.05 < P < 0.10$
36	5.88	$0.01 < P < 0.02$
48	18.17	$P < 0.001$
60	5.88	$0.01 < P < 0.02$

The distance from Bjørnøya to the Solway in a straight line is about 2400 km, though via the Norwegian coast this could be as far as 2700 km. Geese flying at 60–70 km per hour without wind assistance would complete the journey in 36–40 hours. Tail winds such as those recorded on departure, up to 40 km per hour, would cut the travelling time to 24–30 hours. Although when the geese depart conditions may be favourable, there is no certainty that these will continue throughout the journey. Indeed mass arrivals have occurred during southerly gales on the Solway in recent years. It seems likely that the average journey lasts between 30 and 40 hours.

Geese arrive on the Solway by day but the majority of birds arrive overnight, which could be 10 hours before 0700 on the day they are first seen. It seems likely, therefore, that most geese depart from Bjørnøya in the morning when wind conditions are favourable, arriving on the Solway the following afternoon or evening. The pattern is consistent with the journey being non-stop for most of the birds.

In spring the first geese arrive in Helgeland between 13 and 25 April, but most do so in the last week of that month and in the first week of May. Only a few stragglers remain on the Solway after 10 May. The northward movement from there is very rapid, in all the years of observation mostly between 15 and 20 May (Gullestad et al. 1984). First arrivals on the Nordenskiöldkysten

Table 1. *Timing of mass arrivals of Barnacle Geese at the Solway in relation to winds at Bjørnøya 24, 36, 48 and 60 hours before 0700 on the day of arrival. In years with two periods of mass movement, both are given. Wind speed is in knots. The frequency distribution of times when the wind was from each of the four quarters during the 20-day migration period 20 September – 10 October is also given (2 wind values each day, 12 years 1971–1982 combined).*

		Wind speed and direction			
Year	*Date*	*24hrs before*	*36 hours*	*48 hours*	*60 hours*
1971	25.9	11 W	11 NW	10 NW	5 NW
1972	12.10	4 SE	5 E	14 N	18 NW
1973	9.10	28 N	19 N	20 N	26 NW
1974	4.10	6 S	8 SW	6 NE	14 NE
1975	8.10	14 NE	23 NE	23 NE	22 E
1976	26.9	29 N	19 SW	9 N	9 N
1976	29.9	8 SE	11 N	21 NE	27 NW
1977	28.9	12 E	12 SW	11 SW	12 SW
1978	30.9	16 N	19 NE	24 N	20 N
1978	7.10	21 E	13 NE	16 NE	19 NE
1979	3.10	15 S	9 S	12 N	13 W
1980	12.10	12 N	20 N	25 NE	15 NE
1981	4.10	8 W	27 N	25 E	6 E
1982	25.9	6 N	12 N	24 N	24 NW

Frequency distribution of wind direction

North (320°–40°)	East (50–130°)	South (140–220°)	West (230–310°)
107 (22.3%)	181 (37.7)	121 (25.2)	71 (14.8)

breeding islands are usually in the last days of May so the geese probably spend up to ten days in southern parts of Spitsbergen and on bird slopes (Prop et al. 1984) to recover from the migration and prepare for breeding.

The movements of the Svalbard geese throughout the year are summarised in Fig. 5. The only part of the migration pattern that remains obscure is the end of the breeding period, when some birds might move direct from Spitsbergen to Scotland without staging at Bjørnøya (see below).

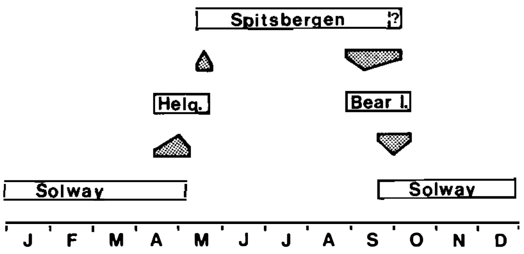


Fig. 5. The locations of geese at different times of year, and the timing and duration of migratory journeys. The blocks represent times when any geese are present; overlaps mean that some birds are at two or more locations.

The Bjørnøya staging area.

Surveys of the island were difficult in 1983 because of fog in that exceptionally mild year, but approximate totals for the island in September, together with the build-up on the Solway, are shown in Fig. 6. The pattern is quite different in the two years, with a preponderance of southerly winds holding back migrants from

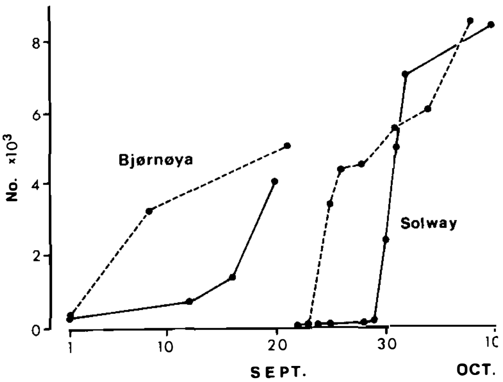


Fig. 6. Numbers of Barnacle Geese counted on Bjørnøya and on the Solway during the autumn migration period in 1982 (dashed line) and 1983 (solid line). Bjørnøya observations terminated when the observers left the island.

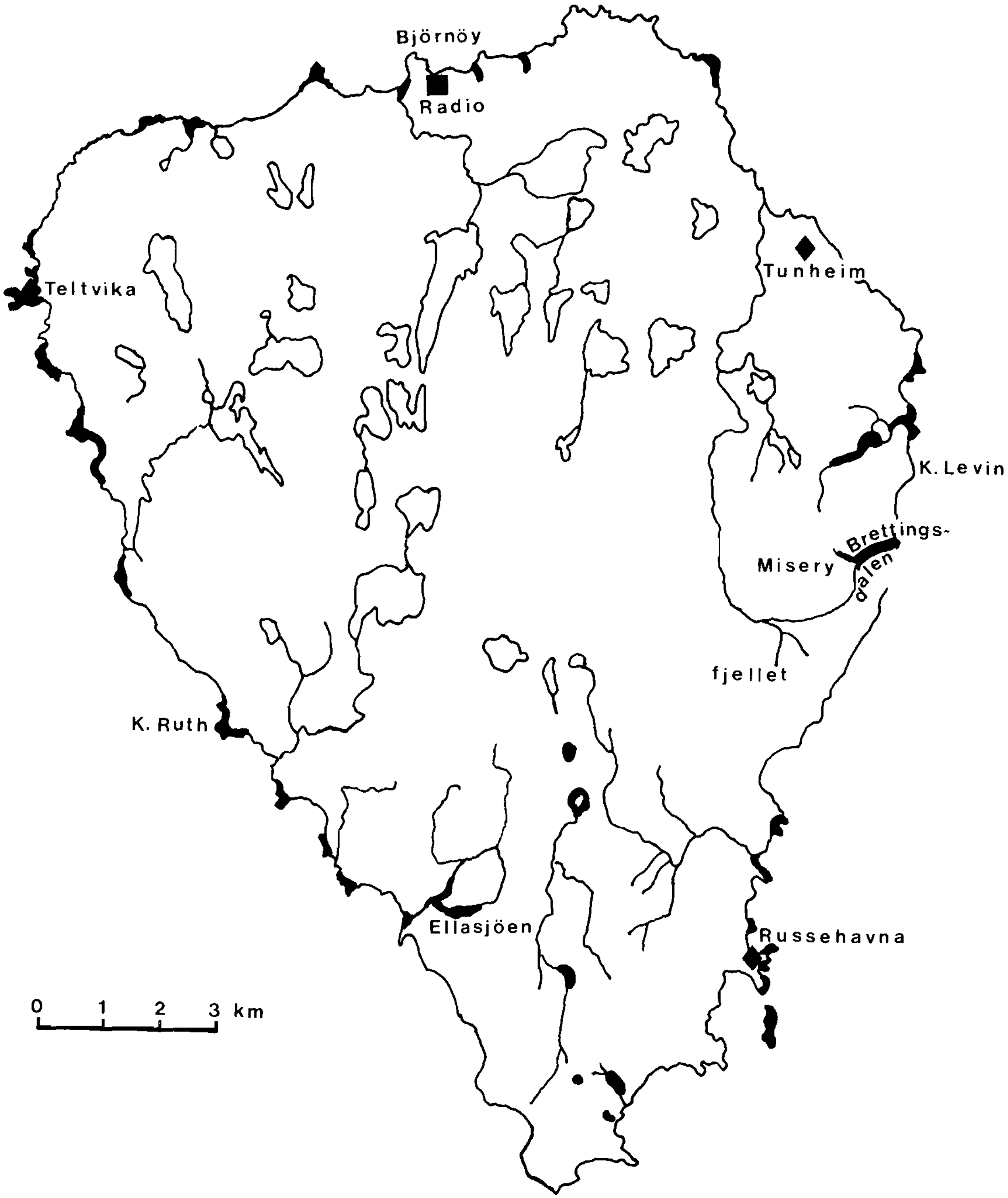


Fig. 7. A map of Bjørnøya showing the location of vegetated areas used by geese. Diamonds mark the positions of huts used as bases in 1982 and 1983.

Spitsbergen in 1983. Mass departure from Bjørnøya was precipitated by northerly storms and blizzards on 22–24 September 1982. Conditions were more normal in 1983 with most birds reaching the Solway during the first few days of October.

The peak number estimated to be on the island represented 59% and 48%, respectively, of the total population in 1982 and 1983. Whether the remainder of the birds arrived on Bjørnøya later or migrated direct to Scotland is unknown. If they visited the island at all, their staging period would be a maximum of about ten days in both years.

The southern part of the island is mountainous and the northern plateau consists largely of boulder fields and lakes of various sizes. Around some of these lakes are mossy bogs, and mossy areas are also found on the higher mountain plateaus. These are very little used by geese. The distribution of grassy vegetation is shown in Fig. 7 and corresponded very closely with the distribution of geese both in 1982 and 1983. Only small scattered flocks were found outside these areas, on the southern and western slopes of Miseryfjellet, and just inland of the north and north-western coasts.

Grassy vegetation is associated with moraines where Little Auks *Alle alle* breed, or with other seabird cliffs in inland valleys. On the coast, headlands and cliffside ponds are nesting or gathering places for Glaucous Gulls *Larus hyperboreus,* of which there are many thousands on the island. Early arriving geese were found on slope sites at Kapp Levin/Brettingsdalen and around Ellasjøen, which might indicate a preference for bird-cliffs over headlands. The vegetation at both sites consisted largely of *Festuca rubra,* with some of the coastal headlands having swards of *Phippsia algida* or *Cochlearia officinalis. Oxyria digyna* was abundant on slopes, and the geese were seen to graze this occasionally. Food selection and diet are being investigated.

The proportion of young birds in flocks at Bjørnøya and on the Solway in 1983 is shown in Fig. 8. No juveniles were seen on the staging area before 14 September and the average proportion in the third week was about 5%. A smaller proportion of families was in the early arriving flocks in Scotland, the proportion building up to the eventual population average of 8% young. Thus families stay later in Spitsbergen than do non-breeders, and either spend a late staging period on Bjørnøya or make the migration non-stop.

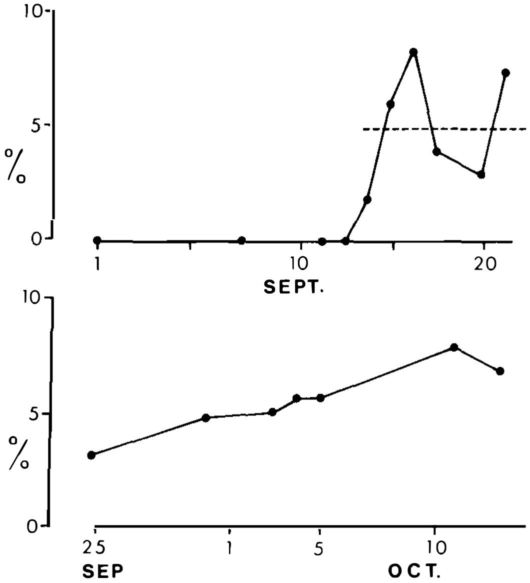


Fig. 8. The age ratio (% juveniles) of goose flocks seen on Bjørnøya and at Caerlaverock, on the Solway in 1983. Sample sizes 200–500 for each occasion at Bjørnøya, 500–2000 on the Solway.

Early arrivals clearly have the advantage of more adundant and probably better quality food than those arriving later, since there is no vegetation growth during the staging period. Non-breeders may migrate early because they fail to compete with families for feeding space on the bird slopes of Spitsbergen, which are probably much richer and more extensive than those on Bjørnøya.

Discussion

In a world where suitable wintering, staging, and breeding areas are few and far between, it is obviously advantageous for geese to maintain well defined and traditional migration routes. The Svalbard Barnacle Goose population has unusually circumscribed distribution and migratory habits. Its wintering and staging haunts cover very small areas, and highly traditional migratory journeys are essential to ensure they are reached in the minimum time. The very small number of records, despite the large ringing programme, of geese outside their normal range illustrates how tightly the geese keep to these traditional pathways.

The non-stop oversea migration of 2400 km or longer is one of the longest of all autumn migrations in geese, although the other Svalbard populations make almost as long journeys to Denmark. It is undertaken without the advantage of an extended staging period, as enjoyed by geese breeding in North America or mainland Eurasia. There are indications that a substantial proportion of the annual mortality is suffered during this autumn journey and that in some years the death rate of juveniles could be considerable (Owen 1982, 1984). Future work on Bjørnøya and in Scotland will aim at testing this hypothesis.

The movements of geese are timed to maximise feeding and breeding opportunities. On the Solway, spring growth of vegetation begins in March or early April and by the end of that month the quality and digestibility of the grass is declining. The movement to Norway is timed to coincide with the average start of the spring flush there. The movement to Spitsbergen allows some feeding there, on the fertile south-facing bird slopes, before the snow clears elsewhere to make nesting possible. These journeys are very precisely timed, within a period of a very few days, though unfavourable winds can cause brief delays.

In autumn, because of the necessity to build up body reserves for the long southward migration, the birds stay in the north for as long as the weather allows. At least in years when the winter comes early to Spitsbergen, the staging area on Bjørnøya is vitally important in extending the period when pre-migration reserves are built up. In milder autumns such as 1983, the staging area may be less important, but its full significance is yet to be understood. The autumn migration period extends for up to six weeks, and in the last week of September and the first two weeks of October there may be geese in the breeding, staging, and wintering areas (Fig. 5).

Weather, particularly wind direction and speed, plays a very important part in determining bird movements. Blokpoel & Gauthier (1975) showed that migrating Snow Geese *Anser caerulescens* showed a strong preference for following winds although late in the season flocks were flying against the wind, when their speed over the ground was lower. Evans (1979) showed a very strong relationship between the movements of Bewick's Swans *Cygnus columbianus bewickii* both in autumn and spring. Mass migrations of Barnacle Geese occur almost invariably on strong following winds (Table 1), but smaller movements take place under less favourable conditions. Choosing good conditions for flying is important in conserving energy – a 30–40 km p.h. following wind maintained over the whole journey could mean an energy saving of 50% and could be a matter of survival for some individuals. Choosing a following wind also ensures a more direct and easier journey, particularly avoiding excessive lateral drifting. In some years some drifting does occur, particularly on south-easterly winds in Scotland, as shown in Fig. 2. In spring there are few records outside the very narrow migration corridor (Fig. 1b). Maintenance of maximal body reserves for breeding could be crucial in spring and the choice of favourable migration conditions could be even more crucial then.

Staging areas are vital to migration geese; the maintenance of those in Helgeland and on Bjørnøya in an undisturbed state is clearly essential to the survival and breeding success of Svalbard Barnacle Geese.

Acknowledgements

We thank all those observers who monitored the movements of geese and sent in records of migrating birds, in particular C.R.G. Campell, A. Dekker, A.O. Folkestad, P.I. Johnsen, G. Nehls, M.J. Nugent, C. Prentice, P. Reynolds, B. Sears, R.L. Wells, and E. Woijtowych.

We are grateful to Kystvakten Norge who provided transport to Bjørnøya in 1983, and the staff of Bjørnøya Radio for practical help. J.M. Black and R. Goater of the Wildfowl Trust were the other two members of that expedition. The Royal Society and Norsk Polarinstitutt provided financial support for work on Bjørnøya.

References

Blokpoel, H. & Gauthier, M.C. 1975: Migration of Lesser Snow and Blue Geese. Part 2. *Can. Wildl. Serv. Rep. Ser. 32.*

Boyd, H. 1961: The number of Barnacle Geese in Europe in 1959–60. *Wildfowl Trust Ann. Rep. 12:* 116–124.

Evans, M.E. 1979: The effects of weather on the wintering of Bewick's Swans *Cygnus columbianus bewickii* at Slimbridge, England. *Ornis. Scand. 10:* 124-132.

Gullestad, N., Owen, M. & Nugent, M.J. 1984: Numbers and distribuion of Barnacle Geese *Branta leucopsis* on Norwegian staging islands and the importance of the staging area to the Svalbard population. *Nor. Polarinst. Skr. 181* (this volume).

Owen, M. 1982: Population dynamics of Svalbard Barnacle Geese 1970-1980. The rate, pattern and causes of mortality as determined by individual marking. *Aquila 89:* 229-247.

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose *Branta leucopsis. Nor. Polarinst. Skr. 181* (this volume).

Owen, M., Gullestad, N., Black, J.M. & Goater, R. 1983: *Bear Island Expedition 1983 – Report.* Unpubl. Rep., Wildfowl Trust.

Prop, J., Eerden, M.R. van & Drent, R.H. 1984: Reproductive success of the Barnacle Goose *Branta leucopsis* in relation to food exploitation on the breeding grounds, western Spitsbergen. *Nor. Polarinst. Skr. 181* (this volume).

JEFFREY M. BLACK and MYRFYN OWEN:

Importance of the family unit to Barnacle Goose *Branta leucopsis* offspring – a progress report

Black, J.M. & Owen, M. 1984: Importance of the family unit to Barnacle Goose *Branta leucopsis* offspring – a progress report. *Nor. Polarinst. Skr. 181:* 79–85.

The families of geese and swans are maintained throughout winter and it has long been supposed that being in a family confers advantages to the young. This study investigates those advantages and examines ways in which family membership might enhance juvenile survival. The performance in encounters and daily activities of juvenile Barnacle Geese within different sized families and of orphaned juveniles were recorded on the wintering grounds. Family juveniles were dominant over single goslings and fed and rested for longer uninterrupted periods while their vigilance burden and aggressive activities increased. Because of the dominance of large families within the flock, their goslings were probably offered better feeding conditions than other goslings. Orphaned young attempted to join large families but were repelled. The fact that parents did not increase their family size by adopting stray juveniles may mean that the optimum brood size as far as winter performance is concerned is not the largest.

Jeffrey M. Black and Myrfyn Owen, Wildfowl Trust, Slimbridge, Gloucester GL2 7BT, United Kingdom.

Indroduction

It is well known that geese and swans provide extended care for their offspring during at least the first year after hatching (Kear 1970). This period of close association has been studied by several workers. Boyd (1953) was among the first to document parental protection of juvenile geese from competition in grazing flocks. Raveling (1970) confirmed this by reporting that parents assisted their offspring in encounters against non-family birds and that family members within a flock are nearest neighbours. Scott (1980) demonstrated that juvenile swans benefit from decreased feeding interference, increased dominance, and increased time spent feeding when in close proximity to parents. Goslings also benefit from parental vigilance bouts which may function in searching for feeding site information, maintenance of family proximity (Madsen 1981), and predator detection (Lazarus & Inglis 1978). Owen (1972) suggested that a gosling's vigilance burden to detect predators is decreased when belonging to a family unit.

On the wintering grounds juvenile Barnacle Geese *Branta leucopsis* often become separated from parents causing them to struggle through the first winter deprived of the benefits described. When the number of young in the population is unusually high many juveniles can become separated accidentally on long migrations, especially in stormy weather, or in the early part of the winter. For example, in 1978 and 1980, when there were respectively 26% and 24% young in the population, as many as a respective 10% and 20% of the juveniles were estimated to be outside a family. There are no data for juvenile mortality in 1980 but in 1978 it was 17.6% for 148 ringed juveniles and 11.3% for 1140 adults. This difference was significant (Chi-square $P < 0.005$). In poor breeding years juvenile losses are similar to adult losses at about 10% (Owen 1982, 1984). This paper compares aspects such as frequency and duration of feeding, vigilance, resting, and aggressive interactions in family and non-family juveniles, thus establishing the significance of the family bond. Suggestions are made concerning the optimum brood size for juvenile survival.

Methods

This study was carried out at the Wildfowl Trust's Caerlaverock Refuge on the Solway Firth, Scotland, between October 1982 and May 1983. Observations were made through a telescope on families of which at least one member had a coded (Darvic plastic) ring which was readable up to 250 metres. Since 1973 over 3000 geese have been caught, ringed, sexed, and measured (see Owen 1982, 1984). Juveniles, which were identified by plumage differences (Owen 1980),

Table 1. *Activity budgets for juveniles in different classes.*

Activities:	*Number of obs. (Min)*	*Feeding*	*Vigilance*[1]	*Aggression*	*Submission*	*Resting*	*Other*[2]
Single	13 (1106)						
% Activity		89.0	4.9	0.2	0.7	0.2	5.1
Number of bouts		230	182	7	26	1	
Mean bout length		47.0	1.8	0.5	0.8	1.2	
Standard deviation		41.8	1.1	1.1	1.0	–	
Brood of one	34 (3609)						
% Activity		82.7	6.3	0.4	0.2	1.3	7.6
Number of bouts		419	313	27	11	9	
Mean bout length		88.5	5.2	1.1	0.7	3.4	
Standard deviation		107.3	9.7	1.7	1.5	11.0	
Brood of two	27 (3308)						
% Activity		82.2	7.2	0.4	0.1	5.9	4.1
Number of bouts		319	262	36	10	8	
Mean bout length		112.8	5.2	1.0	0.8	11.0	
Standard deviation		168.5	4.8	1.4	1.7	38.2	
Brood of three	15 (1785)						
% Activity		84.3	3.8	1.5	0.3	5.4	4.8
Number of bouts		152	89	36	9	9	
Mean bout length		95.3	3.2	3.2	1.2	18.9	
Standard deviation		74.3	3.7	7.0	1.5	48.5	
Brood of four	10 (1377)						
% Activity		83.3	2.6	4.3	0.2	2.6	7.0
Number of bouts		125	81	42	3	1	
Mean bout length		62.2	2.5	4.7	2.3	39.8	
Standard deviation		35.1	1.9	9.0	4.2	–	
One parent	3 (34)						
% Activity		80.8	8.5	0.7	0	0	0.8
Number of bouts		57	38	5	0	0	
Mean bout length		124.7	3.7	2.5	0	0	
Standard deviation		190.9	3.3	1.5	0	0	

[1] Vigilance was recorded when the bird had its head up while standing.

[2] «Other» includes walking, preening, and other comfort movements.
These were excluded because there was no difference between groups.

were classified according to their associates. The categories were: single or non-family juvenile, juvenile belonging to a family unit (broods from one to four), and juvenile associated with only one parent. When observations included unringed individuals, sex, age, and paired status were ascertained. Similar observations which were made on ringed birds proved to be 94% accurate. The sex of unringed juveniles could not be determined. Continuous watches, usually lasting more than ten minutes, were recorded on cassette tapes. These commentaries were later coded through an event recorder onto magnetic tape allowing direct computer input. Computer analyses were performed on frequency and duration of activities. Encounters involving different classes of birds were recorded opportunistically throughout the season. Aggressive interactions were classified, according to their intensity, into four types. A low threat consisted of various head and neck postures (see Radesater 1974). A mid-threat or medium threat included the same postures plus a slight advancement of one or two steps toward the opponent. A contact was recorded when the aggressor bit or forcibly bumped the enemy. Chasing occurred when the aggressor ran after a fleeing subordinant. Threats which did not elicit some degree of submission by the opposition were not used in the analysis. We assume that the energy demand to execute these threats increases from low-threat to chasing. The Chi-square and Kruskal-Wallis statistics are used.

Results

Family and non-family juveniles: a comparison

Table 1 shows that family juveniles feeding bouts were longer than non-family juveniles' (Kruskal-Wallis Chi-square, $P < 0.025$, Fig. 1). Family juveniles spent more time in encounters (Fig. 2) and resting, but slightly less time grazing and avoiding other birds. Vigilance bout length was longer for family juveniles (K-W.Chi-square, $P < 0.05$). Juveniles from any sized brood were more successful in aggressive interactions than were single juveniles (eg.: brood of one vs singles: Chi-square, $P < 0.001$).

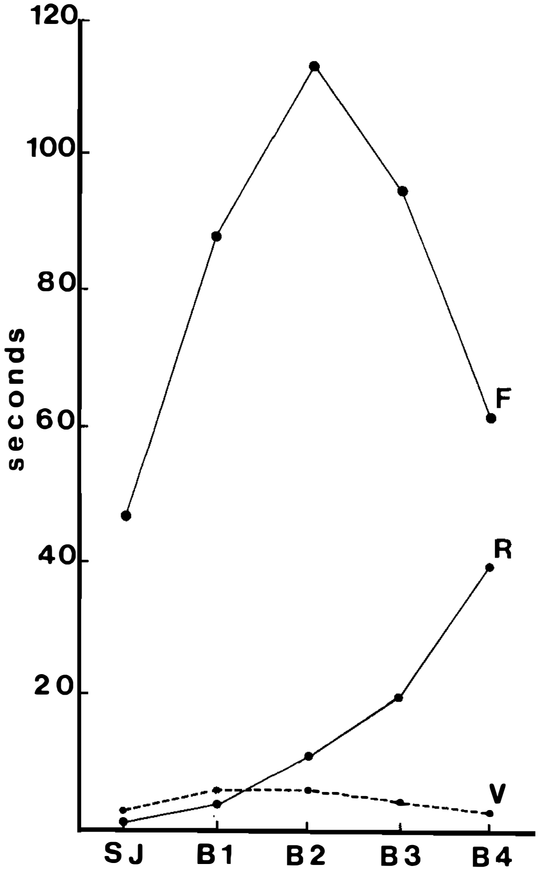


Fig. 1. Activity bout lengths (in seconds) for juveniles of different classes including: F – Feeding, R – Resting, V – Vigilant, SJ –Single Juvenile, B1 – Juvenile from a Brood of 1, etc.

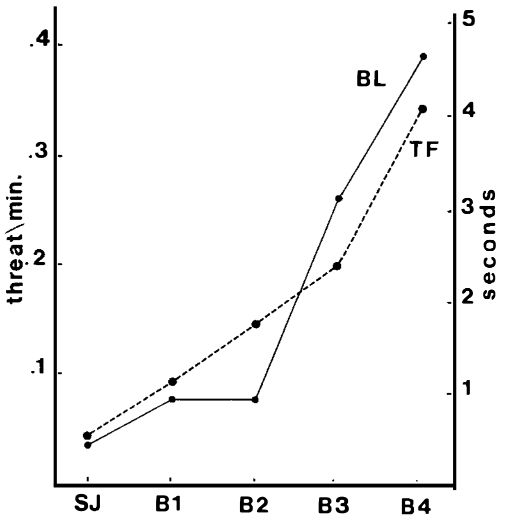


Fig. 2. Agonistic activities for different classes of juveniles. BL – Bout Length of conflict situations in seconds. TF – Threat Frequency per minute. Other conventions as Fig. 1.

Juveniles separated from family groups submitted to their aggressors 85% of the time. They encountered males more frequently than females and other juveniles (Chi-square, $P < 0.001$) (Table 2). The few times single juveniles did dominate they won more conflicts against non-family birds than against individuals from a family (Chi-square, $P < 0.01$), but their performance was not as good at that of family juveniles in this category (Chi-square, $P < 0.001$).

Type of threats used in conflict situations

Juveniles of all classes utilized the low-threat more than other types. They also submitted to this type of threat more than to other types (Table 3). The few times single juveniles were successful in displacing their opponents, they spent more energy by using higher intensity threats to acquire the win than was required for family juveniles to do so. In other words, family juveniles were more successful at winning encounters with low threats than were singles (Chi-square, $P < 0.05$). The low-threat was used more frequently as brood size increased (K-W Chi-square, $P < 0.05$). Thus, juveniles in large broods exerted less effort to acquire wins (Table

Table 2. *Percentage of successful encounters by single juveniles and family juveniles during encounters with geese of different status.*

Status encountered:	*Single Juvenile*	*Single Adult*	*Paired* *Male*	*Paired* *Female*	*Family* *Juvenile*	*Family* *Male*	*Family* *Female*	*Total class encounters*[1]
Single juveniles: % Success	50.0[2] (2)[3]	100.0 (3)	18.2 (11)	25.0 (12)	13.6 (22)	5.0 (40)	23.5 (17)	14.7 (116)
Family juveniles: % Success	86.4 (22)	95.0 (20)	75.0 (8)	100.0 (5)	52.6 (19)	0.0 (12)	38.5 (13)	68.1 (144)

[1] Includes status and class encounters making a grand total.
[2] Percent of encounters which were won per sample.
[3] Sample size.

Table 3. *Intensity of threats displayed when single and family juveniles were dominant, and intensity of threats submitted to when single and family juveniles were subordinate during all encounters. Expressed as percentages of four threat types; no. of observations in parentheses.*

	Low-threat	*Mid-threat*	*Contact*	*Chase*
Single juveniles:				
Displayed	35.3 (6)	23.5 (4)	23.5 (4)	17.6 (3)
Submitted to	60.3 (41)	13.2 (9)	17.6 (12)	8.8 (6)
Brood of one juvenile:				
Displayed	66.7 (20)	10.0 (3)	10.0 (3)	13.3 (4)
Submitted to	100.0 (11)	0 0	0 0	0 0
Brood of two juveniles:				
Displayed	55.0 (22)	22.5 (9)	5.0 (2)	17.5 (7)
Submitted to	80.0 (8)	20.0 (2)	0 0	0 0
Brood of three juveniles:				
Displayed	52.9 (36)	30.9 (21)	2.9 (2)	13.2 (9)
Submitted to	60.0 (9)	13.3 (2)	6.7 (1)	20.0 (3)
Brood of four juveniles:				
Displayed	73.5 (36)	14.3 (7)	8.2 (4)	4.1 (2)
Submitted to	66.7 (2)	0 0	33.3 (1)	0 0

3). Samples were too small when the sex of juvenile was known to test if one sex was more dominant than the other. However, captive studies have shown that male juveniles are more dominant than females (Wurdinger 1975; own unpubl. data).

Brood size comparisons in performance

In this study juveniles' dominance was not significantly related to brood size. Boyd (1953), however, found that success did increase progressively with brood size in White-fronted Geese *Anser albifrons*. His data showed that there was a significant difference between small, medium, and large broods, which indicates that dominance increases with brood size. In this study juveniles from broods of three and four spent a greater proportion of time being aggressive but only half the time being vigilant than did juveniles in smaller broods (Table 1.). There was a slight increase in aggressive bout length (K-W Chi-square, $P < 0.01$) as brood size increased. Resting bout length progressively increased with brood size (Fig. 1), but was not significant because of a small sample for juveniles in broods of four. The mean feeding bout length for broods of four juveniles was at least 25% shorter than juveniles from smaller broods, although this is not statistically significant.

Little relationship could be found between brood size and the number of encounters in which each was involved, except that offspring from broods of three encountered single juveniles more often than expected (Chi-square, $P < 0.01$). When family juveniles avoided others (in 31% of all conflicts) they submitted most to other family males (Table 2). Juveniles and parents sometimes assisted each other in aggressive encounters, but no significant difference in success was found between combined efforts and those where family juveniles were themselves involved.

Juveniles observed with only one parent showed a marked increase in vigilance behaviour, less time feeding, and no time resting (Table 1). If we ranked these juveniles according to performance in these activities and in the dominance rank order, they would be placed below small-brood juveniles and above single juveniles. Further comparisons are not possible in this group because of the small sample size.

Discussion

Assuming that a bird benefits most from uninterrupted feeding periods, little time avoiding dominant neighbours and sufficient resting periods, our findings support the assumption that family units are important for gosling survival. The feeding bouts of single juveniles were frequently interrupted because they suffered more attacks than other geese. As a result they tended to be among the lowest ranking birds in the population, which may partly explain an increase in juvenile mortality as in 1978. However, lower ranking juveniles did win some encounters when confronting higher ranked birds especially against family juveniles and females (Table 2). There is some evidence that these anomalies occurred when family members were some distance apart (own unpubl. data). In the Bewick's Swan *Cygnus columbianus bewickii* there is a definite decrease in cygnet dominance when they are further than four swan lengths from their parents (Scott 1980). Besides a decrease in dominance and feeding performance orphaned juveniles are more vulnerable to shooting (Prevett & MacInnes 1980).

The fact that single juveniles confronted families, with a brood size of three, more than was expected may be explained by the observation of single juveniles who congregated on the perimeter of large families. Lone juveniles may cue onto large families and obtain some benefits. A single juvenile would not need to be as vigilant for predators or potential aggressors when in close proximity to large families which geese of all other classes tended to avoid. They therefore would have fewer interruptions and more feeding space near a family than among lesser ranked birds. Only when these single juveniles got too close, too numerous, or had spent too much time near a large family did they get attacked. As a result of this lone juvenile parasitism the male and juveniles of families were found to be more active in displacing the single juveniles than other geese. No cases were observed where single juveniles were adopted into families as this seems only to occur with young goslings (Glasgow 1977; J. Prop, pers. comm.).

Since single juveniles' vigilance requirement (percent time and bout length) is actually less than that of family juveniles the suggestion of a decreased vigilance burden within a family unit is refuted.

In spite of the increased burdens of being single, non-family juveniles have shown here that they do have the potential for survival, at least on the wintering grounds. It seems that single juveniles spend a longer percentage of the day feeding than other juveniles either because they need to make up for lost energy when frequently chased by dominant neighbours, or they may feed more to make up for the probability that their diet is less nutritious. Single juveniles are able to feed for a greater proportion of the day by altering their behaviour and activities in certain ways. By assuming a dove-like strategy and submitting to most aggressors less time or energy is lost in encounters. A decrease in time spent in activities such as vigilance and resting allows more time for feeding. By maintaining a moderately close proximity to large families they can gain some family benefits.

Since single juveniles are low in the dominance rank order they avoid low-threats more readily than other birds in order to conserve energy; in conflicts they would usually lose anyway. Juveniles also displayed low-threats more than other types for the same reason. When inquiring of an opponent's dominance rank a low-threat requires the least amount of effort and does not commit a bird to full scale battle. Indeed all aggressive threats function as signals which enable geese to maintain dominance rank without actually fighting (Raveling 1970; Scott 1978). The significant finding that the low-threat is used more frequently and is more effective when utilized by family juveniles as opposed to orphaned juveniles and within families as brood size increases indicates another benefit from belonging to a family and especially one with many members.

We suggest that there are two behavioural strategies at work in small and large families. All family juveniles spend the same percentage of time feeding, but juveniles from small broods spend more time vigilant and fleeing from higher ranked birds. It seems that the small brood juveniles spend more of their vigilance time in order to "look out" for potential aggressors in the flock, while large brood juveniles are not required to do so. As a result juveniles from small broods spend less time resting. Conversely, large brood juveniles are able to go anywhere in the flock by just chasing other birds out of their way. Therefore, large brood juveniles and their parents should be able to utilize the best feeding areas, when the food source is in patches, while smaller families are reduced to only second rate foods. They should also be able to feed from these areas more efficiently after longer resting periods, shorter vigilant bouts, and less time spent on energy-draining encounters which are lost.

By catching and weighing juveniles from different brood sizes we expected to find large brood juveniles to weigh more than smaller brood juveniles. But a significant difference was not found in a sample of 81 juveniles whose parents and brood sizes were known. However, juveniles from families with just one offspring were found, although not significantly, to be in a worse condition than other juveniles from larger broods. We are presently monitoring the feeding performances of juveniles in different sized broods when they feed on different food densities. Since large brood juveniles should dominate the best feeding areas their pecking rate and step rate while grazing should be slower than that of small brood juveniles and singles while the intake rate of food should increase (see Owen 1972).

What is the optimum brood size for juveniles to have the best performance and therefore the best chances of survival? The fact that juveniles from large broods were involved in more aggressive encounters per minute may explain why their feeding bout length may be shorter than that of other family juveniles (Figs. 1 and 2). Broods of four juveniles do, however, benefit from longer resting periods which may be essential for young birds. Broods of two, on the other hand, feed for the longest uninterrupted periods, but spend more time being vigilant for dominant geese.

If the advantages to goslings simply increase with size, one would expect families to 'adopt' stray goslings in order to increase their own status. This does not, however, occur. Although orphan goslings make strenuous efforts to link up with large families, they are always repelled. Prevett & MacInnes (1980) suggested that family size is limited in northern geese by the need for frequent brooding, and that large families would be more likely to separate, exposing the individual members to increased risks. It may be, therefore, that optimum brood size is smaller than the maximum.

Investigations, presently underway, into the behaviour of family groups include to what extent offspring aid their parents in acquiring appropriate feeding space and fulfilling the different vigilance requirements, eg. predator watch, maintenance of family proximity, or monitoring neighbours' feeding performance and flock movement. Pairbond age, strength, and past breeding performance are being correlated with winter behavioural performances, such as synchrony and assistance in vigilance and aggressive activities, to establish specific factors that can be attributed to successful pairs.

Acknowledgements

We are grateful to the following people: S. Berrow, M. Nugent, K. Parry-Jones, and P. Webb for reading rings, and to R. Cowie and staff members of the Wildfowl Trust for practical help, encouragement, and advice. This study was partially funded by an Overseas Research Studies award.

References

Boyd, H. 1953: On encounters between wild White-fronted Geese in winter flocks. *Behaviour 5:* 85–129.

Glasgow, W.M. 1977: *Brood mixing behavior and population dynamics of Canada Geese at Dowling Lake, Alberta.* M.Sc. Thesis, University of Alberta, Edmonton.

Kear, J. 1970: The adaptation radiation of parental care in waterfowl. Pp. 357–392 *in* Crook, J.H. (ed.): *Social behaviour in birds and mammals.* London Academic Press.

Lazarus, J. & Inglis, I.R. 1978: The breeding behaviour of the Pink-footed Goose: Parental care and vigilant behaviour during the fledging period. *Behaviour 65:* 62–88.

Madsen, J. 1981: Post-hatching behaviour of families and non-breeding Greenland White-fronted Geese. Pp. 116–122 *in* Fox, A.D. & Stroud, D.A. (eds): *Report of the 1979 Greenland White-fronted Goose study expedition to Edalungmiut Nunat; West Greenland.* Aberystwyth.

Owen, M. 1972: Some factors affecting food intake and selection in White-Fronted Geese. *J. Anim. Ecol. 41:* 79–92.

Owen, M. 1980: *Wild geese of the world.* Batsford, London.

Owen, M. 1982: Population dynamics of Svalbard Barnacle Geese 1979-1980. *Aquila 89:* 229–247.

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose *Branta leucopsis. Nor. Polarinst. Skr. 181* (this volume).

Prevett, J.P. & MacInnes, C.D. 1980: Family and other social groups in Snow Geese. *Wildlife Monographs 71:* 1–46.

Radesater, T. 1974: Form and sequential associations between the triumph ceremony and other behaviour patterns in the Canada Goose *Branta canadensis* L. *Ornis Scand. 5:* 87–101.

Raveling, D.G. 1970: Dominance relationships and agonistic behavior of Canada Geese in winter. *Behaviour 37:* 291–319.

Scott, D.K. 1978: *Social behaviour of wintering Bewick's Swans.* Ph. D. Thesis. University of Cambridge.

Scott, D.K. 1980: Functional aspects of prolonged parental care in Bewick's Swans. *Anim. Behav. 28:* 938-952.

Wurdinger, I. 1975: Vergleichend morphologische Untersuchungen zur Jungendentwick lung von Anser und Branta Arten. *J. Orn. 116:* 65–86.

J. PROP, M.R. van EERDEN and R. H. DRENT:

Reproductive success of the Barnacle Goose *Branta leucopsis* in relation to food exploitation on the breeding grounds, western Spitsbergen

Prop, J., Eerden, M.R. van & Drent, R.H. 1984: Reproductive success of the Barnacle Goose *Branta leucopsis* in relation to food exploitation on the breeding grounds, western Spitsbergen. *Nor. Polarinst. Skr. 181:* 87–117.

Reproductive success was determined for a colony of the Barnacle Goose *Branta leucopsis* on the west coast of Spitsbergen during four consecutive years (1978–81), following upon an expedition (1977) when the majority of the local population were caught and provided with leg rings with individual code inscriptions. Telescope observation revealed 120 pairs (where one or both of the parents were recognizable from afar) associated with the colony, and these pairs were followed through until arrival at the wintering grounds in Scotland. Nest-site selection was found to influence success, both the substrate (food around the nest minimizes absence of the gander) and location (potential information interchange regarding feeding opportunities on the tundra) being implicated. Nesting birds travelled up to 4 km from the colony to feed on the adjacent tundra, but most visits were restricted to within 1 km where mosses and monocots (50% of the diet as revealed by droppings analysis) as well as herbs and horsetails were gathered. On a 4-ha intensive study plot on the foraging grounds a 25 × 25 m grid was staked out and individual search paths mapped in relation to the snow cover (the birds tending to follow the retreating snow carpet). Utilization of plants was quantified by sampling subplots and taking photographic close-ups of the vegetation before and after goose visitation. Depending on site and plant species, 40–90% of food items were cropped, and even a single visit exerted a measurable impact on the food supply. *Salix* buds formed the main food source on the plot, and a plateau of exploitation for the season was already reached after 10–20 seconds of feeding time per m^2 had accumulated, a combined effect of depletion by removal and by plant phenology (opening of the buds after which they are no longer taken). Individuals differed in the intake rates achieved, and birds falling below the median for that date invariably failed to complete incubation. Time-budget studies from a tower overlooking the colony showed that individual females with extended foraging bouts were most liable to fail, and it is argued that these birds were attempting to cope with a lowered state of body reserves, a low intake rate, or a combination of both. Birds from the colony moult on adjoining tundra lake systems, where a mossy vegetation (the protruding *Dupontia* and *Carex* being important foods) reaches capacity at about 100 geese/10 ha. Individual families differ in foraging opportunities at this stage, and the rate of recruitment of goslings to the winter flock in Scotland can be related to feeding condition experienced during the moult. Overall, date of snowmelt is a reliable predictor of gosling production. Late years are characterized by a higher level of non-breeding (one quarter of the parents failing to lay, as opposed to only ten percent in early years) and by a high failure rate during incubation (80% versus 30% in early seasons.). Immediate posthatch losses on the island (due to gull predation) are heavy in late seasons, but no effects of season on gosling survival during the tundra stage could be detected. About half of the goslings hatched reached the winter quarters.

J. Prop and R.H. Drent, Zoological Laboratory, University of Groningen, Haren (Gr.), Netherlands; M.R. van Eerden, Rijksdienst voor de IJsselmeerpolders, Smedinghuis, 8200 AP Lelystad, Netherlands.

Introduction

Reproduction imposes heavy demands (energy, nutrients) on parent birds, particularly on the female. Successful reproduction depends on supplementing current food intake from the environment by drawing on body reserves laid down at some earlier period. In arctic-nesting geese the penalty of laying late is particularly severe (Barry 1962) and this implies that there will be strong selection for early laying, at a time when the environment cannot yet provide sufficient food. The state of the body reserves is hence of paramount importance (Newton 1977) and without this supplement from the spring staging grounds reproduction in the far north would be impossible. The magnitude of this energy subsidy has been quantified by collecting birds at the various stages of breeding, and performing carcass analysis to reveal the annual cycle of body composition. For two species a nearly complete picture has emerged *(Branta canadensis:* Raveling 1979; *Anser caerulescens:* review by Thomas 1983) following the lead of Hanson (1962) who pioneered this approach. Current work is designed to relate the dynamics of the build-up of body condition in spring to diet selection (McLandress & Raveling 1981) and increasing emphasis is being laid on employing external techniques of estimating the state of body reserves (Gauthier & Bédard, in press).

Individual geese differ in the degree of body condition attained before departure for the breeding grounds, and these differences can be related to reproductive outcome. Thus in the Barnacle Goose *Branta leucopsis,* Owen (1980a, 1980b) was able to show that individual females with a more rounded abdominal profile (and hence higher fat content) in the spring were more likely to return with young in the fall, and Ebbinge et al. (1982) were able to demonstrate a similar relation in the Brent Goose *Branta bernicla,* where individual females achieving a high total body weight in spring were more likely to succeed (again ascertained by observing which birds returned with young in the fall). It has been our objective here to extend this individual approach to the nesting grounds, and we ask the question to what extent successful reproduction depends on the use individuals make of the local food supplies. Environmental limitation can be expected both during the egg stage, when the geese face the problem of obtaining food at a relatively early stage of plant phenology when they are restricted to the immediate environs of the colony, and during the subsequent moult as well, when the geese are concentrated along the margins of tundra lakes. Specifically, we ask if local food stocks might already exert density effects on reproductive success. A special problem is posed by the vicissitudes of the weather, and the phenology of snowmelt has unmistakable repercussions on reproduction in the Arctic. We will explore why breeding success of the Barnacle Goose is poor in seasons of late snowmelt (as documented by Owen & Norderhaug 1977) in terms compatible with the individual story.

Crucial to our approach is the ability to monitor reproductive outcome in the individual pair. The Spitsbergen population of the Barnacle Goose has the advantage of relatively small size, and as all winter at the same locality on the west coast of Scotland it is feasible to trace individual birds. This report is part of a larger study undertaken in cooperation with the Wildfowl Trust (see Owen 1984) and relates what can be learned when birds can be kept under surveillance by telescope through much of the year.

Study area and general description of breeding biology

To study the Barnacle Goose *Branta leucopsis* in its summer range, data were collected in 1977–1981 on Nordenskiöldkysten, a coastal plain rich in many shallow ponds and lakes on western Spitsbergen. Along this stretch of coast several colonies of Barnacle Geese, all less than 200 pairs, are located on small islets (cf. Fig. 1). The geese arrive from the end of May onwards, and as is usual in arctic nesting species (Inglis 1977; Raveling 1978) most have settled within three days. Nests are located on three main substrates: barren rocky areas with scarcely any growing plants, mossy areas, where local pockets of grasses and sedges provide food, and finally gravel bordering the moss, where scattered herbs *(Saxifraga* spp., *Cochlearia officinalis)* occur. Eggs are laid within 5–6 days of settling at the colony, and incubation lasts 25 days. Females tend to feed around the nest before clutch completion, but if no food is available they may feed on the mainland tundra. Usually the male stays behind at the nest-site during these tundra excursions. During incubation females visit the tundra regularly to feed, though in late spring nearly complete snow cover may severely restrict foraging for several weeks.

Two vegetation zones on the mainland are of particular importance at this time: the wet moss zone, a carpet of *Calliergon* spp. or *Drepanocladus uncinatus* with grasses (especially *Dupontia fisheri)* and sedges *(Carex subspathacea)* protruding, and the fjellmark, the dry stony areas where a variety of herbs *(Salix polaris, Saxifraga oppositifolia, S. caespitosa, Cerastium arcticum, Draba alpina)* are most abundant, and horsetails *Equisetum* spp. occur in a complex mozaic.

If for some reason both male and female are absent from the nest-site simultaneously, the eggs

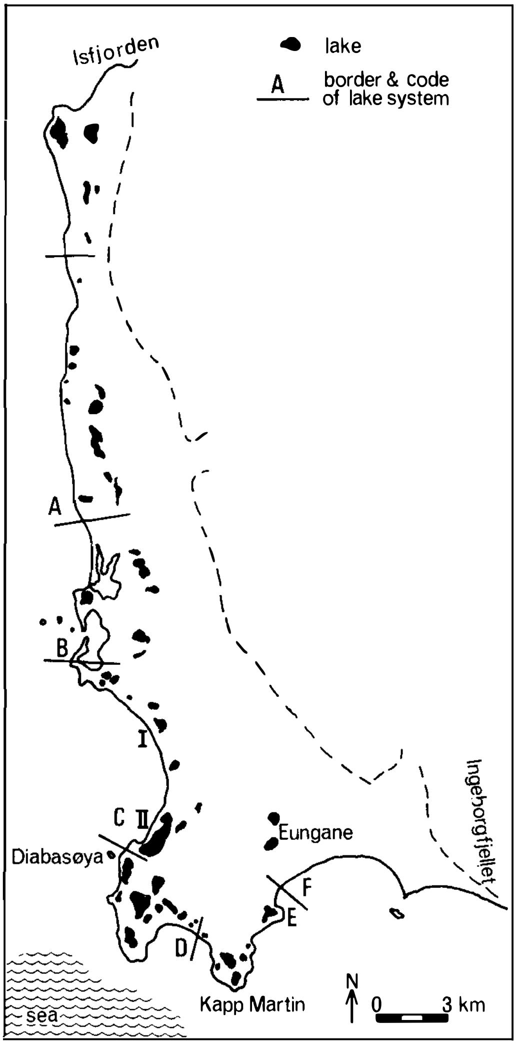


Fig. 1. Map of the study area, Nordenskiöldkysten, Spitsbergen, delineated in the west by the ocean and in the east by steep mountains. Note the dispersed ponds on this coastal plain.

are rapidly taken by Glaucous Gulls *Larus hyperboreus* nesting on the same islets and continually patrolling the colony. The eggs hatch from the end of June to mid-July, and the families leave the colony within two days, weather permitting, for the mainland tundra lakes. Here moulting groups form, although the families are generally separated from non- and failed breeders. At this time the moss belts around the lake margins, where grasses *(Dupontia fisheri, Arctophila fulva)* and sedges *(Carex subspathacea)* occur, are the major feeding areas for the geese, although later in the season they may also exploit the adjoining fjellmark. All through the moulting period when the geese are flightless, the Arctic fox *Alopex lagopus* is a constant threat, and the birds stay close to the lakes where they take refuge when the fox approaches.

After regaining flight the geese disperse over the tundra, as the juveniles are also on the wing by this time. Exploited at this time are the wet and muddy, polygon-studded plains with a varied but sparse growth of grasses, sedges, herbs and horsetails, and the vast ancient raised beaches covered with the lichen *Cetraria,* where horsetails *Equisetum variegatum* form the main food. Finally visits are paid to the slopes beneath the sea-bird cliffs, where a lush growth of grass occurs *(Alopecurus* as well as *Dupontia).* The geese depart from the coast on their autumn migration about mid-September, at a time when the light is rapidly failing and snow becomes frequent.

Phenology of snow-melt

The rate of disappearance of snow in spring is a good measure of phenology in the Arctic, which has profound repercussions on the timing of annual productivity. In the Barnacle Goos a negative relation between date of snow clearance and annual production (as measured by the percentage juveniles counted in the winter flocks in Scotland) was reported by Owen & Norderhaug (1977), and it will be one of the tasks of this paper to discover how this relation comes about. By relying on a standard transect we measured the rate of snow-melt on the tundra adjoining the study colony each year (Fig. 2). The variation is considerable, snow-melt being two weeks behind in the late seasons 1979 and 1981 compared to the early seasons of 1978 and 1980.

Methods and general approach

Focal observation points were the breeding colony Diabasøya with adjacent tundra (hereafter referred as Diabas), where we arrived with the first geese in most seasons, and later on the tundra lakes at Kapp Martin, especially important in the flightless period of the moult (Fig. 1).

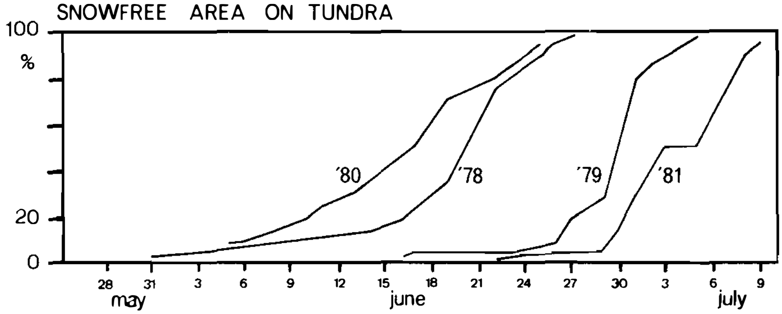


Fig. 2. Progression of snow clearance of the tundra in 4 years, as derived from standard transects.

Hides and a hut for living made it possible to observe the geese without disturbing them, and in many cases observation stints of days on end were undertaken. The colony islet was not visited in the breeding period to avoid disturbance, but a close watch of the colony was kept from a 6 m high tower on the opposite mainland (distance 200-300 m).

In the moult the entire coastal plain was covered by observers to census the goose population, and when the geese were again on the wing it was possible to overlook the southern part of the study area from a system of high ridges. The slopes below Ingeborgfjellet, one of the main feeding areas in September, were visited in some years where detailed observations could be carried out from the permanent hut there.

About 60% of the local population of the Barnacle Goose were provided with individually coded leg rings, most of which were applied in 1977 (for details of the ringing programme, see Owen et al. 1978, Owen & Ogilvie 1979, Owen 1982). Depending on atmospheric conditions and wind the rings could be read by telescope (30x to 80x) up to 500 metres away, although the usual working distance was under 300 m. The rings made it possible to follow individuals throughout the breeding period and on to Scotland in the autumn, and goslings could be identified in relation to their (marked) parents.

By scanning the colony by telescope activities on and around the nest were recorded throughout the egg stage for about 40 pairs each season. Observation bouts ranged from 12 h up to several days, usually spaced one day apart. At the same time small hides on the tundra were manned by other observers to monitor the feeding behaviour of the geese. More specific points on techniques of vegetation study are given in the relevant sections. During the period of hatching the observation tower was manned continuously to record both initial brood-size of individual pairs as well as losses that parents might suffer from various predators.

All nests in the colony visible from the tower were mapped on photographs taken from the observation point. After the geese had departed from the colony, the islet was visited in the 1979, 1980, and 1981 seasons to plot all the nests on a map (scale 1:500) with an accuracy of about 1 metre. Each nest was provided with a numbered stake that could subsequently be read from the tower and hence related to the island silhouette photographs used earlier in the season. In this fashion breeding parameters (identity of nest owners, fate of every nest, phenology of laying, hatching or predation, number of goslings produced) were collected for about 80% of the nests in the colony (the remainder were hidden from observation). Droppings were collected from the nest-rim at the time of the island visit for all nests monitored during the colony scans. These samples were microscopically analysed subsequently to assess diet.

During the tundra phase (July-August), family flocks were followed for many days at a stretch, observations which could be related later on to measurements of the vegetation at the site in question, undertaken when the geese shifted to another feeding area.

The Diabas colony population

Considering the birds still alive in 1981, during the years of the study 120 identifiable pairs (where one or both members were marked with

Table 1. *Breeding success in four consecutive years for ringed females.*

Number of successful years (hatching at least 1 egg)	*0*	*1*	*2*	*3*	*4*	*x̄*
1976-cohort	7	19	5	1	0	1.0
Older females	11	14	15	9	4	1.6
Total	18	33	20	10	4	1.4

coded rings) used the colony. Six of these pairs (5%) bred only once in the study colony, and are known to have nested successfully at other sites during the observation period. The share of this colony-switching segment accounts for only 1.9% of the observed breeding attempts by marked parents (6/316). We conclude that exchange between colonies is limited, and our study colony can be viewed as a more or less discrete group of birds returning year after year. Our detailed data for birds at this colony can thus be taken as a record of total breeding performance for the individuals concerned. For this analysis we restrict ourselves to the marked females, and find (Table 1) that for birds alive throughout the period the number of successful breeding attempts (i.e. at least one egg hatched in a given year) ranges from 0 to 4, and this disparity is reflected in the overall number of goslings per female brought to the mainland tundra (0 to 14 goslings, see Fig. 3). Also just 20% of the females are responsible for half of the offspring produced during the four-year period, and 27% of the mature females produced no goslings at all. Part of this disparity will be due to differences in age (and hence experience) of the parents. Of the marked females, those born in 1976 led 2.4 goslings out of the colony (n = 32), in contrast to the 4.2 achieved by the parents from 1975 or earlier (n = 53). Unfortunately it is not possible to pursue this age influence further as most of our marked females were ringed in the 1977 season as 'adult, born in 1975 or earlier'. From Owen (1982) it can be calculated that the mean span of reproductive life is eight seasons in this species (that starts to breed in its third year) and performance can be expected to improve over a number of years, as has been documented for Snow Geese *Anser caerulescens* by Finney & Cooke (1978) and for Canada Geese *Branta canadensis* by Raveling (1981) and Aldrich & Raveling (1983). We concede that it will be impossible here to partition out the influence of age, and in examining the factors limiting reproductive performance must content ourselves with identifying observable differences in behaviour associated with differences in reproductive success, and must await further work to elucidate the role of ontogeny in contributing to these differences.

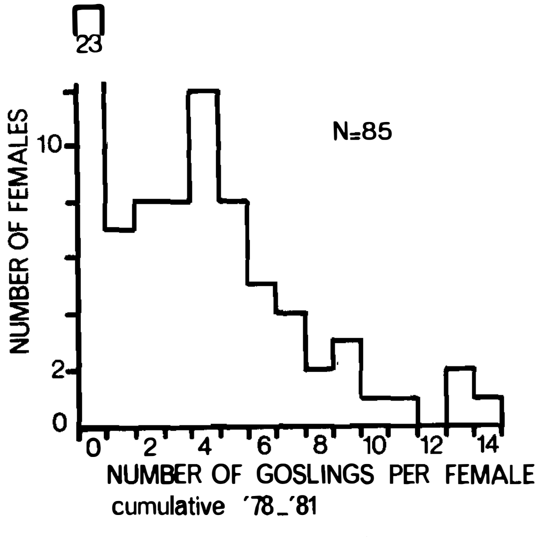
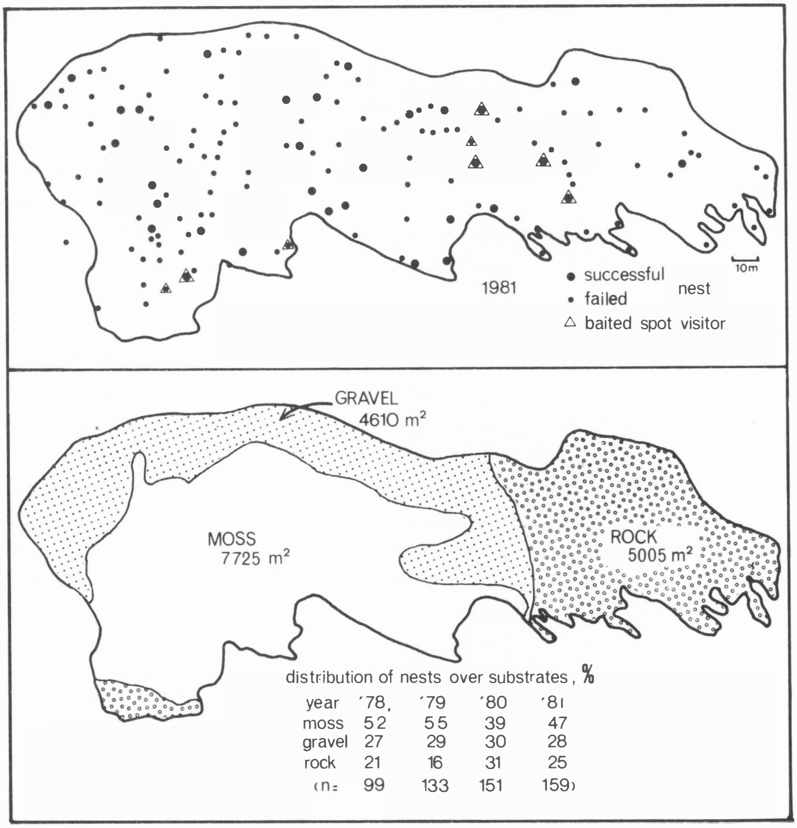


Fig. 3. Frequency distribution of cumulative number of goslings produced over 4 years (1978–1981) for 85 individual females. (Measured at the moment of colony departure.)

Nesting substrate and capacity of the nesting island

The distribution of nests in the colony is given in Fig. 4 for 1981 (see also Fig. 5). As can be seen, most of the island is occupied, and those areas free of nests in 1981 were used in one of the other years. We conclude that most of the island is in fact suitable nesting terrain, although the vagaries of snow cover may inhibit use of some sectors in seasons of late snow-melt such as 1981, and the presence of a nesting pair of Glaucous Gulls may likewise have a local effect. For the three substrate types, nest density does not differ (mean values for three years are 8.9, 9.2, and 7.3 nests per 1000 m^2 for moss, gravel, and bare rock respectively) although success varies dramatically



distribution of nests over substrates, %

year	'78	'79	'80	'81
moss	52	55	39	47
gravel	27	29	30	28
rock	21	16	31	25
(n=	99	133	151	159)

Fig. 4. Distribution of successful and failed nests in the colony in 1981 (upper). Pointed out are nests of females that exploited a baited area. The lower diagram shows the division of the island by substrate type, and for each type the relative number of nests per year is given.

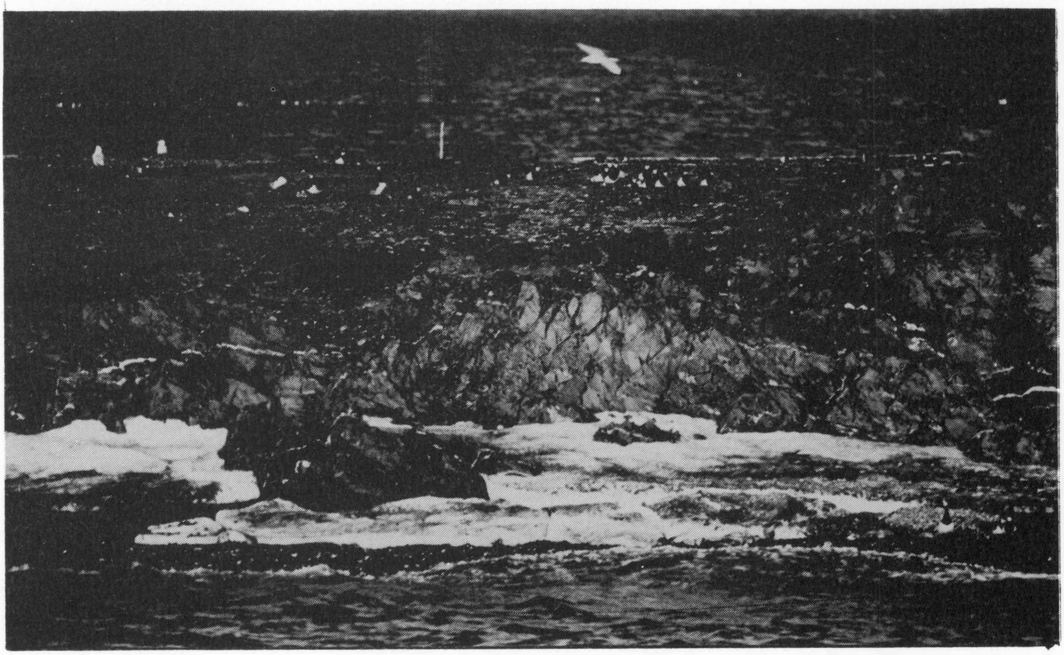


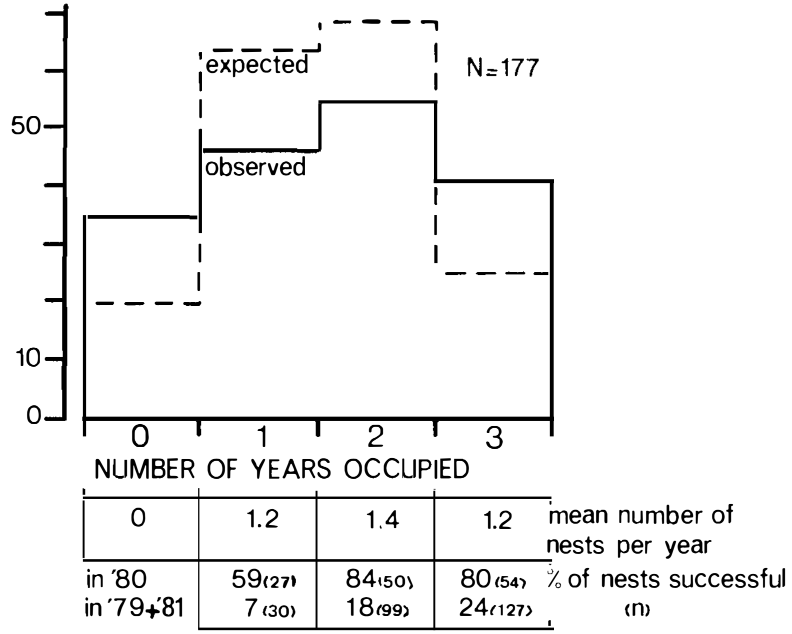
Fig. 5. Part of the breeding island, as seen from the observation tower in July. Some late hatched broods are visible.

Table 2. *Nest success for each substrate in the colony.*

Substrate	*Year*							
	1978		*1979*		*1980*		*1981*	
	%	*(n)*	%	*(n)*	%	*(n)*	%	*(n)*
Moss	70.6	(51)	23.5	(51)	87.0	(54)	30.0	(60)
Gravel	74.1	(27)	12.9	(31)	65.7	(35)	25.0	(36)
Rock	28.6	(21)	12.5	(16)	69.7	(33)	13.5	(37)

(Table 2), being highest in the moss areas and lowest for the rock sites. Moss substrates provide the best opportunities for feeding, especially important for females before and during laying, and for males throughout incubation. Better feeding opportunities near the nest will be especially important in minimizing absence of the gander, and hence ensuring maximal nest guarding during incubation. Other factors contributing to success are more speculative, and might involve the exchange of information. Particularly opportunity to view both other nesters and the more distant tundra provides information that may assist the individual in making the decision of when and where to feed that day. There is an indication that geese do react to each other in this way in locating good feeding spots, as can be seen when the nesting sites of individuals lured to a baited area on the tundra are plotted on the map (Fig. 4).

Both local feeding opportunities and field of view might hence be combined in some complex way in defining intrinsic quality of the nest-site. Consistently productive subdivisions of the island have been identified by considering nest establishment and outcome (eggs hatched or not) in a grid of 10 × 10 m squares. Some squares are used every year (Fig. 6) and these also achieve the highest success. Ceiling densities in these preferred sectors are no doubt set by social factors, and the modal nearest neighbour distance is 7 m irrespective of the substrate. Applying the densities achieved in the occupied parts over the entire island, 350 nests could be accommodated in all. This is twice the maximum number recorded. Space per se is thus not likely to be the limiting factor in the next few years except in years of exceptionally late snow-melt, but we would expect that as the available habitat is more fully utilized, mean nest success will decline (because less favourable sectors have to be utilized). This last can be seen to happen already in Fig. 4: with increasing numbers in the colony relatively more pairs are settling in the gravel and rock substrate. Only when the as yet unsaturated areas are filled up, will it be possible to quantify the contributions made by information exchange as distinct from local feeding (and perhaps cover during periods of inclement weather).



0	1.2	1.4	1.2	mean number of nests per year
in '80	59 (27)	84 (50)	80 (54)	% of nests successful
in '79+'81	7 (30)	18 (99)	24 (127)	(n)

Fig. 6. Occupation intensity (i.e. number of years occupied by one or more nests) of 10 × 10 m squares in the breeding colony. Expectation is based on a random distribution. No difference exists in the densities for each year between the occupied squares, but most frequently used squares have highest nestsuccess scores.

Feeding during the egg stage

Distribution pattern from colony and diet

The geese are largely dependent on the tundra as food source during incubation. The question of whether numbers might be limited by feeding opportunities in the vicinity of the colony can only be answered if an attempt is made to measure how many geese the tundra around the colony can sustain. Geese may range up to 4 km from the colony at this time, but concentrated their feeding within a 1 km range for most of the time. Here we chose two study sites (see Fig. 7): a low-lying boggy habitat where mosses *Calliergon* spp. and, when available, grasses *Dupontia fisheri* and sedges *Carex subspathacea* formed the main constituents of the diet, and a higher and hence drier habitat (fjellmark) where horsetails *Equisetum* and dicots (especially *Salix* buds and flowers of *Saxifraga oppositifolia)* were eaten (see Fig. 8).

A convenient source of information on the diet in the egg stage is provided by the droppings accumulated around the nest-rim. Analysis of these composite samples shows that roughly half of the diet of females is composed of mosses and monocots, with herbs and horsetails making up the remainder. Although food availability varied widely between the years depicted on account of differences in the timing of snow clearance, food composition for the colony as a whole showed relatively little change. In late years the contribution of grasses falls, as they become available too late, and relatively more *Equisetum* is taken (Fig. 9). It is hard to escape the conclusion that the geese are striving to assemble a diet composed of a mix of different plants, a point deserving explanation in terms of foraging theory.

Our observations show that the phenology of the vegetation in the different seasons does entail a differing degree of utilization of the various foraging areas (Table 3). In particular, the low-lying moss creek area was less heavily used in the late year 1981. At this site grasses and sedges only began to penetrate the moss bed in the very last days of the egg stage, making it an area where virtually only mosses were eaten. Indeed, in 1981 the females travelled further afield, and foraged in areas where we had never observed breeding birds in previous years. Nevertheless, the grazing pressure on the subarea 'Camp' remained closely similar in both years, and this finding points to a more consistent food supply in that area. Fortunately it was possible to achieve near-complete coverage of the foraging visits of the nesting females to this area, and the following sections will lead on to a description of vegetation exploitation on an individual level.

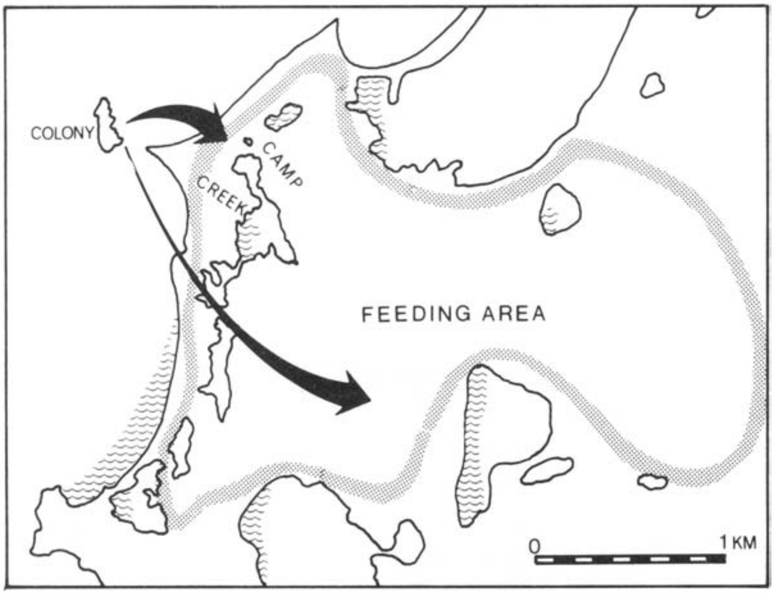


Fig. 7. Map of the colony island and neighbouring tundra. Given is the range of feeding trips of Barnacle Geese from the colony.

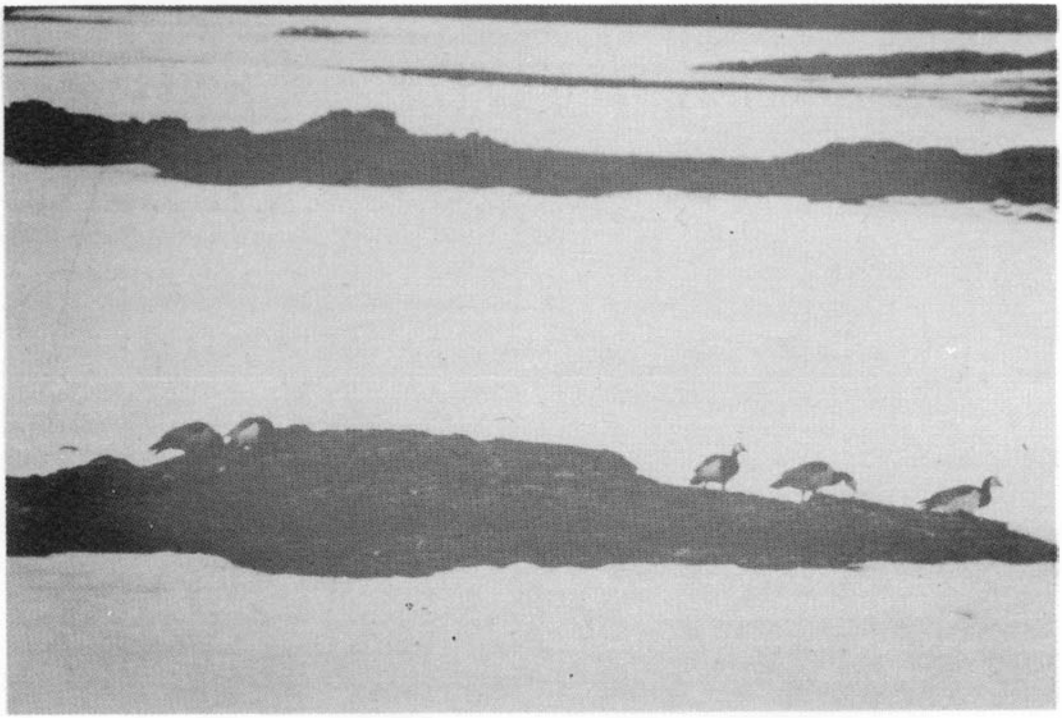


Fig. 8. The fjellmark (camp) in the early season. Only some snow free islands are exploitable for the geese.

Monitoring feeding on the dry tundra

A large part of the tundra in the surroundings of the breeding island consisted of a bare and rather dry, stony type. A 4.2 ha study plot was chosen and a small hide mounted on a ridge overlooking the area. The study area was divided into cells of 25 × 25 m marked with small poles. The hide was manned continuously during the egg stage, the observer being present during the time of greatest activity of female geese (8–20 hrs, cf Prop et al. 1980). The vegetation was mapped in order to distinguish between the main phenological units of the main food plant of the geese in these areas, *Salix polaris*. *Salix* density was measured by counting leaves in 3360 100 cm^2 areas, well spaced over the entire area (Figs. 10 and 11).

The area covered by snow was mapped carefully once every second day, in some areas each day. Small mesh wire exclosures prevented geese from grazing in certain areas. The vegetation was monitored every other day both in and outside the exclosures. Counting of distinct items (flowers, buds, leaves, fruits, a.o.) was done in microplots of 100 cm^2, indicated nearly invisibly

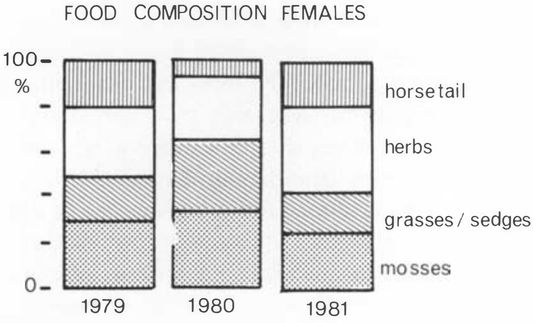


Fig. 9. Diet composition of females in the egg stage for 3 years (mean of about 40 individuals).

Table 3. *Time spent on the tundra by breeding females (hours).*

	Year	
	1980	*1981*
Sum of all females (A)	2020	1970
On the 'Camp' (B) = fjellmark	85	54
On the 'Creek' (C) = wet moss	900	390
Other areas (A–B–C)	1035	1526

Fig. 10. Sampling the vegetation – counting food items in early summer.

by small match-sized sticks standing less than 0.5 cm above the vegetation. At times of absence of geese and observers all plots were covered in order to prevent grazing by male geese and reindeer, in total being of little importance in the period of study however (< 10% of grazing impact by all herbivores).

The consumption of *Equisetum variegatum* branches was determined using photoplots, where at close range goose grazing was registered (grazing seconds and individual pecks), accompanied by photographs of the same areas before and after the geese had visited the area (Fig . 12). The creeping leaves of this perennial were measured from photographs; a conversion into biomass was possible due to the regular shape of the branches.

Individual birds were followed, paying most attention to individually ringed birds. Each five minutes its position was recorded, in some areas as often as 30 seconds. Behaviour was recorded for at least one minute. Up to two hundred metres a major distinction was possible concerning the main type of food plants ingested. Willow buds *Salix polaris* were eaten commonly, the birds having relatively high peck rates and were very often seen removing pieces of *Cetraria* lichen vegetation in a characteristic way. The same occurred when *Equisetum* was chosen, but here the obvious sideward turning of the head was very conspicuous, the bird's bill acting as a forceps, carefully placed in between the *Cetraria* vegetation leading to relatively low peck rates. Flowers of *Saxifraga oppositifolia* formed a third major part of the diet of the female geese. Following superficially placed pecks, considerable lateral movements of the head frequently occurred, slightly turned aside.

Whole plants of *Cochlearia officinalis* and *Polygonum viviparum* were seen being dug out by some birds, inserting their bills deeply into the surrounding moss cover. Spilled material allowed an extra check in some cases after the birds had gone.

Salix, Saxifraga, and *Equisetum* usually comprised up to 80% of the visible plant material ingested in this area, confirmed also by dropping analysis.

Food exploitation

Due to rapid changes in available habitat from one day to another because of snow-melt, the birds meet an ever changing environment. Besides this, plant phenology also causes marked changes in profitability. Though very abundant, the buds of *Salix* at a given spot can only be exploited by the geese for about five days in succession. Later on the leaves are very unattractive because of high fibre content and the incorporation of secondary compounds which lowers digestibility. In Fig. 13 this rapid change in food availability has been depicted following date since snow-melt. The birds can maintain a diet comprising of *Salix* only by a continuous switch to new feeding sites. The different spots of *Salix* have somewhat different patterns of development of buds, due to differences in degree of exposure to sunlight, soil moisture, and other factors influencing microclimate. Similar patterns were found for the flowering of *Saxifraga oppositifolia, Cerastium arcticum,* and *Draba alpina,* these being the most abundant species in both the

Fig. 11. Salix polaris with buds.

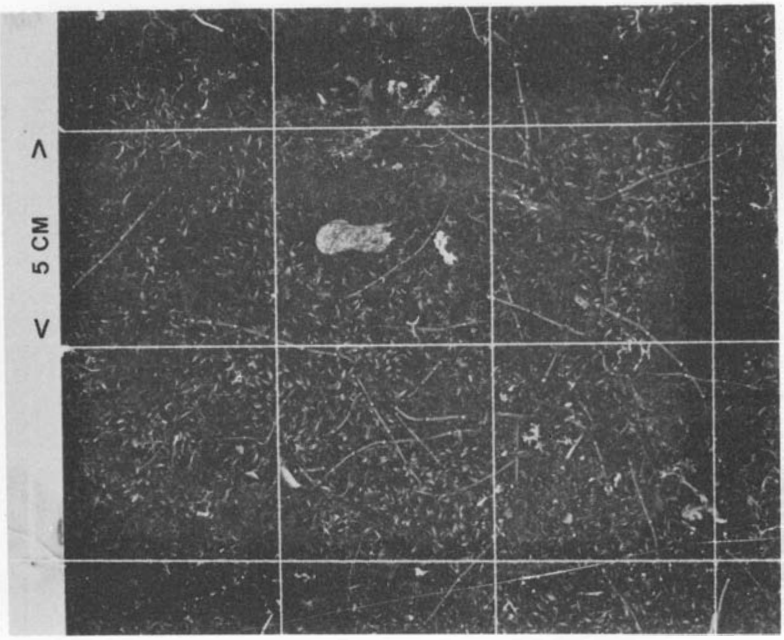


Fig. 12. Branches of *Equisetum variegatum* protruding through the lichens.

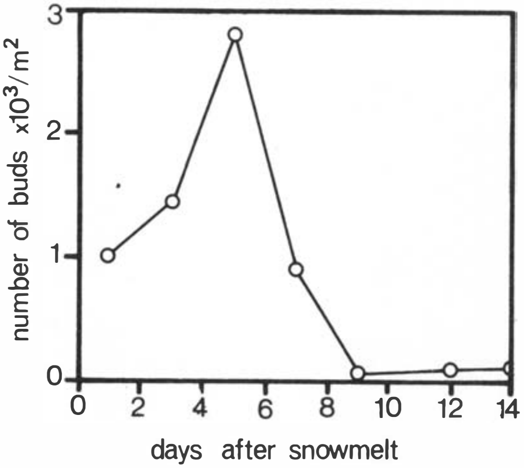


Fig. 13. Density of *Salix* buds in relation to disappearance of snow.

field and the goose diet. Less abundant but not sensitive to plant induced changes were seedheads of the previous summer of the plant species mentioned above, together with *Cerastium alpinum* and *Saxifraga caespitosa.* Also the green parts of *Equisetum variegatum* were available as soon as the snow had disappeared, no major changes occurring afterwards. The same holds for the less preferred mosses being present as an ever ready, low quality source of food (cf. Fig. 9).

Once the first snow free spots become available to the geese these habitat islands attract birds. Around big stones and on steep slopes of micro ridges and large rock outcrops, a number of different food items become exploitable. The patches being snow free, while the overall snow cover still amounts to c. 75%, were grazed at a relatively high rate. The mean levels of utilization were as follows (Fig. 14): *Salix* buds 70–80%, *Cerastium* seedheads 60–90%, *Saxifraga* flowers 40–65%.

The lower lying parts of the tundra were more uniform according to plant species, the patchiness being caused mainly by differences in plant phenology and density of buds of *Salix.* These areas suffered a mean loss of 5–10% of *Salix* buds. Scattered items such as *Polygonum* plants (25%), and *Cochlearia* plants (40–90%), were less widespread, and an estimated 50–80% removal of standing stock of leaves of the grass species *Poa arctica* also belongs to this group of very patchily distributed food items, being less than 1% of overall biomass of higher plants.

At times of an overall snow cover of just 25% or less, the best patches of *Equisetum* become available, and sought after by the geese. Especially on moist days the birds were exploiting these patches, probably because of fewer problems in removing the (then soft) *Cetraria* lichen partly covering the brittle pieces of horsetail. The photoplots showed a mean exploitation level of 60–80%, parts longer than 20 mm being highly selected for (Fig. 15).

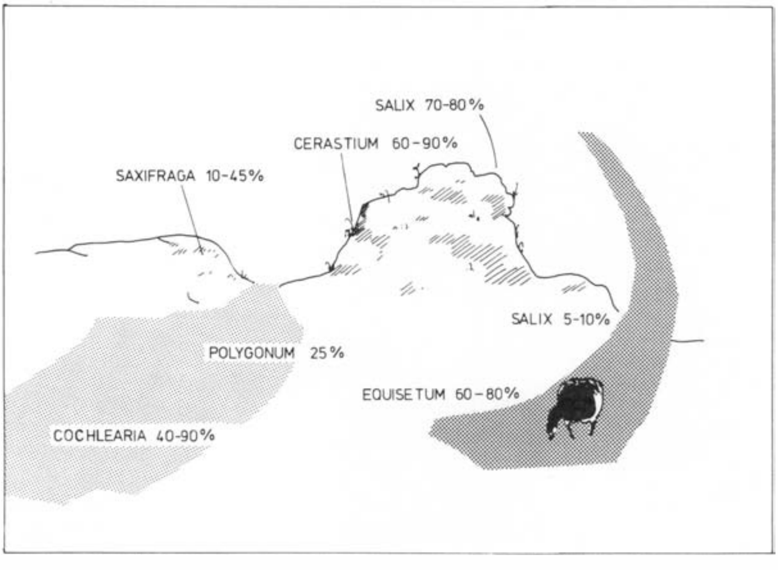


Fig. 14. Utilization of fjellmark tundra during the egg stage. Figures refer to overall consumption of different food items recorded in various study plots. Notice highest levels in rock outcrop areas and *Equisetum* avenues.

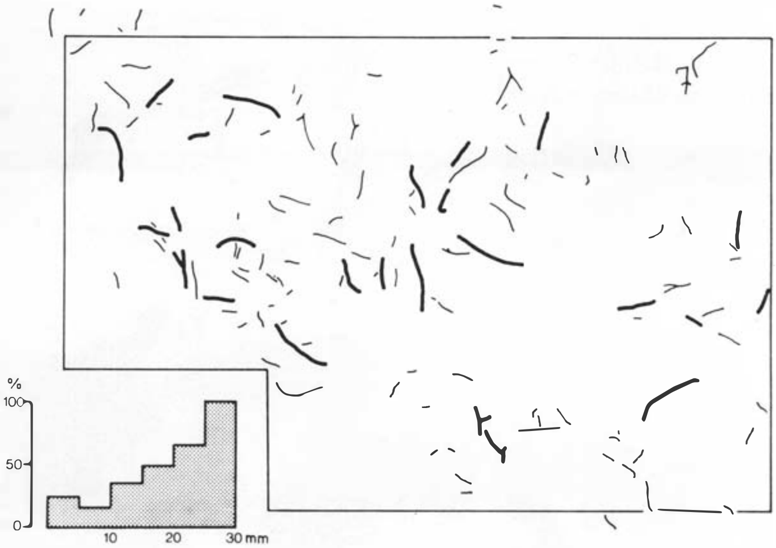


Fig. 15. Equisetum variegatum grazing impact as determined by photoplots. All branches removed by grazing geese within sixteen foraging seconds are heavily marked. The inset shows preference of the geese for the longest branches.

So in many cases measurable effects could be noticed, the highest impact of goose grazing occurred in the very beginning of snow-melt and during the period of disappearance of the last snow. Notably during these periods the Barnacle Geese were seen carfully following the snow edges. As stated earlier, this behaviour can be interpreted as a response to differences in phenological stage at which food plants emerge as the snow carpet retreats.

Foraging trips and intake rate

Female Barnacle Geese were watched throughout their active day when foraging trips were made on the tundra. Very often the landing of a single bird was followed by one to eight others landing close by.

These birds went through the area as a nucleus giving rise to more landings but also departures to other feeding areas or back to the breeding island. Because of the occurrence of distinct food items, intake rate for main food types was assumed to correspond to peck rate times dry weight of a single food item. For *Equisetum* the photoplots revealed a mean length of 18 mm per peck, corresponding to 0.0025 g. Comparable values per peck on a basis of dry weight are *Salix* buds 0.0030 g and *Saxifraga* flowers 0.0068 g.

Once a bird has landed, flying hardly occurs and all birds walk through the area, hopping only short distances at times of existence of snow free habitat islands. Very small islands at the beginning of the period of snow-melt are not visited when they are not connected to others nearby. Isolated ones are only visited by geese when they are above an apparent minimal size of ca. 50 m^2. The following case illustrates the main events occurring during the period of beginning of snow-melt at a certain spot. 27 June 1981 the first bird to arrive was KTN, being a well known successful breeder in previous years. Her foraging path was mapped with 30-second intervals and is shown in Fig. 16. KTN stayed 24 minutes in the area being the first visit of that season. After she had gone detailed sampling could not detect any significant difference in density of buds of *Salix,* but due to a different phenological stage of the plants bigger buds were found on her track as compared to one or two metres either side. Standing stock at that time amounted to 0.14 compared to 0.08 g per 100 cm^2 patch, respectively. It seems this bird chose her way according to the amount of available food present, not just the encounter rate of individual food items. *Salix* buds, being the main food overall, were alternated with *Saxifraga oppositifolia* flowers. In one single visit KTN removed 30.2% of all flowers present in that area (Fig. 16). She visited 45 out of 71 plants (63%) which had a somewhat advanced phenological stage as indicated by the mean number of flowers that were open already: 3.1 against 2.0 per plant, as a

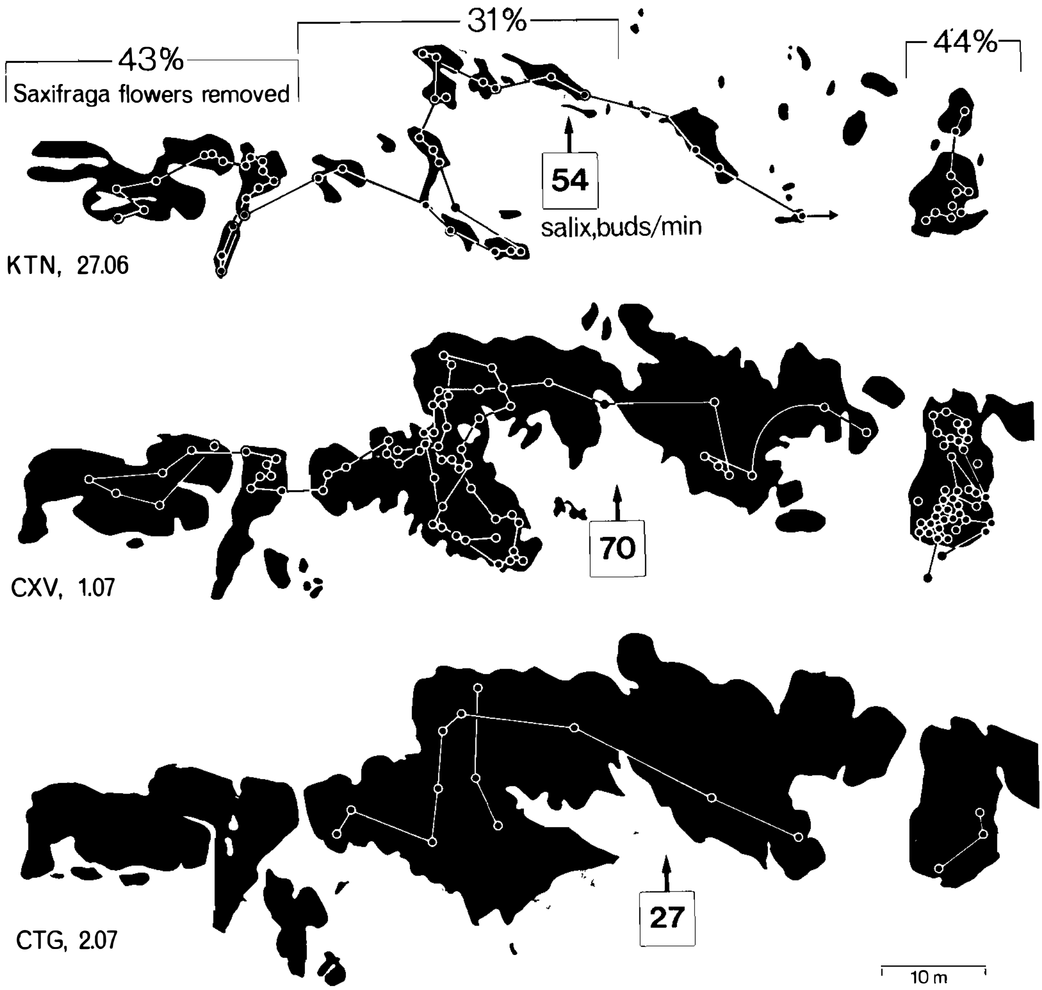


Fig. 16. Goose visit and foraging path in connection with snow-melt. Each dot maps the bird's position every 30 seconds. Overall values for intake rate of *Salix* buds and *Saxifraga* flowers are given.

percentage 62% against 33%, respectively. The next bird to arrive was CXV, four days later on, which spent about twice as much time in the same area (45 minutes). At that time the stepping stone pattern of snow free patches had disappeared and one big habitat island had emerged. This bird concentrated solely on *Salix* buds which had grown bigger in the time that had passed (1.6 to 2.8 mg dwt per bud). Intake rate of CXV was higher than that of KTN, measured over the same area, being 70 against 54 bites per minute for KTN. In this case the actual size of the buds being taken is not known but in accordance with the findings earlier on it is likely to assume an increase in the mean weight of buds eaten, at least to the same ratio as that in the field. This leads per minute to an overall intake rate of 86 mg for KTN and 196 mg for the later arriving CXV. The total uptake from the area was 2.06 g dwt for KTN and 8.82 g dwt of *Salix* for CXV.

The next day CTG arrived in the same area, spending just six minutes; later on that day another unringed female spent 1.5 minute. Both birds made a very hurried appearance and, combining the data for both females, these birds experienced a mean intake rate of 27 buds per minute, very low as compared to the very first birds.

One reason for this was the process in development of leaves, another being probably the

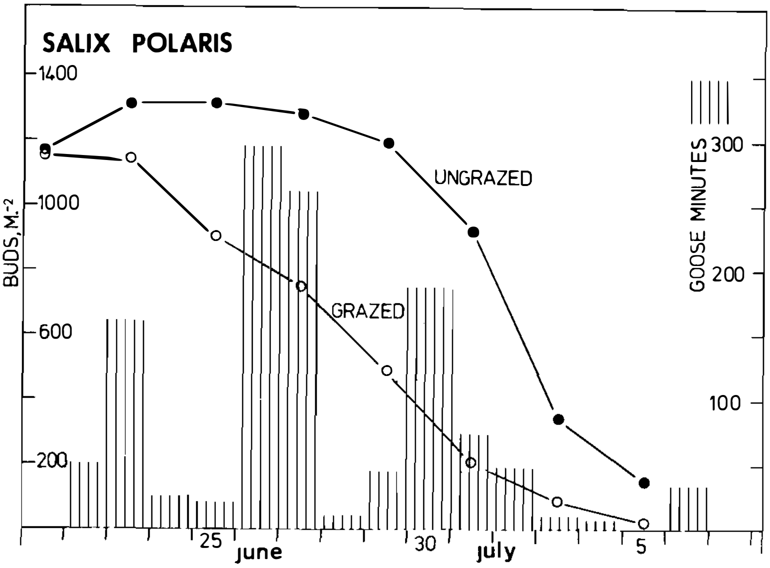


Fig. 17. Density of *Salix* buds on habitat island in early summer. Exclosures show the effect of goose grazing.

negative effect of the hardening of the *Cetraria* lichen carpet on the availability of buds of *Salix*, as only the buds that are not covered by *Cetraria* too much can easily be eaten. This situation is typical for days with sunny weather and in general is more likely to happen on top of small ridges (draining effects).

The rest of the season the geese concentrated in other areas, leaving the centre part of the ridge untouched.

This series of observations showed that intake rate at a given spot may vary considerably. The geese meet an ever changing environment as far as food availability is concerned. They have to adjust their foraging efforts to the timing of major phenological events of their food plants. As indicated above one visit of a single goose means that measurable effects occur in the vegetation present.

Plant phenology and individual performance

Several of these habitat islands were watched and the most attractive areas to the geese were monitored carefully. Small exclosures were set up in order to count *Salix* buds without being grazed, while other unprotected plots nearby served as a reference for estimating the impact of grazing. As seen in Fig. 17, starting from equality, a clear difference in standing stock was observed due to grazing effects in 14 consecutive days.

Goose visits to this area appeared to happen in three major waves as expressed in numbers of goose minutes spent per day on the habitat island. Probably this pattern was strongly influenced by social effects. Birds often follow each other from the breeding island to the tundra and once a bird has landed it is likely that more birds follow. Because the timing of visiting the tundra by female Barnacle Geese is scattered throughout the day, patterns of prolonged attraction can last for several hours. Of course this happens only at sites with a high return in terms of exploitable food.

Because of the combination of data on mean predation pressure (exclosures) of *Salix* buds with goose usage (goose minutes per m^2 *Salix* area), a mean bite frequency could be computed for the three periods of visit separately, assuming that each peck corresponded to the removal of a single bud of *Salix*. This expected bite frequency is not constant for the three main waves of visit.

For this area the actual rates of intake of individually ringed birds can be compared with the expected value. In Fig. 18 the median peck rates for each individual seen on this habitat island on a given day are shown. A large scatter is obvious between birds and days but generally speaking the individuals nicely group around the expected values.

The highest intake rates are measured during the very first days of visit, thereafter falling continuously during twelve days. From Fig. 18 it is seen that individual birds that revisited the area also experienced this drop in intake rate. It is reasonable to suggest that this drop in profitability of the spot is caused both by depletion of *Salix* buds by grazing and by the development into young leaves. Mean grazing pressure on this spot was very high, for the three waves being 5.14, 4.25, and 2.60 goose minutes per m^2, respectively.

A great reduction in the scatter of intake rates is obtained when regrouping all females to known breeding success for that year. Successful females tended to have higher intake rates on *Salix* than birds which failed to hatch young. Differences in the rate of intake might be related to experience (or age of bird) and to the social status of the bird (within flock hierarchy).

Carrying capacity

What might be the limit of grazing pressure in these areas at which foraging is still worthwhile? As noticed earlier, measurable decline of the food stock existed already, caused by grazing of relatively few birds, resulting in clear drops in intake of individual birds. This depletion sets a limit to the utilization by the geese. The intensity of usage of the most visited part of the camp-area worked out to be 15.8 and 12.9 seconds per m^2 in 1980 and 1981, respectively, and we conclude that a level of 10–20 seconds per m^2 is the plateau value in grazing pressure this part of the tundra can sustain.

Nest attentiveness and success

Time spent on the tundra differed widely between the years. The general pattern is that the female remains almost continuously at the nest

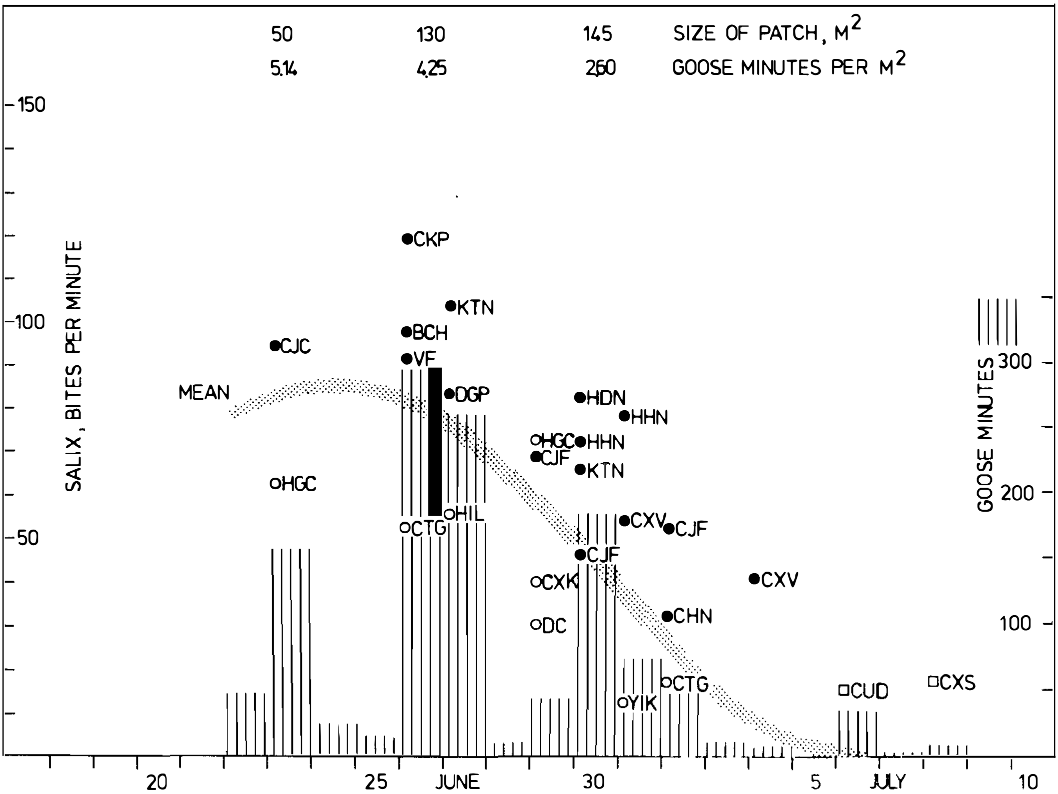


Fig. 18. Intake rate of *Salix* buds on habitat island in relation to expected mean rate of intake for all birds based on data from Fig. 17 and size of snow free area. Closed dots refer to successful, open dots to failed breeders. As is clearly seen intake rate is correlated with breeding success. Open squares indicate flower-eating failed breeders.

during the first week or so of incubation, after which the daily foraging trips tend to increase gradually in length up to about five days before hatch, when feeding time declines sharply. This pattern is comparable to that observed in White-fronts *Anser albifrons flavirostris* in West Greenland (Stroud 1982) and Pinkfeet in Iceland (Inglis 1977), although the feeding times reported were generally somewhat shorter than in our observations. The more southerly breeding Canada Goose *Branta canadensis maxima* leaves its nest every day to feed throughout incubation (Cooper 1978), as does the subspecies *moffiti* in captivity (Aldrich & Raveling 1983).

How do the differences in food availability between the years affect the feeding pattern of individual geese? As an example the time off the nest is given for female KTN in Fig. 19, and her feeding pattern reflects that of the colony mean. In late years tundra feeding is delayed, the highest levels of tundra-feeding are reached in these years, however. The geese might compensate for a longer period of virtual starvation beforehand, and partly compensate for lower rates of intake.

Extended feeding on the tundra has its dangers, however: as shown in Fig. 20, the longer an individual spends feeding on the tundra the lower is the probability of successful nesting, though in late years an additional negative factor seems to play a role. According to our observations there is a spiral of events as follows: as feeding absences of the female lengthen from day to day there comes a time when the male no longer stands guard but instead can be seen feeding at some distance from the nest, sometimes even making tundra visits on his own. In such cases it is simply a question of time until predation puts an end to the nesting attempt. Generally there is a sudden increase in foraging bout length of the female, from one day to the next, as was also observed by Inglis (1977) in the Pinkfoot. A higher absenteeism of the female, foreshadowing eventual nest failure, was also observed in Snow Geese (Harvey 1971) and has been interpreted as an indication that the nutrient

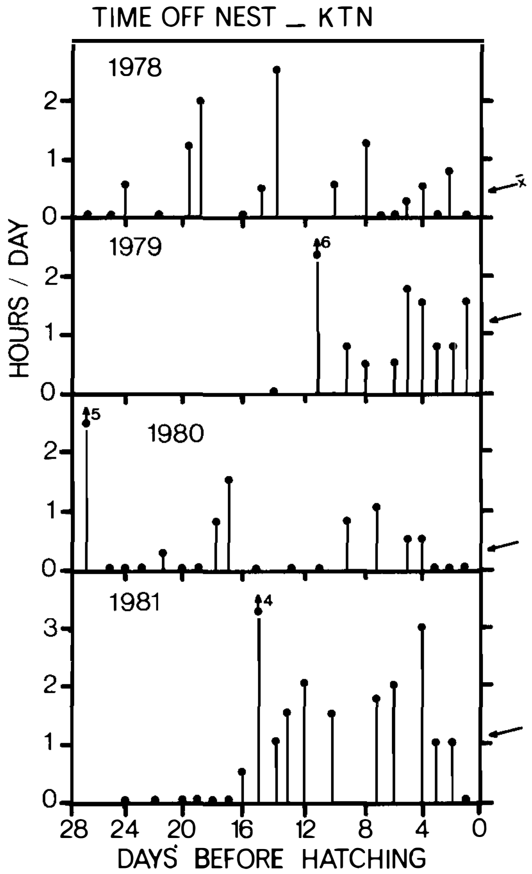


Fig. 19. Pattern of time off nest over the incubation period of one female – KTN – in four consecutive years. Indicated on the right side is the yearly mean.

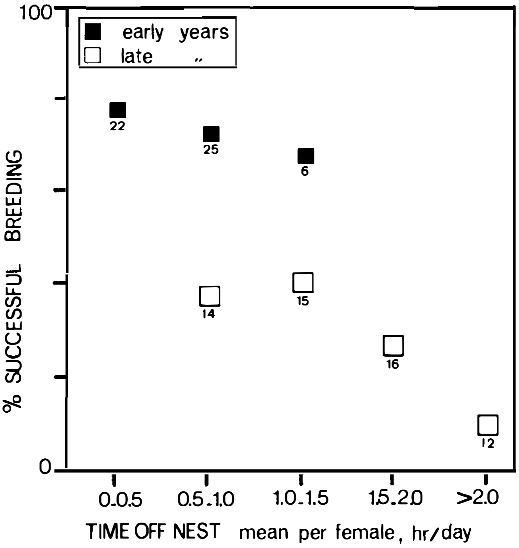


Fig. 20. Relation between nest success and individual mean time off.

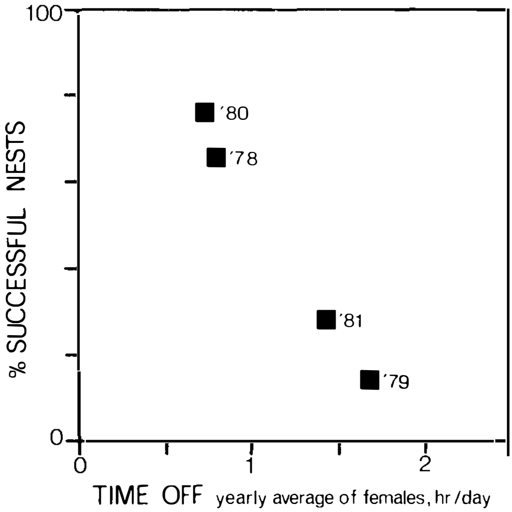


Fig. 21. Relation between yearly nest success of colony and the mean time off (of females).

reserves of the sitting bird are approaching exhaustion. The wide variation in time off the nest between the years (as a mean for all scanned individuals) can be read from Fig. 21, and it is shown that a low level of nest success coincides with years with the highest absenteeism.

Dispersion during the moult: the tundra lake systems

All lakes in the coastal strip can be grouped into units, defined by our sightings of ringed birds as all lakes between which movements of flightless birds regularly occur. Families from the three colonies move to units nearby (Fig. 22) and just as pairs tend to return to the same colony to breed, there is a strong tendency to spend the moult in the same lake system each year. Diabas families can choose between two units of approximately equal capacity (see Table 4) but 71% (n = 34) of the pairs return to the same system in the years they have goslings. For the visitor-pairs breeding at Diabas mentioned earlier, two successfully hatched their eggs and were traced with their goslings far from Diabas, in lakes close to their presumed colony of origin (20 and 8 km away), emphasizing the fidelity to moulting site. Geese without goslings are less consistent (63%, returning, n = 49) and also utilized lakes where no families were ever observed. This means that some shifts occur from year to year depending on breeding status of the individual pairs.

The period when the geese are restricted to the tundra lake system, starts for non-breeders and failed breeders at the moment that they commence wing moult. According to our observations of ringed birds, the flightless period lasts 27 days, and throughout this time the geese stay close to the water's edge in order to minimize the risk of predation by Arctic foxes.

The start of the moult of non-parents coincides with the arrival of the families in early seasons, but in late years the non-parents take up their moult stations about one week in advance of the families (Fig. 23). As about three weeks elapse between colony departure and the start of the moult of the parents, there is little overlap in the flightless period of parents and non-parents. The non-parent groups are composed of both non-breeders and failed breeders. As the non-

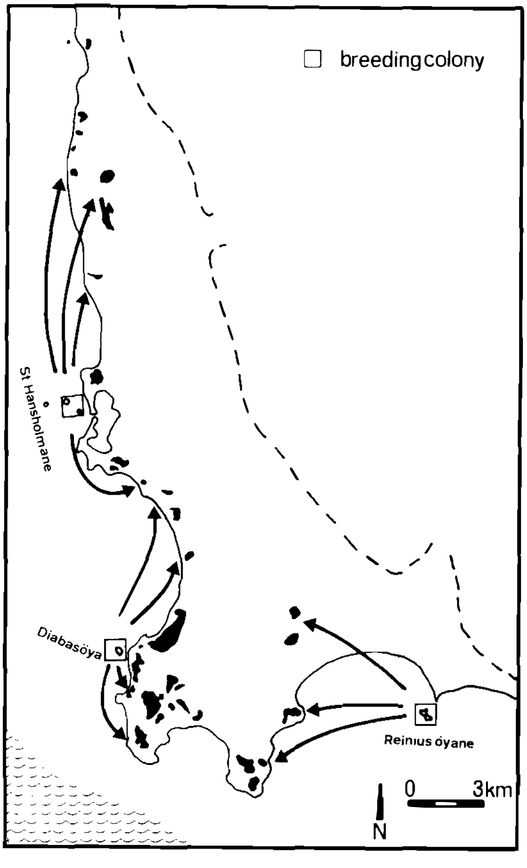


Fig. 22. Dispersal of Barnacle Goose families from the breeding colonies. Only lakes utilized by geese in the moult are shown.

Table 4. *Numbers of Barnacle Geese (adults + juveniles) per lake system in the years 1975, 1977, 1978–1981, Nordenskiöldkysten, and density on the moss vegetation for the peak year. (Between brackets the percentage of of non-parent adults).*

Lake system			*Year*				*Number of geese/10 ha of moss vegetation in peak year*
	1975	*1977*	*1978*	*1979*	*1980*	*1981*	
A	?	308(79)	414(22)	286(70)	812(34)	475(87)	67
B	314(9)	342(100)	250(100)	308(100)	20(100)	325(100)	105
C I		(79)	(31)	(92)	(100)	(95)	
II		(100)	(100)	(100)	(100)	(97)	
I + II	?	385	378	398	437	449	107
D	?	186(94)	273(15)	203(70)	381(22)	262(76)	87
E	?	58(80)	186(19)	171(75)	247(35)	340(100)	87
F	?	54(93)	215(63)	166(75)	147(45)	7(0)	61
total	1060	1333	1716	1532	2044	1858	
(% juv.)	(24.5)	(4.4)	(31.5)	(8.4)	(37.3)	(4.7)	

See Fig. 1 for topographical position of lake systems. Data of 1975 deduced from Ebbinge & Ebbinge–Dalmeijer (1977) and Dittami et al. (1979).

breeders are the first geese to moult, as documented in the 1977 season (Owen & Ogilvie 1979), the early commencement of moult in 1979 and 1981 is likely the result of the preponderance of yearlings (none breeding) in the non-parent groups.

A summary of the distribution of the geese over the different lake systems in the period 1975–1981 is given in Table 4. Two lakes are only important for non-parents. The share of parents and goslings in numbers at the other lakes varies with breeding success.

Moss vegetation with graminoids protruding forms an important food habitat during the moult (Fig. 24), and the area covered by this vegetation type is a reasonable approximation of food supply. Two lake systems seem, however, to be undervisited. Both are more than one kilometre inland, and aside from this distance it is probable that ice on those lakes melts later than on the other lakes closer to the sea, but we have no exact observations of melt date in relation to goose occupation. The question if the lake systems have already reached a limit in the number of moulters they can support is addressed in Table 4. Two systems, Oddvatna and Femvatna-Flosjø, do not show an increase in numbers in the same seasons of high numbers overall as is the case in the other lakes, and indeed the highest densities in relation to the food supply were found here (100 geese/10 ha moss).

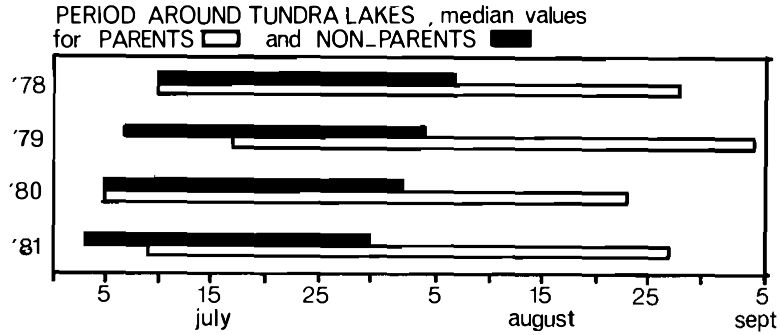


Fig. 23. Phenology of tundra lake-bound period for non-parents (moulting for 27 days) and families (48 days before fledging) in 1978-1981.

Fig. 24. Barnacle Goose families in the fledging period – feeding in the moss vegetation close to the wateredge.

Fig. 25. A family group in the fledging period running from one lake to another.

Vegetation exploitation during the moult

A flock of eleven families was followed throughout the moult in the Lågnesputtane-Jovatnet area, where they utilized six adjoining lakes and surrounding tundra. Between some lakes ancient raised beaches obstruct vision for the geese, and make overland movements hazardous events. Every such overland trek was preceded by a period of extreme wariness on the part of the adults, and a cautious walking progression away from the lake margin, changing into a very fast run to cover the second half of the trip (Fig. 25). During the flightless period this group lost three of the 28 goslings. In one case predation by Arctic fox was directly observed halfway between the lakes (week 3) and in the other two the goslings disappeared after having been seen far from water feeding with their parents, and were presumably also taken by a fox. The movements between the lakes are shown in Fig. 26, where the width of the circles represents the total grazing time accumulated at that lake area in the period given. Sometimes the group stayed at one site more than one week, but most visits lasted only 1–3 days. Hence every lake margin was grazed more than once during the moult. Measurements of grass blade density imply a heavy usage of the food supply (grass and sedge blades) forcing the geese to move to another site; on a following visit the regrowth can be cropped. The net result is that geese spend most of their time on the lake margins with the largest food supply, as measured in terms of the area of moss with *Dupontia* and *Carex* blades protruding (Fig. 27).

How do the various families fare in the face of a depleting food supplv? While the geese were

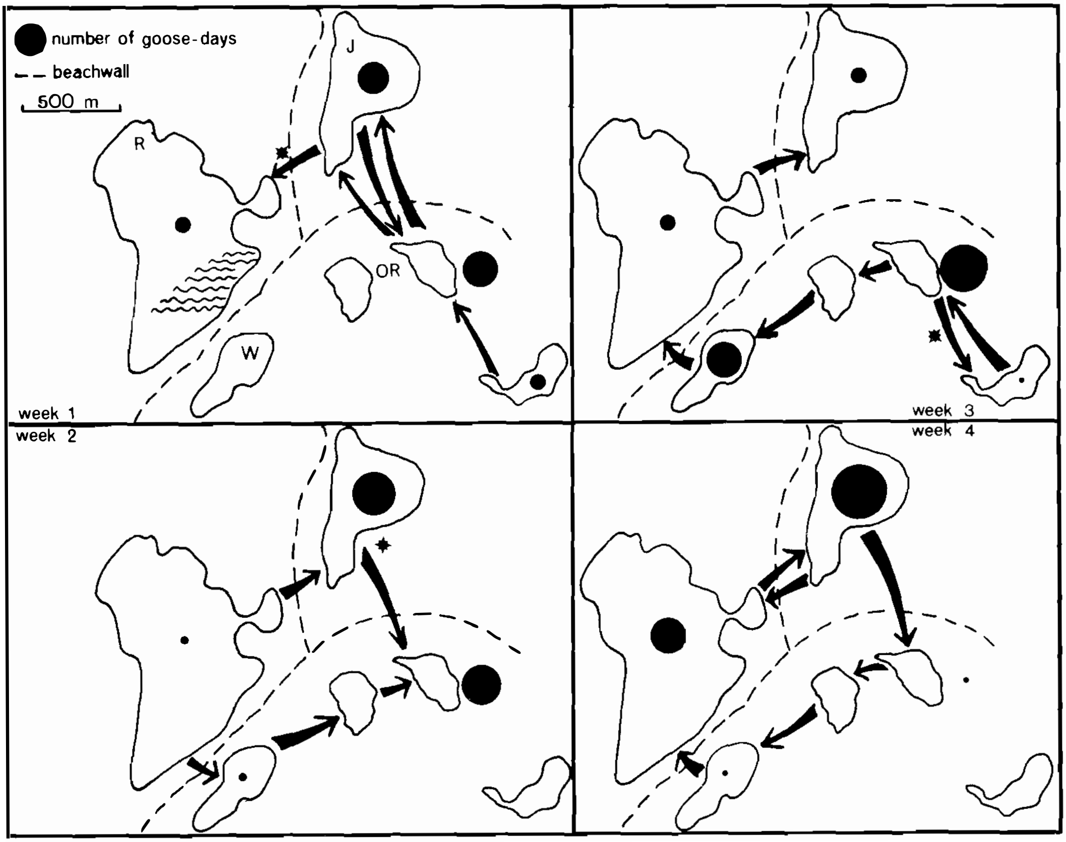


Fig. 26. Exploitation pattern of a lake system by a flock of 11 Barnacle Goose families. Every movement between lakes is shown. ★ = predation of gosling.

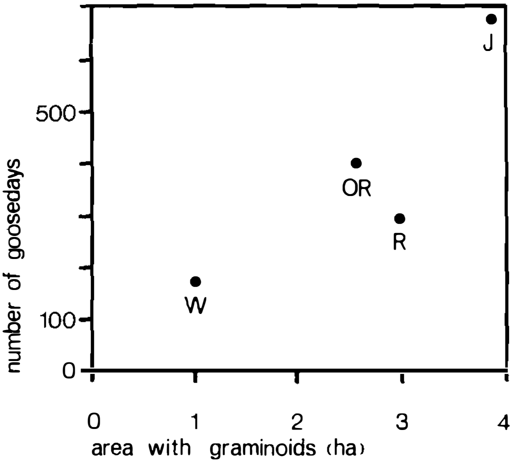


Fig. 27. Relation between grazing pressure (number of goose days) and food availability (area of moss vegetation with grasses or sedges) per lake. The letters refer to lakes on Fig. 26.

grazing another area, a grid with squares of 2 × 4 m was set out with small stakes along the lake margin, and the density of grass blades *Dupontia fisheri* sampled in each bloc. Subsequently the movements of the goose flock were watched from a nearby hide, and the presence of every identifiable family plotted with regard to the grid. Fig. 28 gives the distribution of two of the families as an example: family B frequented higher grass blade densities than did family A, which was seen over a far wider spectrum of densities. These differences in access to the richest feeding areas are related to differences in dominance, and in keeping with observations on other geese (Raveling 1970) we found families with a large number of goslings to dominate those with few. The next step in the argument is to present data on feeding performance in relation to the brood-size, in fact in relation to the dominance position of the family. Since we did not always have the advantage of a grid system of sampled vegetation quality, we here rely on an indirect observational measure of food supply, foraging seconds per step (the slow walkers are in the richest areas). It could be demonstrated that the larger the family – and hence the higher the dominance status – the more favourable the feeding conditions experienced. That these inequalities in feeding opportunities may well lead to differences in survival subsequently is hinted in Fig. 29, where the recruitment of goslings to the winter flock at Caerlaverock has been used as a survival yardstick (based on intensive telescope watching in October). Clearly the larger broods suffer proportionately less mortality, and we suggest that the higher losses of the small-brooded families are a consequence of the cumulative effect of being excluded from the richest feeding sites.

The post-moult tundra period and departure

In the first half of August non-parents regain their powers of flight, and by the second half of the month the families are generally able to fly as well. As soon as the geese regain flight they leave the lakes with their heavily grazed margins, and exploit instead moss vegetations with grasses and sedges, too far distant from the sea or lakes to be visited during the moult, and in some cases still

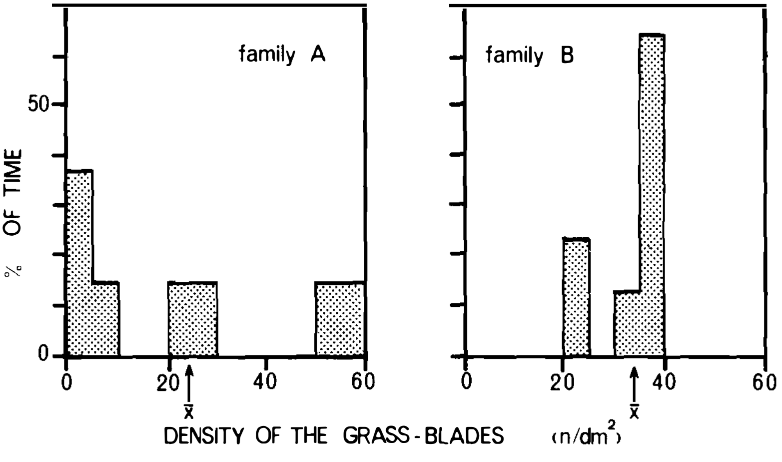


Fig. 28. Allocation of feeding time in relation to food supply (density of grass blades).

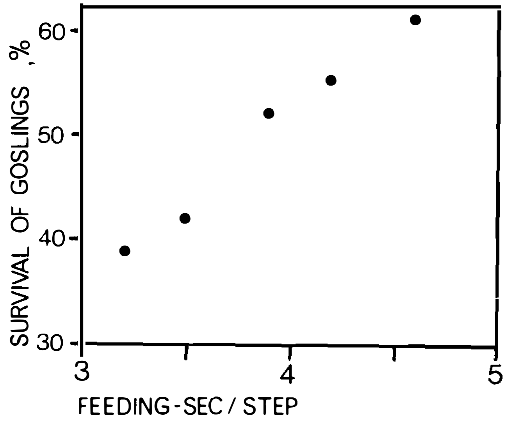


Fig. 29. Survival of goslings in relation to a feeding parameter (feeding time per step, for female parents).

Table 5. *Distribution of Barnacle Geese over different vegetation types after the wing moult (data of 1981). (In percentage of total geese observed).*

Period:	*8–22 Aug.*	*23 Aug.– 9 Sept.*
Vegetation type		
wet moss/grass	82.8	25.4
fjellmark, *Cetraria/Equisetum*	6.9	39.9
rest, including polygons	10.3	34.7
Total observed geese	3188	6243

encased by ice at that time. As an example, the exploitation of the mossy areas around Eungane is shown in relation to the phenology of moult at Fjørungen (see Fig. 30). As soon as the geese regained their mobility they left Fjørungen, and numbers rose sharply at Eungane, a lake ice-covered until mid-July. At the new site large numbers of geese grazed the rich grass zone for more than two weeks. In the last week of August, by which time the families are also on the wing, a further shift occurs, in favour of the dry hilly slopes (fjellmark) with extensive growth of *Equisetum variegatum,* as well as the muddy wet alluvial plains, where a great variety of graminoids and herbs are to be found among the polygons (Table 5). Both of these habitats are far from open water. In the final phase prior to departure, especially from the second week of September on, the geese visit the lush green meadows underneath the sea-bird cliffs (Ingeborgfjellet) (see also Fig. 31). To rest the geese return to the lakes, and they may sleep on islets in glacial streams as well.

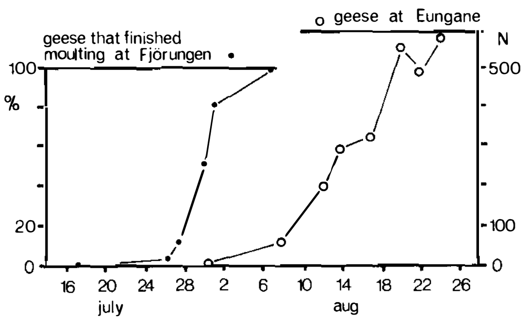


Fig. 30. Timing of regaining flight abilities of a moulting flock (non-parents, Fjørungen 1981). The flying geese colonize a new feeding area (around Eungane).

Despite the vast dimensions of the area accessible to the geese when they regain flight (Fig. 32), exploitation of the vegetation is relatively heavy. In the grassy areas a cycle of grazing occurs, whereby regrowth seems to be used, and on the hilly slopes a single grazing wave may remove more than 40% of the *Equisetum* stock. This final feeding phase may well be critical in achieving the condition needed to undertake the return migration to the wintering areas successfully. Especially for the goslings the autumn migration is likely to be a major hurdle. Comparison of family size at last sighting in Spitsbergen at the end of the summer, with the number of goslings accompanying the same marked parents at first observation in Scotland, gives a measure of gosling mortality during migration. Early hatching broods suffered a lower mortality than late broods (13.4% and 37.5% respectively, $P < 0.01$) in 1980, presumably on account of the longer preparatory period. Access to better feeding areas may further enhance the opportunities of the early families to build up condition prior to the migration.

Discussion: avian reproduction in relation to nutrient requirements

An overview of the factors determining reproductive outcome in the Barnacle Goose is given in Fig. 33. Evidence for the importance of spring

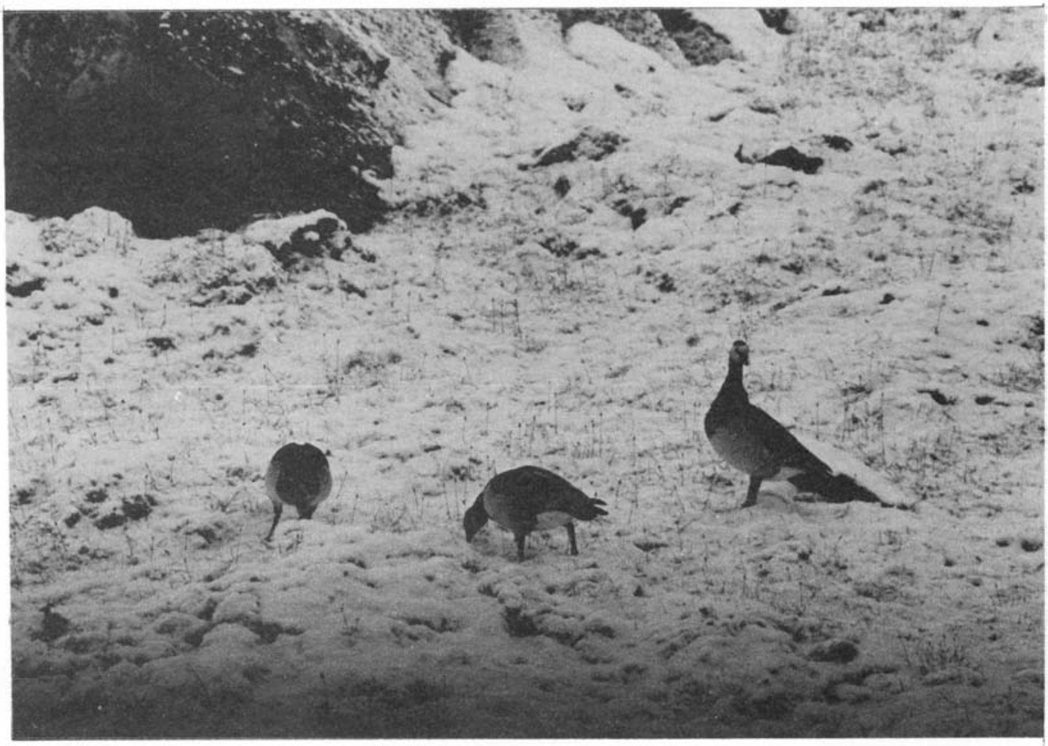


Fig. 31. One of the last days of the Barnacle Geese on Spitsbergen: second half of September in the snow.

body condition in this species is still fragmentary (Owen 1980b) and efforts should be redoubled to actually measure the rate of accumulation of body reserves in the spring staging areas, in particular along the Norwegian coast (see Gullestad 1984) and relate state of reserves in individual birds to subsequent events. The reality of the link between condition and reproductive success is underlined by work on other geese, and the best data on the individual level are those on the Brent presented by Ebbinge et al. (1982). Less direct evidence on the crucial importance of spring accumulation of reserves is forthcoming when events on the breeding grounds are related to spring weather. Davies & Cooke (1983) demonstrate a disruption in breeding (lowered clutch size, higher incidence of non-breeding) in the Snow Goose nesting on Hudson Bay in response to drought conditions on the prairie staging grounds and postulate a causal link to lowered state of reserves in such years. The importance of body reserves in ensuring reproductive success, or in more general terms in modulating reproductive output, is not restricted to arctic-nesting geese but is likely to be a pervasive factor important in all birds. A recent evaluation of the individual state of body reserves in an autopsy study of the Lesser Black-backed Gull *Larus fuscus* demonstrated a close correlation between egg number and egg quality with measures of body condition (Houston et al. 1983) and we expect similar relations to emerge in other species as work on this neglected topic proceeds.

The importance of food intake on the breeding grounds is the subject of this report, and the first point to consider is the interrelation between intake, weather, and success. Owen & Norderhaug (1977) pointed out that breeding success in this species is low in seasons when spring is late in the north, and they quantified this relation by comparing the annual crop of young (expressed as per cent juveniles observed in the winter flocks in Scotland) with the date of snowmelt in the breeding area (recorded through the years at the Isfjord Radio Station at Kapp Linné, and thus close to our own study area). A strong negative relation was apparent in these data (Fig. 34) and

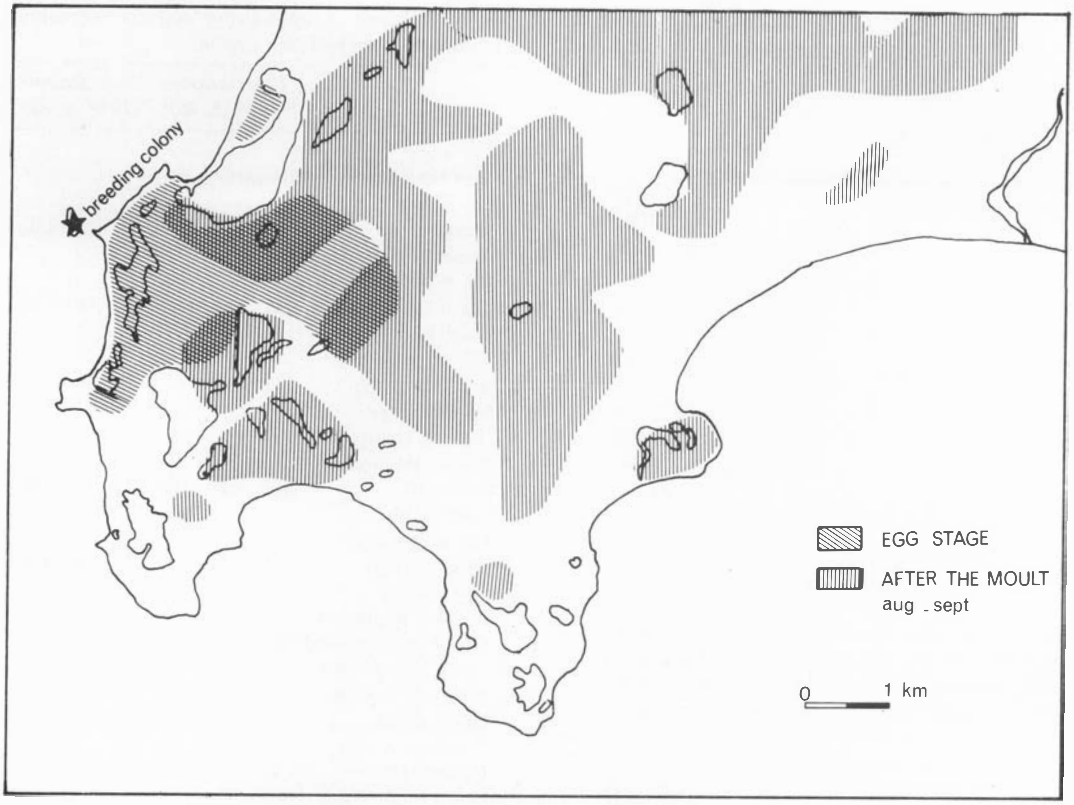


Fig. 32. Utilization of tundra by Barnacle Geese throughout the summer (1981). In the moult period the lakes and immediate surroundings are used.

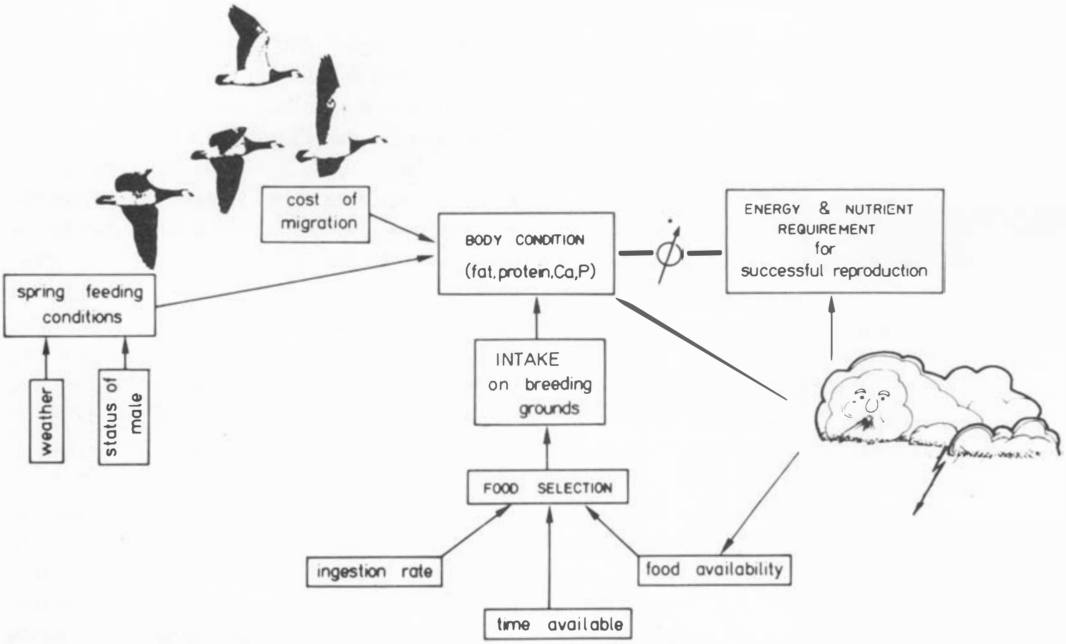


Fig. 33. Main factors impinging on reproductive success in the Barnacle Goose (see text).

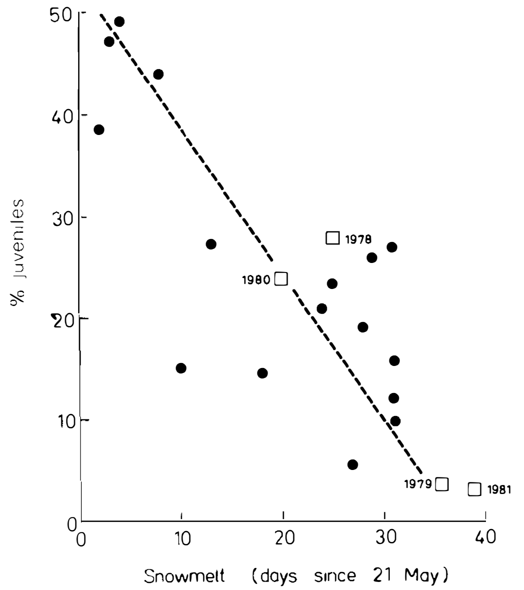


Fig. 34. Relation between reproductive success (as measured by percentage juveniles observed in the winter flock in Scotland) and date of snow-melt in the breeding area. The data (taken from Owen & Norderhaug 1977) refer to snow-melt at the Isfjord radio station at the north end of our study area, and when the four years of our study (1978--81) are entered they fit the regression from former years reasonably well, even though we relied on snow-melt data at the colony (see text).

Table 6. *Decrease in reproductive potential: comparison between early and late season.*

	Early seasons (1978 & 80)	*Late seasons (1979 & 81)*
1. *Egg stage*		
(a) non-breeding* (% of pairs not laying eggs)	11%(n=205)	26%(n=231)
(b) failing in egg stage (% of nests/clutches not hatched)	32 (n=183)	77 (n=172)
(c) total loss (% of pairs not hatching eggs)	39	83
2. *Gosling stage*		
(a) loss in colony (% of goslings predated)	10 (n=181)	27 (n=143)
(b) tundra phase (% of goslings disappearing)	24	24 (n=454)**
(c) loss during autumn migration (% of goslings lost)	21	21 (n=378)**
(d) total loss gosling stage (% young hatched not reaching winter quarters)	46	56

*) calculated over all pairs three years or older.

**) since there were no consistent differences, gosling losses after island departure pooled for all seasons.

when the points for the years of our study are added they fit the pattern quite well. For 1978–81 we have had to rely on our own snow transect data since unfortunately the observations at Isfjord Radio have been discontinued. It should be noted that in our experience snowmelt at Diabas is several days later than at the opening of the Isfjord where the radio station is located, so the fit of the recent years to the earlier regression line is still closer than indicated in the figure. Why are snow conditions so sensitive a predictor of gosling recruitment in the Barnacle Goose?

When our data for the two early seasons and the two late seasons are compared (Table 6) it will be noted that up to the point of island departure higher losses are suffered in late seasons at all stages. First, a higher proportion of the potential parents (all pairs in the vicinity three years of age or older) that actually lay is much lower, and failure during incubation is more than doubled. The net result of these two effects is that less than one fifth of the parents produce goslings in late seasons, as contrasted to more than half in early seasons. In the immediate post-hatch period goslings suffer predation on the island and on the shorebound journey, on account of Glaucous Gulls *Larus hyperboreus* that share the breeding island and patrol continuously. According to our observations, the parent geese were far less effective in protecting their goslings in late years, in some cases showing what might even be termed negligence in allowing the goslings to straggle. A major contributory cause to the higher loss is the added difficulties the geese experience in finding a suitable point at which to take to the water, as in late seasons much of the island perimeter is ice-bound. Long hesitation on the cliff edge and trekking back and forth between alternative departure sites together exert a heavy toll. In distinction to these findings, we obtained no evidence that survival of the goslings once they had reached the tundra was unfavourably influenced in the late seasons.

Late seasons are thus typified by a high rate of failure during the egg stage in the Barnacle Goose, and we must seek an explanation. From other goose studies we know that body reserves are being steadily depleted at this period, and the pattern of depletion will have a decisive influence on the daily ration required to balance the budget. The most extensive data refer to the Canada Goose *Branta canadensis* studied in semi-captivity by Aldrich & Raveling (1983). In this study the incubating females were weighed regularly, and nest recesses to feed were also recorded. It was found that the weekly decrement in body weight in fact declined in the course of incubation, and to compensate for this the nesting birds spent progressively longer away from the nest feeding. In other words, as incubation proceeds less and less energy is available from internal reserves, and the birds must collect more and more from the environment to make up for this shortfall. In these experiments, food was always available in excess, and Aldrich & Raveling point out that an endogenous control of body weight loss is implied, food intake being regulated to maintain body weight along a predetermined trajectory of decline, supporting the earlier observations of Sherry et al. (1980) on penned Burmese Red Jungle Fowl, where the pattern of weight loss during incubation was not altered by providing supplementary food. The pattern of weight loss in these single-sex incubators thus approximates the pattern during starvation, where Maho et al. (1981) provide detailed records for the domestic goose, again showing that the provision of energy from the body reserves follows a steadily declining course. Referring to carcass analysis, Aldrich & Raveling (1983) calculate that the observed weight decline in incubating Canada Geese implies a near-exhaustion of the fat supplies in the body, and a partial reliance on muscle protein as well.

An interpretation of these results for our situation entails postulating a generalized pattern of weight loss typical for the species at this time, and a direct relationship between the amount of supplies becoming available from the body and the need for supplementary foraging on the tundra. Given the pattern established for the Canada Goose (and confirmed for the Barnacle Goose by Owen (1980b) who measured the decline in body weight of birds breeding in captivity in England) we would therefore expect an increasing need for tundra foraging in the course of incubation. When we plot our time budget data for individual birds in relation to calendar date, an increasing trend emerges unmistakably (Fig. 35). Moreover, when the data are segregated for parents subsequently hatching their eggs or failing to do so, the two groups differ distinctly (see the figure). Both groups show a similar slope (i.e. the increment in feeding time with date is similar) but the failed nesters operate at a higher level. Either these individuals started with lower levels of reserves, or they suffered a lower rate of return during tundra foraging (as documented on the *Salix* plots). In our view it is likely that both factors combine, birds with higher foraging proficiency (under the influence of experience as well as social status)

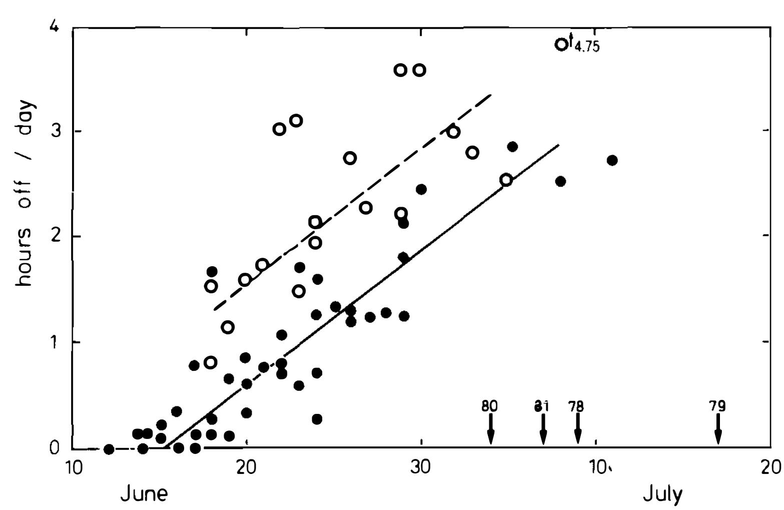


Fig. 35. Daily nest absence (in hours) in relation to date for female geese (open circles eventually failing, solid circles successfully hatching eggs) at the Diabas colony. Data for all seasons combined (arrows show mean date of hatch each year).

both attaining better condition beforehand as well as higher intake rates on the nesting grounds. Relevant to our observation of differences in nest attendance between individuals, Aldrich & Raveling (1983) found that Canada Goose females entering incubation at higher body weights spent less time away from the nest than those at lower body weight.

These findings throw light on the problems faced by the geese in late seasons. As time goes on the daily foraging requirement increases steadily, and in the late years (see arrows in Fig. 35) long absences are unavoidable, with all the risks these entail for egg loss. The problem is made worse by the sharply curtailed foraging opportunities in the late seasons, but we cannot yet quantify this effect in terms of the time penalty involved. To sum up, few parents manage to hatch eggs in late seasons primarily because the high rate of nest attendance required is not compatible with the depleted state of the internal reserves, and high rates of intake cannot be achieved on the tundra to compensate for this. Put in another way, individual females can be arranged each year along a gradient of ascending body condition, and where the cut-off point comes as concerns ability to complete incubation successfully will depend on weather and plant phenology in the season involved. Nest desertion is the underlying cause of egg loss, predation being merely the agency removing eggs from the nest already in the process of abandonment, in keeping with the view earlier formulated by Newton & Kerbes (1974) in their studies on nesting failure in the Greylag Goose *Anser anser*.

In view of the low hatching rate in late seasons, and the penalties to the females that lay in terms of lowered survival (J. Prop, unpubl.) it is something of a paradox that only some 25% of pairs fail to lay, i.e. decide at the onset not to breed. McInnes et al. (1974) provide a six-year run of data on Canada Goose breeding in the Arctic and report a comparable rate of non-nesting in late years. An interpretation of why the majority of parents persist in attempting to breed in the face of virtually hopeless conditions must depend on evaluating the contribution such late seasons may make to recruitment of goslings that later become parents themselves. As we have seen, from the point of hatching on, no penalties accrue to the young of late seasons, and in view of the lesser degree of competition it is possible that there are special advantages enjoyed by young surviving from late seasons, making it worthwhile for the parents to undertake the risk of breeding. For instance, if young in late seasons achieve larger physical size, this will confer a higher dominance rank in later life as has been demonstrated in captive flocks (Würdinger 1975). Conceivably the strain on the parents of tending the young through the winter may be paid for in terms of a lower body weight in spring (as has been found in Bewick's Swan *Cygnus bewickii* (Scott 1980a, 1980b)) and this may be less in years when there are few young in the population. Studies on individually marked young will be needed to follow these points up.

We have emphasized the role of maternal nutrition in ensuring reproductive success in the Barnacle Goose, and there are many parallels from studies on other herbivorous birds, particularly tetraonids. Watson and his co-workers have underlined the crucial importance of maternal nutrition in determining reproductive output (clutch size, hatching success, subsequent survival chances of the young) in the Red Grouse *Lagopus lagopus* (Moss et al. 1975) and this view was upheld in later experiments on the Ptarmigan *Lagopus mutus* (Moss et al. 1984). In the Red Grouse, variations in the quality of the main food (heather) was deemed responsible for variations in success from place to place and from year to year, and the search for «quality» implicates the important contribution made by growth conditions in the spring (weather influencing plant composition). A complete answer can only be given at a biochemical level, but current work emphasizes the importance of protein content in the food of herbivores. This point is demonstrated for the Ruffed Grouse *Bonasa umbellus* in Fig. 36, summarizing results from a captive study. Groups of hens were held on diets differing in protein level but not in metabolizable energy, and although the test groups began laying about the same date, egg weight, clutch size, hatching success, chick weight and survival were all related linearly to increasing protein content of the ration (Beckerton & Middleton 1982). It is unfortunately not known where the natural food falls on this protein scale. Recent studies on

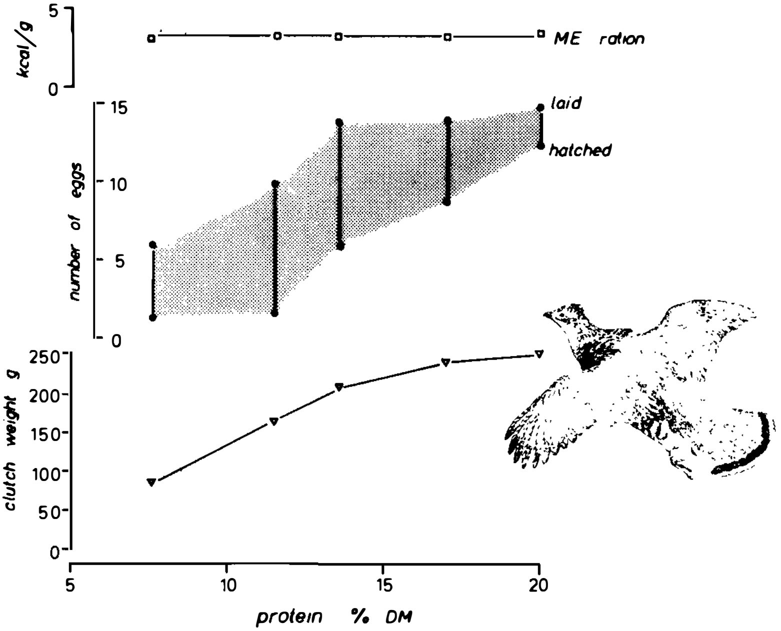


Fig. 36. The crucial role of protein in the maternal diet on reproductive output in the Ruffed Grouse *Bonasa umbellus*, studied in captivity (assembled from Beckerton & Middleton 1982). Groups of hens were kept on rations of differing protein content, but closely similar energetic content (upper graph). With increasing protein levels in the diet more eggs are laid, egg weight increases, and hatching success improves.

selection of specific plants by geese preparatory to breeding have also emphasized the role of protein (Ydenberg & Prins 1981; Thomas & Prevett 1982). The final answer will come when the repercussions of diet selection for accumulation of body condition becomes known at an individual level, and this is a path we need to follow.

Not all parent Barnacle Geese are equally proficient in exploiting the tundra vegetation, and both in the colony phase and during the moult these differences between parents have implications for reproductive output. The social grazing system assists the individual in finding food and minimizes the risk of predation (especially by the Arctic fox, a constant danger on the tundra) but at the same time entails inequality in grazing opportunity. The effects of inequality of feeding opportunities are cumulative with regard to reproductive output, and the point in the breeding chronology at which loss or failure occurs will depend on the severity of the season. Parent geese face a series of hurdles as follows: a) achieve spring condition, b) obtain nest sites providing extra food, protection from the elements and view of neighbours, c) maximize food intake during nest absence by precise timing of foraging trips in relation to the local plant cycle of abundance, and d) obtain access to the richest feeding areas during the moult. It may come as a surprise to find that even at current population levels geese in the study area effectively deplete the food source in the prime areas, such that density effects on reproductive output are already measurable. The Barnacle Goose is adapted to fill an extremely demanding niche and this makes the safeguarding of its year-round chain of habitats an obligation for all of us.

Acknowledgements

Any expedition is a joint venture, and it is not possible to thank everyone involved. We make an exception in rendering thanks for the unstinting support provided by the Sysselmannen på Svalbard and his staff, and we remember with gratitude the many courtesies extended by Norsk Polarinstitutt and the staff of Isfjord Radio, our link to the outside world. The logistic support of the Netherlands Foundation for Scientific Research in the Arctic is gratefully acknowledged. Sjoerd Dirksen, Eduard Koopman, Martin Nugent, Herbert Prins, Robert Rubertus, Tom van Spanje, Jan de Vries and Theo Vulink all had an important share in the collection of the data presented. The expeditions were funded by the Pieter Langenhuys Fonds, and received additional help from the Ecosciences Panel in Brussels, the Royal Society (London), the British Ornithologists' Union, the Netherlands Organisation for the Advancement of Pure Research (Z.W.O.), and Groningen University. The project was conceived and carried out as a joint undertaking with the Wildfowl Trust, and we would like to mention particularly Myrfyn Owen and Malcolm Ogilvie for their help over the years.

References

Aldrich, T.W. & Raveling, D.G. 1983: Effects of experience and body weight on incubation behavior of Canada Geese. *The Auk 100:* 670–679.

Barry, T.W. 1962: Effect of late seasons on Atlantic Brant reproduction. *J. Wildl.Manage. 26:* 19–26.

Beckerton, P.R. & Middelton, A.L.A. 1982: Effects of dietary protein levels on Ruffed Grouse reproduction. *J.Wildl. Manage. 46:* 569–579.

Chapin, F.S.III. 1978: Phosphate uptake and nutrient utilization by Barrow Tundra vegetation.Pp. 483–507 *in* Tieszen, L.L. (ed.): *Vegetation and production ecology of an Alaskan Arctic Tundra.* Springer Verlag.

Cooke, F., Scott Findlay, C., Rockwell, R.F. & Abraham, K.F. 1983: Life history studies of the Lesser Snow Goose *(Anser caerulescens caerulescens)* II. Colony structure. *Behav. Ecol.Sociobiol. 12:* 153–159.

Cooper, J.A. 1978: The history and breeding biology of the Canada Geese of Marshy Point, Manitoba. *Wildlife Monographs No. 61.* 87 pp.

Davies, J.C. & Cooke, F. 1983: Annual nesting productivity in Snow Geese: Prairie droughts and arctic springs. *J. Wildl. Manage. 47:* 291–296.

Dittami, J., Kennedy, S. & Thomforde, C. 1979: Observations on Barnacle Goose *Branta leucopsis* breeding in Spitsbergen 1975. *J.Orn. 120:* 188–195.

Drent, R., Ebbinge, B. & Weijand, B. 1981: Balancing the energy budgets of arctic-breeding geese throughout the annual cycle: a progress report. *Verh.orn.Ges.Bayern 23:* 239–264.

Ebbinge, B. & Ebbinge-Dalmeijer, D. 1977: Barnacle Geese *(Branta leucopsis)* in the Arctic summer – a reconnaissance trip to Svalbard. *Norsk Polarinstitutt Årbok 1975:* 119–138.

Ebbinge, B., St. Joseph, A., Prokosch, P. & Spaans, B. 1982: The importance of spring staging areas for arctic-breeding geese, wintering in western Europe. *Aquila 89:* 249–258.

Finney, G. & Cooke, F. 1978: Reproductive habits in the Snow Goose: the influence of female age. *Condor 80:* 147–158.

Gauthier, G. & Bédard, J. in press: Fat reserves and condition in Greater Snow Geese. *J.Wildl.Manage.*

Harvey, J.M. 1971: Factors affecting blue goose nesting success. *Can.J.Zool. 49:* 223–234.

Houston, D.C., Jones, P.J. & Sibly, R.M. 1983: The effect of female body condition on egg laying in Lesser Black-backed Gulls. *Larus fuscus. J.Zool.,Lond. 200:* 509–520.

Inglis, I.R. 1977: The breeding behaviour of the Pink-footed Goose: behavioural correlates of nesting success. *Anim.Behav. 25 :* 747–764.

Jefferies, R.L., Jensen, A. & Abraham, K.F. 1979: Vegetational development and the effect of geese on vegetation at La Perouse Bay, Manitoba Canada. *Can.J.Bot. 57:* 1429–1450.

Jefferies, R.L., Cargill, S.M. & Bazely, D.R. 1983: Effects of grazing by Lesser Snow Geese on vegetation of an arctic salt marsh. *(Lund symposium).*

Korschgen, C.E. 1977: Breeding stress of female Eiders in Maine. *J.Wildl.Manage. 41:* 360–373.

Lazarus, J. & Inglis, I.R. 1978: The breeding behaviour of the Pinkfooted Goose: parental care and vigilant behaviour during the fledging period. *Behaviour 65:* 62–87.

Maho, Y.le, Vu Van Kha, H., Koubi, H., Dewasmes, G., Girard, J., Fevré, P. & Cagnard, M. 1981: Body composition, energy expenditure, and plasma metabolics in long-term fasting geese. *Am.J.Physiol. 241:* E342–354.

McInnes, C.D., Davis, R.A., Jones, R.N., Lieff, B.C. & Pakulak, A.J. 1974: Reproductive efficiency of McConnel River Small Canada Geese. *J.Wildl.Manage. 38:* 686–707.

McLandress, M.R. & Raveling, D.G. 1981: Hyperphagia and social behaviour of Canada Geese *Branta canadensis* prior to spring migration. *Wilson Bull. 93:* 310–324.

Moss, R., Watson, A. & Parr, R. 1975: Maternal nutrition and breeding success in Red Grouse *(Lagopus lagopus scoticus). J.Anim.Ecol. 44:* 233–244.

Moss, R. & Watson, A. 1984: Maternal nutrition, egg quality and breeding success of Scottish Ptarmigan *Lagopus mutus. Ibis 126:* 212–220.

Newton, I. 1977: Timing and success of breeding in tundra-nesting geese.Pp. 113–126 *in* Stonehouse, B. & Perrins, C. (eds.): *Evolutionary ecology.* MacMillan.

Newton, I. & Kerbes, R.H. 1974: Breeding of Greylag Geese *Anser anser* on the Outer Herbrides Scotland. *J.Anim.Ecol. 43:* 771–783.

Owen, M. 1980a: The role of refuges in wildfowl management. Pp. 144–156 *in* Wright, E.N., Inglis, I.R. & Feare, C. (eds.): *Bird problems in agriculture.* British Crop Protection Council, London.

Owen, M. 1980b: *Wild geese of the world.* Batsford Ltd., London, 236 pp.

Owen, M. 1982: Population dynamics of Svalbard Barnacle Geese 1979–1980. *Aquila 89:* 229–247.

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose *Branta leucopsis. Nor. Polarinst. Skr. 181* (this volume).

Owen, M. & Norderhaug, M. 1977: Population dynamics of Barnacle Geese *Branta leucopsis* breeding in Svalbard, 1948–1976. *Ornis Scand. 8:* 161–174.

Owen, M. & Ogilvie, M.A. 1979: Wing molt and weights of Barnacle Geese in Spitsbergen. *Condor 81:* 42–52.

Owen, M., Drent, R.H., Ogilvie, M.A. & Spanje, T.M.van. 1978: Numbers, distribution and catching of Barnacle Geese *(Branta leucopsis)* on the Nordenskiöldkysten Svalbard in 1977. *Norsk Polarinstitutt Årbok 1977:* 247–258.

Prop, J., Eerden, M.R.van, Daan, S., Drent, R.H., Tinbergen, J.M. & St. Joseph, A.M. 1980: Ecology of the Barnacle Goose *(Branta leucopsis)* during the breeding season: preliminary results from expeditions to Spitsbergen in 1977 and 1978. Pp. 50–112 in: *Proceedings of the Norwegian-Netherlands Symposium on Svalbard* (Arctic Centre, Groningen).

Raveling, D.G. 1970: Dominance relationships and agonistic behavior of Canada Geese in winter. *Behaviour 37:* 291–317.

Raveling, D.G. 1978: The timing of egg laying by northern geese. *The Auk 95:* 294–303.

Raveling, D.G. 1981: Survival, experience, and age in relation to breeding success of Canada Geese. *J.Wildl.Manage. 45:* 817–829.

Ryder, J.P. 1972: Biology of nesting Ross's Geese. *Ardea 60:* 185–215.

Ryder, J.P. 1975: The significance of territory size in colonial nesting geese – a hypothesis. *Wildfowl 26:* 114–116.

Scott, D.K. 1980a: Functional aspects of the pair bond in winter in Bewick's Swans *(Cygnus columbianus bewickii). Behav. Ecol.Sociobiol. 7:* 323–327.

Scott, D.K. 1980b: Functional aspects of prolonged parental care in Bewick's Swans. *Anim.Behav. 28:* 939–952.

Smith, T.J. & Odum, W.E. 1981: The effects of grazing by Snow Geese *Anser caerulescens* ssp. *atlantica* on coastal salt marshes. *Ecology 62:* 98-106.

Stroud, D.A. 1982: Observations on the incubation and post-hatching behaviour of the Greenland White-fronted Goose. *Wildfowl 33:* 63–72.

Sherry, D.G., Mrosovsky, N. & Hogan, J.A. 1980: Weight loss and anorexia during incubation in birds. *J.Comp.Physiol. Psychol. 94:* 89–98.

Thomas, V.G. 1983: Spring migration: the prelude to goose reproduction and a review of its implications. Pp. 73–81 *in: First Western Hemisphere waterfowl and waterbird symposium* (ed. H.Boyd). Canadian Wildlife Service, Ottawa.

Thomas, V.G. & Prevett, J.P. 1982: The role of Horsetails (Equisetaceae) in the nutrition of northern-breeding geese. *Oecologia 53:* 359–363.

Würdinger, I. 1975: Vergleichend morphologische Untersuchungen zur Jungendentwicklung von Anser- und Branta-Arten. *J.Orn. 116:* 65-86.

Ydenberg, R.C. & Prins, H.H.Th. 1981: Spring grazing and the manipulation of food quality by Barnacle Geese. *J.appl. Ecol. 183:* 443–453.

JESPER MADSEN:

Status of the Svalbard population of Light-bellied Brent Geese *Branta bernicla hrota* wintering in Denmark 1980–1983*

Madsen, J. 1984: Status of the Svalbard population of Light-bellied Brent Geese *Branta bernicla hrota* wintering in Denmark 1980–1983. *Nor. Polarinst. Skr. 181:* 119–124.

The present knowledge of the size of the Svalbard population of Light-bellied Brent Geese is summarized together with a description of the migration pattern and habitat utilization in its Danish wintering grounds. During the period 1970 to 1980-83 the population has increased from 1600–2000 to 3500–4000 individuals. The population has five regular haunts in Denmark and one in England. The size of the wintering population in Lindisfarne, England, is negatively correlated to winter temperatures in Denmark. The Brents have a narrow feeding habitat spectrum ranging from shallow waters/mud flats to salt marshes, and to a lesser degree pastures. A shift from shallow waters to saltings takes place in spring.

Jesper Madsen, Institut for Zoologi og Zoofysiologi, Zoologisk Laboratorium, Aarhus Universitet, DK-8000 Aarhus C, Denmark.

Introduction

The dramatic break-down of the Svalbard population of Light-bellied Brent Geese *Branta bernicla hrota* in the first half of this century has been documented by Salomonsen (1958) and Norderhaug (1970). A later review of the status of the population (Fog 1972) showed that the population had diminished to 1600–2000 individuals by 1970, making it one of the most endangered goose stocks of the world.

During the three year period 1980/81 to 1982/83 the Goose Study Group of the Danish Ornithological Society has carried out a national survey of the staging and wintering goose populations in Denmark in cooperation with the Game Biology Station, Kalø, the National Agency for the Protection of Nature, Monuments and Sites, and the Zoological Museum, Copenhagen. This paper summarizes the present knowledge of the size of the Svalbard Brent population together with a description of the seasonal pattern of migration and habitat utilization in the Danish wintering grounds during the three seasons mentioned. Furthermore a comparison with the numbers wintering in Lindisfarne, England, is made. A detailed account on the methods and organization of the goose counts is given by Madsen & Lund (1982). In a more detailed report under preparation site descriptions including threats and management of the goose haunts will be given, and the present paper only outlines the overall situation of the population.

Population level and breeding success

Despite the small population size it is difficult to survey the flocks and make a correct estimate of the annual population level, partly because the population is very mobile, partly because the haunts are often difficult to cover from the ground due to their vast size. In Table 1 the totals from the three survey seasons in Denmark are presented together with the Lindisfarne counts. The total number of geese counted is seen to vary a lot between months. Especially in October, November, and March, geese are overlooked by the counts.

The breeding success expressed as the proportion of juveniles seen in the flocks in Denmark in winter and spring was extremely bad in 1981 (Table 2), while 1980 and 1982 were relatively

---

* Report No. 3 of the Goose Study Group of the Danish Ornithological Society.

Table 1. *Mid-monthly totals of Light-bellied Brents in Denmark and Lindisfarne, England. Peak numbers recorded in each season are in italics.*

		Oct.	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*
1980/81	Denmark	53	851	2107	716	1550	1283	2550	2144
	Lindisfarne	8	560	560	700	204	56	0	0
	Total	65	1411	*2667*	1416	1754	1339	2550	2144
1981/82	Denmark	861	73	2500	0	480	2115	2679	3436
	Lindisfarne	23	350	950	1800	1800	5	0	0
	Total	884	423	*3450*	1800	2280	2120	2679	3436
1982/83	Denmark	38	538	1992	3142	2013	1508	2841	2652
	Lindisfarne	10	360	610	270	180	12	0	0
	Total	48	898	2602	*3412*	2193	1520	2841	2652

successful seasons. However, compared to the maximum number of geese counted in the following winter, there is poor agreement between the number of geese expected from the breeding success and the observed number. Thus, the highest number during the three years was reached in December 1981/82 with 3450 individuals (Table 1). This season, however, there were hardly any juveniles in the flocks. This indicates that the population numbers at least 3450 birds, whereas in seasons with good breeding success the population probably exceeds 4000 birds. Where the remaining, missing geese stay is unknown, but methodological problems in connection with the counts probably play a significant role. However, there may be some hitherto overlooked, remote haunts, e.g. in the Wadden Sea where parts of the population may be hidden. Sightings of flocks in the Dutch Wadden Sea have recently been reported, and these might indicate the whereabouts of the missing geese. This question needs further documentation.

Table 2. *Juvenile percentage 1980–1983 in Light-bellied Brents. In 1980 two estimates are given (from Denmark and England, resp.).*

	Juv. (%)	*Sample*
1980	16.5–25	450
1981	1.5	813
1982	18.3	898

Distribution of the population

The population has five regular haunts in Denmark which are used almost in succession: the Wadden Sea, the Mariager and Randers Fjords, Nissum Bredning, Agerø, and Nissum Fjord. Fig. 1 gives an impression of the seasonal distribution and migration pattern of the Brents within the Danish and English wintering areas.

The Light-bellied Brents are the earliest of arctic nesting geese to arrive in Denmark in the autumn. The passage at Blåvandshuk in Western Jutland peaks before mid September (birds on their way to the Wadden Sea), more than two weeks before the peak passage of Dark-bellied Brents *Branta bernicla bernicla* (Meltofte 1973). In October flocks are seen almost exclusively in the Wadden Sea (irregularly in the Nissum Fjord), and a flock of 795 is the maximum single flock recorded here during the three seasons (in September 1978, 1100 were counted at Mandø (H. Meltofte pers. comm.)). However, due to the vastness of the area and mixing of the flocks of Light-bellied and Dark-bellied Brents, the numbers are without doubt underestimated, although local observers believe that 'thousands' cannot be overlooked (T. Bregnballe pers. comm.). From November to March a major part of the population is seen in the Mariager and Randers Fjords, though in varying numbers depending on the severeness of the winter. From November to March geese in varying numbers are seen in Lindisfarne. Wintering flocks are also seen in the Wadden Sea, but the exact numbers are unknown. By March most geese have left Lindisfarne and the numbers increase in western and north-western Jutland (the importance of Nissum Bredning might be underestimated due to the vast areas of shallow water which are difficult to cover from the ground). In April and May the population is concentrated in Nissum Fjord and around Agerø. Mass departure from Nissum Fjord has been recorded in two of the three seasons: 29 May 1982 and 27 May 1983.

The migration to Lindisfarne has been analys-

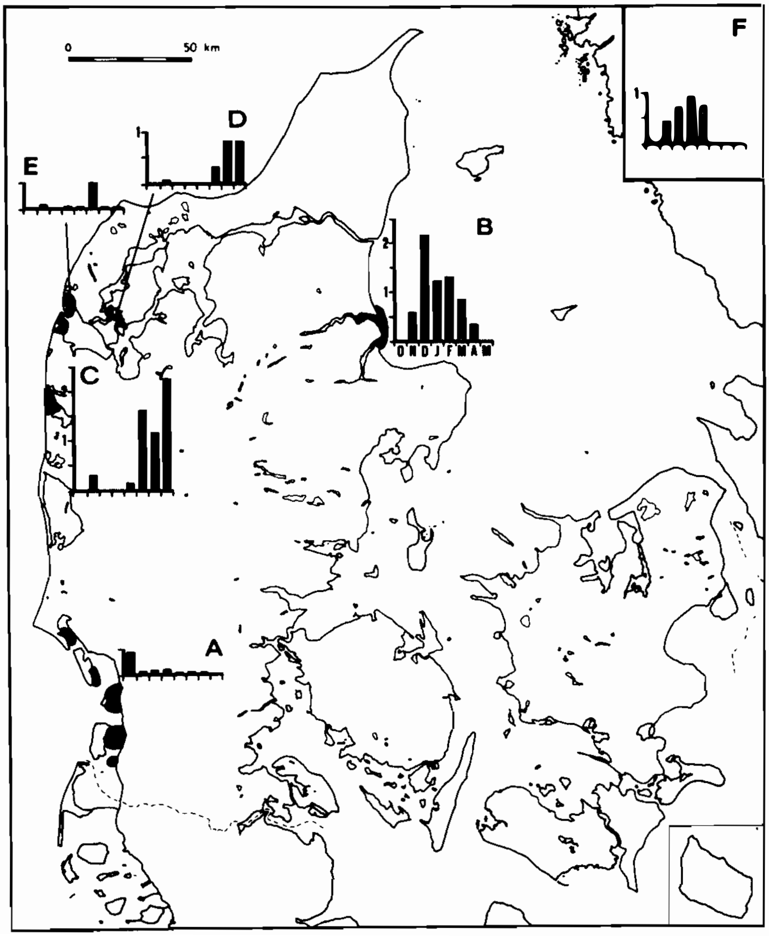


Fig. 1. Seasonal distribution of Light-bellied Brent in the winter range (mean of monthly maxima 1980–83). A: Wadden Sea, B: Mariager/Randers Fjords, C: Nissum Fjord, D: Agerø, E: Nissum Bredning, F: Lindisfarne. Regular haunts are black; in the Wadden Sea two irregular sites are shaded. Figures are in thousands.

ed in relation to weather conditions in Denmark. In the period 1971/72 to 1982/83 a significant inverse relationship is found between the numbers in Lindisfarne and the mean monthly temperatures in December, January, and February (Table 3) whereas there is no correlation in November and March. The strongest correlation is found in January (see also Fig. 2). The explanation of this compared to the correlation in December is probably that it takes some time before the shallow waters (feeding habitat of the geese in winter – see below) are ice-bound in cold winters and the geese displaced; the weaker correlation in February may be due to the fact that the geese which were displaced to Lindisfarne in January will stay there despite the fact that February is mild in Denmark. The analysis is rough, as it takes no notice of population development (because the exact annual level is unknown) and does not take the temperature in Lindisfarne into account. If the population development from 1971 to 1982 is assumed to have had a linear course, the proportion of the population wintering in Lindisfarne can be used instead of the actual number. This conversion gives a correlation coefficient similar to that above (Table 3). Both analyses indicate that (1) big flocks of Brents are only seen in Lindisfarne when the Danish waters are icebound, and (2) only a small segment of the population (200–700 geese) migrates to Lindisfarne independently of temperatures in Denmark.

Habitat utilization

In the Danish goose count scheme, all flocks of geese within a site have been mapped and related to habitat (with a view to the activity of the flocks). For each site the number of goose days per month in the three seasons has been calcul-

Table 3. *Relationship between mean monthly temperatures in Denmark and the number of Brents observed in Lindisfarne 1971/72 to 1982/83 expressed by the Spearman's rank correlation coefficient.*

	Nov.	*Dec.*	*Jan.*	*Feb.*	*Mar.*
Mean temp. °C in Denmark	5.0	2.0	0.4	- 0.1	2.7
Mean number of geese in Lindisfarne	120	632	731	538	81
r_s	0.16	0.64	0.91	0.60	- 0.08
p	n.s.	< 0.05	< 0.01	< 0.05	n.s.
n	12	12	12	10	10

ated for each habitat type (operating with 12 different types; see Madsen & Lund 1982). Fig. 3 shows the overall utilization of feeding habitats of the Light-bellied Brents from October to May (all sites summed). The population is seen to have a narrow feeding habitat spectrum ranging from shallow waters/mudflats to saltings, and to a small degree, pastures. In autumn and winter the geese feed almost exclusively on shallow waters and mud-flats (probably the diet in these two habitats is similar), and to a small extent on saltings during high tide in the Wadden Sea. In early spring up to 16% of the goose days are spent on fertilized pastures (Nissum Fjord), but in April and May feeding on saltings predominates (Nissum Fjord and Agerø), although some feeding still takes place on shallow waters in Nissum Fjord. This sequence of habitat shift is quite similar to that of the Dark-bellied Brents in Denmark and in the North Frisian Wadden Sea (Prokosch 1981). The short period of pasture feeding may reflect an earlier primary production there compared to the saltings, but may also be caused by an attraction to flocks of Pink-footed Geese *Anser brachyrhynchus* feeding in this habitat in the Nissum Fjord in the spring.

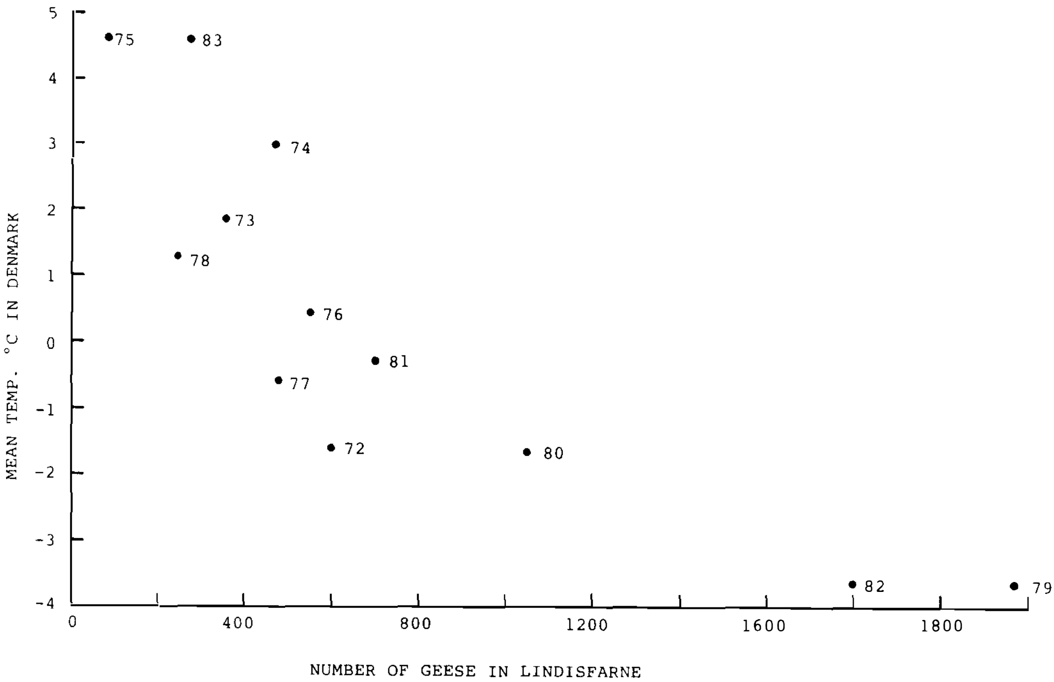


Fig. 2. The relationship between mean temperature in Denmark and number of Brents in Lindisfarne in January 1972–83.

Discussion

From a level of 1600–2000 individuals in 1967/68–1970/71 (Fog 1972) the population has by 1980–1983 increased to 3450–4000 birds, varying with the annual breeding success. Already in the mid 1970s Fog (1977) noted an increase to at least 2750 individuals. As no ringing of the population has taken place in recent years, nor has the annual breeding success been estimated prior to 1979, the doubling of the population cannot be evaluated by means of an analysis of the population dynamics. However, the increase has taken place since the general protection of the Brent Goose was introduced in Denmark in 1972, and a decreased shooting mortality is the most probable reason for the positive development. Compared to the other Svalbard geese the Brents have the lowest reproductive rate (compare Madsen 1984; Owen 1984) and a high adult survival rate is a prerequisite to maintain the population. Prokosch (1981) has shown, although later modified, that the protection of the Dark-bellied Brent (especially the 1972 protection in Denmark) increased the adult survival rate, leading to population growth.

The development is without doubt real. In the last decade the spring population in the Nissum Fjord has remained unchanged or has increased a little (P.U. Jepsen pers. comm.), while the saltings around Agerø only recently have been taken into use by the population (the last 7–8 years), and the population here is still increasing.

Because of the difficulties in surveying the population, it is necessary to continue simultaneous counts covering all sites, including Lindisfarne, in order to obtain good population estimates. Judging from surveys carried out so far, the best coverage is reached in mid-winter (January) and April/May. Efforts should be made for a continued coordination of the counts and for annual assessments of the breeding success.

There are still several questions to be solved concerning the movements of the population within the winter range. More extensive studies are needed, and an individual darvic marking would be a useful tool in this connection. Over time the marking would also provide a useful insight into population dynamics and in relationship to feeding and behavioural ecology.

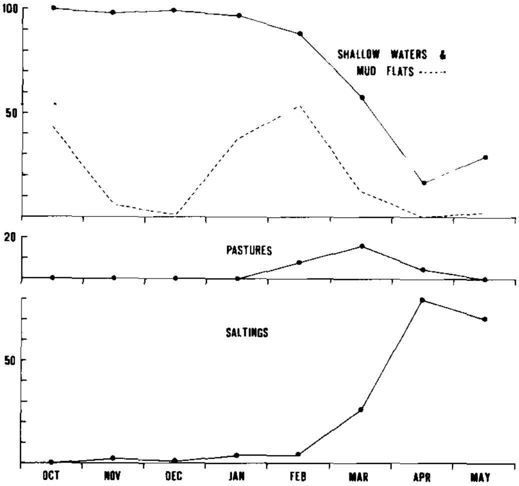


Fig. 3. Habitat usage of Light-bellied Brent in Denmark expressed as proportion of total number of goose days (average of three seasons).

The spring foraging and weight increase have proved to be of vital importance to the breeding success of the Dark-bellied Brent population and probably of most arctic nesting goose populations (Ebbinge et al. 1982). In the Light-bellied Brent population spring feeding is concentrated on two saltings (Nissum Fjord and Agerø). There are certain indications that the carrying capacity has been reached in the Nissum Fjord (many strips of saltings have recently been cultivated and others are still threatened), and investigations of the significance of this to the population dynamics should be started in the near future.

Acknowledgements

Thomas Bregnballe, Anders Holm Joensen, and Hans Meltofte are thanked for helpful comments on the manuscript. Malcolm Ogilvie and D.A. O'Connor are thanked for the provision of the goose counts at Lindisfarne.

References

Ebbinge, B., St. Joseph, A.K.M., Prokosch, P. & Spaans, B. 1982: The importance of spring staging areas in arctic-breeding geese, wintering in Western Europe. *Aquila 89:* 249–258.

Fog, M. 1972: *Status for Knortegåsen (Branta bernicla) in Denmark.* Game Biology Station, Kalø, 104 pp.

Fog, M. 1977: Knortegåsesituationen. *Dansk Vildtforskning 1976–77:* 59–61.

Madsen, J. 1984: Numbers, distribution, and habitat utilization of Pink-footed Geese *Anser brachyrhynchus* in Denmark 1980–1983. *Nor. Polarinst. Skr. 181* (this volume).

Madsen, J. & Lund, T. (eds.) 1982: *Årsrapport 1981, Dansk Ornitologisk Forenings Gåsegruppe.* National Agency for the Protection of Nature, Monuments and Sites, 62 pp.

Meltofte, H. 1973: Trækket af gæs *Anserinae* ved Blåvandshuk 1963–1971. *Dan. Orn. Foren. Tidsskr. 67:* 35–41.

Norderhaug, M. 1970: The present status of the Brent Goose *(Branta bernicla hrota)* in Svalbard. *Norsk Polarinstitutt Årbok 1968:* 7–23.

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose *Branta leucopsis. Nor. Polarinst. Skr. 181* (this volume).

Prokosch, P. 1981: *Bestand, Jahresrhytmus und traditionelle Nahrungsplatzbindung der Ringelgans (Branta bernicla) im Nortfrisischen Wattenmeer.* Mathematisch-Naturwissenschaftliche Fakultät der Christian Albrechts Universität Kiel, 146 pp.

Salomonsen, F. 1958: The present status of the Brent Goose *(Branta bernicla* (L)) in Western Europe. *Vidensk. Meddr. Dan. Naturhist. Foren. 120:* 43–80.

PETER PROKOSCH:

The occurrence of *Branta bernicla hrota* in Brent Goose flocks in the German Wattenmeer

Prokosch, P. 1984: The occurrence of *Branta bernicla hrota* in Brent Goose flocks in the German Wattenmeer. *Nor. Polarinst. Skr. 181:* 125–127.

The German Wattenmeer holds about 100,000 Brent Geese (autumn and spring). They belong almost totally to the Siberian population of *Branta bernicla bernicla.* Only negligible numbers of Light-bellied Brent Geese *Branta b.hrota,* which may belong to the Svalbard population, are present every year. During systematic checks of 145 flocks, including 275,000 individuals, only 79 Light-bellied Geese were found (1975–1983). The figures indicate an annual spring occurrence of some 30 *Branta b.hrota* on the German North Sea coast.

Peter Prokosch, WWF – Wattenmeerstelle Schleswig-Holstein, Olshausenstrasse 40–60, D-2300 Kiel, Federal Republic of Germany.

Introduction

Lambeck (1981) suggested that a small part of the Svalbard/Frans Josef Land population of Light-bellied Brent Geese *Branta bernicla hrota* mixes with flocks of Dark-bellied Brent Geese *Branta b.bernicla* in the Wadden Sea area. He implied that the total population size obtained from counts at Nissum Fjord in Denmark may be an underestimate by some 5–10% in normal winters, if Dutch data are representative for the whole Wadden Sea. This underestimate could be even more important if the number of *B.b.hrota* increases from the southwest towards Denmark in the northeast.

It may therefore be of some interest to examine the occurrence of *B.b.hrota* in Brent Goose flocks in the German part of the Wadden Sea, the «Wattenmeer», which, with an area of 450,000 ha, covers 62% of the whole international Wadden Sea (730,000 ha). At peak (simultaneous international count on 14 May 1983), the German Wattenmeer holds about 100,000 *B.b.bernicla,* i.e. nearly 50% of the total population of that subspecies (202,500; A.St.Joseph pers. comm.). The other 50% of Dark-bellied Brent Geese are spread over coastal regions of Denmark and the Netherlands in April/May (Ebbinge et al. 1981).

Number of Light-bellied Brent Geese

In the course of detailed studies in the North Frisian Wattenmeer of colour-ringed Brent Geese, millions of geese in thousands of flocks were individually checked (Prokosch 1981, 1982). In the case of 145 flocks (including some 275,000 birds), the subspecies were carefully distinguished. During these systematic observations 79 Light-bellied Brent Geese have been found, i.e. about 1 in 3000 (Table 1). They included 9 juveniles, while of the older birds, 9 were definitely unpaired and 53 may have been unpaired as well.

In addition to these, there have been five observations of seven different individuals in Schleswig-Holstein (Berndt & Busche 1977, 1981; unpubl. data of the Ornithologische Arbeitsgemeinschaft Schleswig-Holstein) and six records including ten birds in Niedersachsen (Hofmann 1971; Prokosch unpubl.).

Relating the figures in Table 1 to the total number of geese seen on each site in spring 1983, the April total of Light-bellied Brents in the North-Frisian part of the Wattenmeer would add up to no more than 25 individuals, plus a further five birds in the rest of the German Wattenmeer.

Discussion

B. Ebbinge (pers.comm.) estimates that 20–50 Light-bellied Brent Geese spend the spring in the Netherlands, while Madsen (1984) has mentioned the observations of some hundred Light-bellied Brent Geese in the Danish part of the Wadden Sea. Both these totals may be exceptionally increased in periods of hard weather.

It is still unclear if all the *B.b.hrota* recorded in the Wadden Sea really belong to the Svalbard/

Frans Josef Land population. Certainly it has already been proved that Svalbard Brent Geese do visit the Danish part of the Wadden Sea (several recoveries of birds ringed in Svalbard and found between Rømø and Fanø; Fog 1972, 1976). There are also two indications to suggest that at least some of the Light-bellied Brent Geese seen in North Friesland could belong to the Svalbard population:

1. One single adult colour-ringed *B.b.hrota*

Table 1. *Occurrence of Light-bellied individuals* Branta bernicla hrota *among Brent Geese in the North-Frisian Wadden Sea area 1975–1983.*
a) total figure of geese examined; b) total number of flocks checked; c) individuals of Branta bernicla hrota *found;* d) *proportion of Light-bellied Brent Geese in ‰.*

Site		Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total
Sylt	a)	–	15635	2600	–	–	–	–	–	–	18235
	b)	–	21	2	–	–	–	–	–	–	23
	c)	–	20	2	–	–	–	–	–	–	22
	d)	–	1.28	0.77	–	–	–	–	–	–	1.21
Rodenäs	a)	–	–	–	–	–	–	4150	5000	–	9150
	b)	–	–	–	–	–	–	5	3	–	8
	c)	–	–	–	–	–	–	5	10	–	15
	d)	–	–	–	–	–	–	1.20	2.00	–	1.64
Föhr	a)	–	–	–	–	–	–	31865	40739	23569	96173
	b)	–	–	–	–	–	–	31	24	14	69
	c)	–	–	–	–	–	–	8	3	3	14
	d)	–	–	–	–	–	–	0.25	0.07	0.13	0.15
Langenes	a)	395	29488	4307	1700	4920	2938	1227	1666	450	47091
	b)	1	33	10	6	5	7	2	2	3	69
	c)	1	13	1	0	2	0	0	0	0	17
	d)	2.53	0.44	0.23	0	0.41	0	0	0	0	0.36
Hooge	a)	–	–	–	–	–	61	2500	1188	3625	7374
	b)	–	–	–	–	–	1	3	2	2	8
	c)	–	–	–	–	–	0	0	0	1	1
	d)	–	–	–	–	–	0	0	0	0.28	0.14
Nordtrandisch-moor	a)	–	–	–	–	–	–	3000	5140	4000	12140
	b)	–	–	–	–	–	–	1	4	3	8
	c)	–	–	–	–	–	–	0	0	1	1
	d)	–	–	–	–	–	–	0	0	0.25	0.08
Norstrand	a)	–	–	152	–	–	–	1010	10650	1820	13632
	b)	–	–	1	–	–	–	2	5	3	11
	c)	–	–	0	–	–	–	0	4	0	4
	d)	–	–	0	–	–	–	0	0.38	0	0.29
Süderoog	a)	–	–	–	–	–	–	2700	4860	17954	25514
	b)	–	–	–	–	–	–	2	3	10	15
	c)	–	–	–	–	–	–	0	2	2	4
	d)	–	–	–	–	–	–	0	0.41	0.11	0.16
Eiderstedt	a)	–	–	800	–	–	–	3845	6250	4865	15760
	b)	–	–	1	–	–	–	5	8	4	18
	c)	–	–	0	–	–	–	0	0	1	1
	d)	–	–	0	–	–	–	0	0	0.20	0.06
other sites*	a)	–	8260	2000	–	–	–	13000	3258	4030	30548
	b)	–	5	1	–	–	–	2	2	6	16
	c)	–	0	0	–	–	–	0	0	0	0
	d)	–	0	0	–	–	–	0	0	0	0
Northfrisian Wadden Sea (total)	a)	395	53383	9859	1700	4920	2999	63297	78751	60313	275617
	b)	1	59	15	6	5	8	53	53	45	245
	c)	1	33	3	0	2	0	13	19	8	79
	d)	2.53	0.62	0.31	0	0.41	0	0.21	0.24	0.13	0.29

*) including Norderoog (Oct.; 8260), Hamburger Hallig (Nov., Mar., Apr., May; 19500), Gröde (May; 350), Habel (May; 500), Pellworm (Apr., May; 1938), Südfall (May; 2620).

observed at Rodenäs on 8 May, 1982, by I. Bierwisch, came from a catch of 60 Light-bellied Brent Geese at Nissum Fjord in Denmark (14 May 1979; St. Joseph, in litt.). 2. The relative occurrence of Light-bellied Brent Geese (Table 1) is significantly higher in the most northern areas of Sylt and Rodenäs (one *B.b.hrota* in 800 and 600 Brent Geese, respectively) than in any other site in the North Frisian Wattenmeer, the former sites being closest to the Danish wintering sites of Svalbard birds (Fig. 1).

On the other hand there is also a single sighting (2 May 1976, saltings Linthorst-Homanpolder, province of Groningen) of a neck-collared *B.b.hrota* ringed on Bathurst Island, arctic Canada, in the summer of 1975 (Lambeck 1977).

It seems that we can very well leave it to the Danes to monitor the Svalbard/Frans Josef Land population, since nearly all birds can be seen in Jutland during the spring. But synchronous spring counts should probably include the Danish section of the Wadden Sea, and, if possible, Sylt and Rodenäs as well. The rest of the Wadden Sea area with a maximum ratio of 1–2% can only then be easily neglected. In addition a marking programme would help us to understand the dynamics and distribution of the Svalbard Brent Geese.

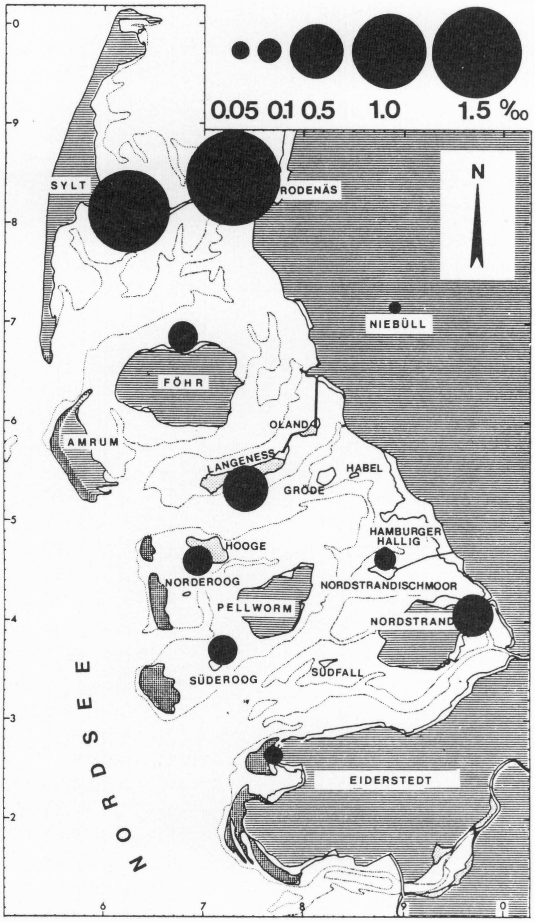


Fig. 1. The relative occurrence of *Branta bernicla hrota* in Brent Goose flocks in the North-Frisian Wattenmeer in ‰ (after Table 1).

References

Berndt, R.K. & Busche G. 1977: Ornithologischer Jahresbericht der OAG für 1975. *Corax 6:* 1–42.

Berndt, R.K. & Busche G. 1981: Ornithologischer Jahresbericht für Schleswig-Holstein 1979, mit besonderer Berücksichtigung des Kältewinters 1978/79. *Corax 8:* 226–265.

Ebbinge, B., Fog M. & Prokosch P. 1981: Brent Goose *(Branta bernicla). In* Smit, C.J. & Wolff W.J (eds): *Birds of the Wadden Sea. Final report of the section «Shorebirds» of the Wadden Sea Working Group.* Rotterdam.

Fog, M. 1972: *Status for Knortegåsen* (Branta bernicla). Game Biology station. Kalø. 104 p.

Fog, M. 1976: Passage of Geese through Denmark. *In* Kumari, E. (ed.): *Bird Migration.* Tallinn.

Hofmann, B. 1971: Hellbäuchige Ringelgänse *(Branta bernicla hrota)* im Borkumer Watt. *Vogelk. Ber. Niedersachs. 3:* 82.

Lambeck, R.H.D. 1977: Het Voorkomen van Rotgans *Branta bernicla* Ondersoorten in het nederlandse Waddengebied tijdens het Voorjahr von 1976. *Limosa 50:* 92–97.

Lambeck, R.H.D. 1981: De huidige status van de Spitsbergen/Frans Jozef Land-populatie van de Witbuikrotgans *Branta bernicla hrota. Limosa 54:* 52–56.

Madsen, J. 1984: Status of the Svalbard population of Light-bellied Brent Geese *Branta bernicla hrota* wintering in Denmark 1980–1983. *Nor. Polarinst. Skr. 181* (this volume).

Prokosch, P. 1981: *Bestand, Jahresrhythmus und traditionelle Nahrungsplatzbindung der Ringelgans* (Branta bernicla) *Im Nordfriesischen Wattenmeer.* Diplomarbeit. Kiel. 146 p.

Prokosch, P. 1982: *Branta bernicla* in the Wadden Sea with special reference to the Northfrisian section (Schleswig-Holstein). *Aquila 89:* 175–186.

PÅL PRESTRUD and ASBJØRN BØRSET:

Status of the goose populations in the bird sanctuaries in Svalbard

Prestrud, P. & Børset, A. 1984: Status of the goose populations in the bird sanctuaries in Svalbard. *Norsk Polarinst. Skr. 181:* 129–133.

Between 1300 and 1600 pairs of Barnacle Geese were breeding in the sanctuaries in 1982. This is about 70% of the Barnacle population that attempts breeding each year in Svalbard. There has been a marked increase in the breeding Barnacle Goose population since the last counts in the 1960s. The Barnacle population will probably be limited by available breeding habitats, if it does not start breeding in steep cliffs in the inland or along the coast, as it did earlier. The Barnacle and the Eider seem to compete for good breeding habitats. The breeding Brent population in the sanctuaries has remained low and nearly constant since the last counts took place in the 1960's. In accordance with earlier observations the breeding Pink-footed Goose population in the sanctuaries is small.

Pål Prestrud, The Governor's office, 9170 Longyearbyen, Norway. Asbjørn Børset, Fylkesmannen, Julsundv. 1B, 6400 Molde, Norway.

Introduction

Fifteen small areas on the west coast of Svalbard were established as bird sanctuaries in 1973 (Fig. 1), to protect the most important breeding grounds for the Eider *Somateria mollissima* the Barnacle Goose *Branta leucopsis* and the Brent Goose *Branta bernicla hrota* in Svalbard. Successful breeding for these three species depends on their breeding grounds not being accessible to the Arctic fox *Alopex lagopus*. Such breeding grounds are found on small islands along the west coast and in a few restricted areas on Spitsbergen, the main island of the Svalbard archipelago. There are very few small islands along the coast of Svalbard. A large proportion of the Eider, Barnacle and Brent populations therefore congregate in relatively few localities, and are consequently extremely vulnerable to human disturbance.

The selection of localities for protection was based on data collected by Norderhaug (1971). Little work has been done in the sanctuaries since his counts in the 1960s. In 1977, Norderhaug (1977) censused the bird populations in some of the sanctuaries, but his work was hampered by bad weather and ice-conditions.

A project was started by the Governor's office in Svalbard in 1982, with the purpose of obtaining data to show possible changes and trends in the development of the bird populations breeding in the sanctuaries. This was necessary to evaluate the effect of the protection measures, and to establish whether (excessive further) protection is required.

This is a preliminary report on the observations in 1982 and 1983, concentrating on the goose populations in the sanctuaries.

Methods

To reduce the disturbance upon the breeding birds and the predation by the Glaucous Gull *Larus hyperboreus* upon Barnacle and Eider eggs, the following method was used: the counting of breeding pairs was done from selected localities, together covering the whole colony. All movement between the localities was made by boat or by walking along the beach. As far as we could see the number of non-breeding geese was low in all the sanctuaries. The numbers of breeding pairs are given as rough estimates because of uncertainties in the method used. There are variations in the range of the estimates from place to place and from one year to another, because of differences in the terrain, in the number of people taking part in the counts, and in the time spent on the various islands. Apart from Sørkapp, all the bird sanctuaries were visited in the breeding season between 19 June and 7 July, 1982 and 1983. Data from Kongsfjorden were collected by us in 1978–1979, and by F.

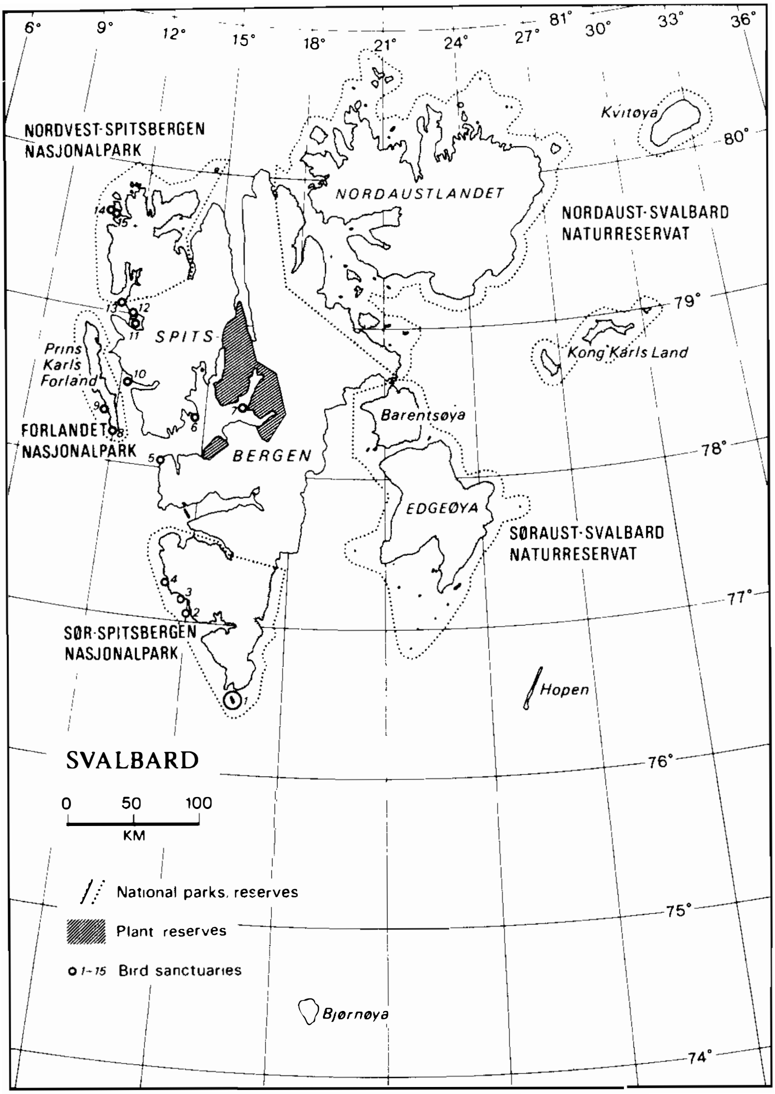


Fig. 1. Map of Svalbard with national parks, nature reserves, plant reserves, and bird sanctuaries. Name of the sanctuaries are given in Table 1.

Mehlum, Norsk Polarinstitutt, in 1981–1983. Empty nests were counted at the Sørkapp and Dunøyane sanctuaries after the end of the breeding season in 1982.

Results and discussion

Barnacle Geese were breeding in 11 of the 15 bird sanctuaries (Table 1). The most important breeding areas were found in the small, flat, offshore sanctuaries, especially on Dunøyane, Isøyane, Forlandsøyane, and Moseøya. Few Barnacles bred in the sanctuaries in the fjords. The breeding population has increased considerably since the count in the 1950s and 1960s. This is exemplified by four of the sanctuaries where we have counts running 20–30 years back (Table 2). The Barnacle Goose was a new breeding species in four of the sanctuaries since the last counts in the 1960s. The increase in the breeding Barnacle population is in agreement with the general increase in the population observed through counts in the winter quarters (Owen & Norderhaug 1977; Owen 1982). We have counts also from the late 1970's from Isøyane, Olsholmen and Moseøya. Since then the breeding population on Isøyane has not increased. Great parts of the largest island, Nordre Isøya, were void of nests and the density was much lower than on any of the three islands in the neighbouring Dunøyane bird sanctuary. If the availability of suitable nesting sites is the restricting factor through territorial mechanisms, the small size of the breeding population on Nordre Isøya seems incomprehensible. But this was an exception; at all other sanctuaries the breeding population of either Barnacle Goose or Eider was high.

The breeding population of Barnacle Geese at Olsholmen has doubled since 1977. The density of breeding pairs was exceptionally high, and there was hardly more room left for breeding. The development at Moseøya in the north is also interesting. Breeding Barnacles were first found in 1971 (Norderhaug 1973), when five pairs bred. In 1978, 65–70 pairs were breeding (Larsen 1979), and in 1982, 100–150 pairs.

About 1300–1600 pairs of Barnacle Geese were breeding in the sanctuaries in Svalbard in 1982. This is 30–35% of the total population (Owen 1982). Nine localities were not visited in 1983, so that a total 1983 estimate could not be given. The breeding conditions were favourable both years with early snow melting, and relatively good weather. Assuming that about 40% of the population counted in the winter quarters during autumn attempts breeding in good years (estimate based on Ebbinge & Ebbinge 1977; Owen & Norderhaug 1977; Owen 1982), more than 70% of the potential breeding pairs were breeding in the sanctuaries in 1982. But only a small part of

Table 1. *Breeding pairs of Barnacle Geese, Brent Geese and Pink-footed Geese in the sanctuaries in the period 1978–83. There were no breeding geese in bird sanctuary No. 5, Kapp Linné.*

		Barnacle Goose		*Brent Goose*			*Pink-footed Goose*		
No.	*Sanctuary*	*1982*	*1983*	*1978–81*	*1982*	*1983*	*1978–81*	*1982*	*1983*
1	Sørkapp	0	–	–	0	–	–	moulting flocks	–
2	Dunøyane								
	Store Dunøya	240–350	210–300	–	4	0	–	0	0
	Nordre Dunøya	150–180	–	–	7	–	–	0	–
	Fjørholmen	145–175	–	–	2	–	–	0	–
3	Isøyane								
	Nordre Isøya	85–105	–	–	0	–	–	0	–
	Isøykalven	50– 55	–	–	0	–	–	0	–
4	Olsholmen	65– 70	–	–	0	–	–	0	–
6	Gåsøyane	3	6–8	–	1	0	–	10	30-50
7	Bohemanneset	–	45–65	–	–	0	–	–	0
8	Plankeholmen	5– 10	–	–	0	–	–	0	–
9	Forlandsøyane								
	Sørøya	3	12–15	–	1	10 non-breeding	–	0	0
	Midtøya	260–300	200–280	–	3	6–8	–	15	6
	Nordøya	100–110	70–110	–	9	2	–	0	0
10	Hermansenøya	–	10-15	–	–	3 non-breeding	–	–	3–5
11	Kongsfjorden	2–3	8	1	0	0	20-40	25	15
12	Blomstrandhavna	0	0	0	0	0	moulting flocks	2	1
13	Kapp Guissez	?	?	–	0	–	moulting flocks	moulting flocks	0
14	Skorpa	15–25	–	–	0	–	–	0	–
15	Moseøya	100-150	–	–	0	–	–	0	–

–: Not visited this year.
No.: Refers to the map in Fig. 1.

Table 2. *Number of breeding pairs of Barnacle Geese in four sanctuaries in the last 30 years (data from Løvenskiold 1954, 1964 and Norderhaug 1971b, 1977).*

No.	*Sanctuary*	*1950s*	*1963*	*1964*	*1965*	*1968*	*1977*	*1982*	*1983*
2	Dunøyane	12	142	164	198	–	–	535–705	–
3	Isøyane	3	60	87	100	–	150	135–160	–
4	Olsholmen	–	–	16	–	–	30	65– 70	–
9	Forlandsøyane	0	3	–	–	25	–	360–410	280–400

–: Not visited this year.
No.: Refers to the map in Fig. 1.

this number are successful breeders. According to Ebbinge & Ebbinge (1977), Prop et al. (1979), and Owen (1982), more than 50% of the birds that attempt breeding seem to be unsuccessful.

As far as we can see a change in the breeding distribution of the Barnacle Geese has taken place, as a consequence of the increase in the population. When the population was small and starting to increase, the Barnacles bred in the most southern sanctuaries. The establishment first took place in these sanctuaries. Comparing Moseøya and Forlandsøyane in the north with Dunøyane and Isøyane in the south, the breeding population is found to be 2–300 pairs in the southern sanctuaries in the 1960s, and very low in the northern ones (Table 2). The establishment of the breeding Barnacle population on Moseøya in the north took place in the late 1970s.

Because of the limited number of available breeding localities on offshore islands, Owen & Norderhaug (1977) stated that «it seems likely therefore that it is the scope of the breeding area which will set the ceiling of future population expansion», a view reinforced by Owen (1984). If this statement is correct, the breeding population has now probably reached its maximum size in Svalbard; the breeding areas have hardly any more room left for breeding Barnacles and the expansion possibilities to new islands are limited. The only islands along the western and northern coast with few or no breeding Barnacles are found in Isfjorden, Kongsfjorden, and Liefdefjorden, where the breeding population of Eiders is high.

In addition to the mentioned sanctuaries, the Barnacle Goose today also breeds on small rocks or stacks in the sea, on 4–5 small islands not protected as bird sanctuaries, and on steep cliffs along the coast among other places known at Gipshuken, Midterhuken, and the southern coast of Barentsøya. About 90% of the breeding population breeds in the sanctuaries and on these 4–5 small islands that are not protected. Norderhaug (1970) observed a change in the breeding localities of Barnacles in Svalbard with more nests found on offshore islands in the 1960s than earlier. Løvenskiold (1954, 1964) found that Barnacles formerly also bred on steep cliffs along the shore and in the interior. If the Barnacle Goose in Svalbard starts breeding on steep cliffs again, the size of the population will probably not be limited by available breeding sites.

Owen & Norderhaug (1977) wonder if the competition for breeding areas between Barnacle and Brent Geese is one reason for the decline in the Brent Goose population in Svalbard. We also feel that the same explanation may be applied for the Eider population. Compared to earlier observations the breeding Eider population is very small in sanctuaries where the Barnacle population has increased considerably during the last 20 years. At the Forlandsøyane bird sanctuary, for example, about 1500 pairs of Eider and only 25 pairs of Barnacles were breeding in 1968. Today only 3-400 pairs of Eiders are breeding here while the Barnacle population has increased to 3–400 pairs.

In sanctuaries where only few pairs of Barnacles are breeding (e.g. in Kongsfjorden, and on Gåsøyane), the Eider population is very high. On several occasions we saw aggravated Barnacles attacking Eiders in the sanctuaries. This aggressive behaviour probably indicates an interspecific competition between the Eider and the Barnacle. The decline in the Eider population may be caused by an increase in Glaucous Gull predation upon Eider eggs following the Barnacles' aggressive behaviour, or by a direct competition for good breeding sites between the Eiders and the Barnacle Geese.

Table 3. *Number of breeding pairs of Brent Geese in the Dunøyane and Forlandsøyane bird sanctuaries in the last 30 years.*

No.	*Sanctuary*	*1950s*	*1963*	*1964*	*1965*	*1968*	*1977*	*1982*	*1983*
2	Dunøyane	12	10	6	16	–	–	13	–
–	Nordre Dunøya	–	6	6	6	–	7	7	–
9	Forlandsøyane	–	8	–	–	25	–	13	10

–: Not visited this year.
No.: Refers to the map in Fig. 1.

There have been only small changes in the Glaucous Gull population in the sanctuaries since the 1960s. Today the most important Barnacle breeding places are found in places where the Glaucous Gull population is highest. Here the Barnacle population has increased in recent years while the Glaucous Gull population has remained constant and high (e.g. 2–300 pairs in the Forlandsøyane and Dunøyane sanctuaries). Predation by the Glaucous Gull is probably a minor factor in the regulation of the Barnacle population.

Breeding Brent Geese were only observed in the Dunøyane, Gåsøyane, Forlandsøyane, and Kongsfjorden bird sanctuaries (Table 1). The breeding population in the sanctuaries has probably remained nearly constant and very low since the last counts in the 1960s (Table 3). However, the observations from the winter quarters in Denmark and England show that the Spitsbergen population of Brent Geese has increased in recent years (Madsen 1984). The breeding areas are not known in detail, but the most important ones are found on the east coast of Svalbard (Norderhaug 1970b). Earlier observations (Løvenskiold 1954, 1964) indicate that the Brent Goose formerly bred in the Sørkapp, Dunøyane, and Isøyane bird sanctuaries in great numbers.

The Pink-footed Goose has never bred in great numbers in the sanctuaries (Løvenskiold 1964; Norderhaug 1971b). The breeding population in the sanctuaries is still low (Table 1), and the main localities are found on Gåsøyane and in Kongsfjorden. The most important breeding areas of this species are on the main islands of the Svalbard archipelago; this goose is able to protect itself against the Arctic Fox.

References

Ebbinge, B. & Ebbinge-Dallmeijer, D. 1977: Barnacle Geese *(Branta leucopsis)* in the Arctic summer. *Nor. Polarinst. Årbok 1975:* 119–138.

Larsen, T. 1979: Observations of animal life in Svalbard in 1978. *Nor. Polarinst. Årbok 1978:* 69–79.

Løvenskiold, H.L. 1954: Studies on the Avifauna of Spitsbergen. *Nor. Polarinst. Skr. 103.* 131 pp.

Løvenskiold, H.L. 1964: Avifauna Svalbardensis. *Nor. Polarinst. Skr. 129.* 460 pp.

Madsen, J. 1984: Status of the Svalbard population of Light-bellied Brent Geese *Branta bernicla hrota* wintering in Denmark 1980–1983. *Nor. Polarinst. Skr. 181* (this volume).

Norderhaug, M. 1970a: The present status of the Barnacle Goose *(Branta leucopsis)* in Svalbard. *Nor. Polarinst. Årbok 1968:* 24–35.

Norderhaug, M. 1970b: The present status of the Brent Goose *(Branta bernicla hrota)* in Svalbard. *Nor. Polarinst. Årbok 1968:* 7–23.

Norderhaug, M. 1971a: *Verneverdige naturområder på Svalbard nr. 2. Kartlegging og klassifisering av hekkeområder for ærfugl og gjess ved Spitsbergens vestkyst.* Report to the Norwegian Ministry of the environment (in Norwegian). 68 pp.

Norderhaug, M. 1971b: The present status of the Pink-footed Goose *(Anser fabalis brachyrhynchus)* in Svalbard. *Nor. Polarinst. Årbok 1969:* 55–69.

Norderhaug, M. 1973: Iakttagelser over dyrelivet på Svalbard 1971. *Nor. Polarinst. Årbok 1971:* 87–92.

Norderhaug, M. 1977: *Rapport fra undersøkelser i Svalbards fuglereservater, juni 1977.* Report to the Norwegian Ministry of the Environment. 15 pp.

Owen, M. & Norderhaug, M. 1977: Population dynamics of Barnacle Geese *(Branta leucopsis)* breeding in Svalbard 1948–1976. *Ornis Scand. 8:* 161–174.

Owen, M. 1982: Population dynamics of Svalbard Barnacle Geese 1970–1980. *Aquila 89:* 229–247.

Owen, M. 1984: Dynamics and age structure of an increasing goose population – the Svalbard Barnacle Goose *Branta leucopsis. Nor. Polarinst. Skr. 181* (this volume).

Prop, J., van Erden, M. R., Daan, S., Drent, R.H., Tinbergen, J. M. & St. Joseph, A. M. 1979: Ecology of the Barnacle Goose *(Branta leucopsis)* during the breeding season: preliminary results from expeditions to Spitsbergen in 1977 and 1978. Pp. 50–112 in: *Proceedings of the Norwegian–Netherlands Symposium on Svalbard* (Arctic Centre, Groningen).

PETER PROKOSCH:

Breeding sites and distribution of geese in the northwest Isfjord area, Svalbard, 1982

Prokosch, P. 1984: Breeding sites and distribution of geese in the northwest Isfjord area, Svalbard, 1982. *Nor. Polarinst. Skr. 181:* 135–139.

In June/July 1982 the total number of geese in the lowlands of Daudmannsøyra, Alkhornet, Vermlandryggen, Erdmannflya, and Bohemanflya was surveyed. 690 Pink-footed Geese *Anser brachyrhynchus* (including 221 breeding pairs), 640 Barnacle Geese *Branta leucopsis* (including 262 breeding pairs), and 13 Brent Geese *Branta bernicla* (no breeding pairs) were found. These figures of a formerly poorly investigated area represent significant proportions of the Svalbard goose populations.

Peter Prokosch, WWF-Wattenmeerstelle Schleswig-Holstein, Olshausenstraße 40–60, D-2300 Kiel, Federal Republic of Germany.

Introduction

Although the position of the investigation area on the northwest coast of Isfjorden is quite close to Longyearbyen (some 25 km to the nearest point), the most frequented place in Svalbard, the general information on birds was scarce (Norderhaug in litt.). Therefore in the summer of 1982 a small expedition was mounted to get a complete ornithological survey of the coastal lowlands between Farmhamna (Forlandsundet) and Bohemanneset (Isfjorden). A main objective was study of breeding sites and distribution of geese. Party members included B. Diel, W. Knief, V. Looft, W. Schultz and H. Thiessen.

Methods and area covered

From different bases (19–23 June Alkhornet, 23–28 June Wilkinsbukta/Daudmannsøyra, 28 June–2 July Esmarkmorena/Erdmannflya, and 2–4 July south coast of Bohemanflya) we covered most of the area on foot, walking over the tundra in a long line with a distance of about 100 m between each party member. The coast of Vermlandryggen was checked by boat (23 June). In all we covered the lowlands of Daudmannsøyra (120 km^2 between Farmhamna and Alkhornet), the coast lines of Trygghamna and Ymerbukta, the snowfree areas of Erdmannflya, and 35 km^2 (the southeast part) of Bohemanflya (Fig. 1). Apart from a brief visit to the Selmaneset rock we did not visit any island, in order not to disturb the breeding birds. But we tried to count the birds on these islands from the opposite mainland coast using telescopes.

Snow conditions and breeding situation

When we passed along Bohemanflya and Erdmannflya by boat on 19 June, most of the lowlands was still covered with snow. At Alkhornet some 50% of the vegetated zones were already snowfree. A few nests of Pink-footed Geese *Anser brachyrhynchus* on 20 June indicated that the species had started breeding or laying: 3 nests (2 with 4 and 1 with 5 eggs) seemed to be completed. Another nest with one egg had two eggs the next day. On 23 June, 23 nests of Barnacle Geese on Selmaneset indicated that this species had started breeding as well: 1 (1 egg), 2 (2 eggs), 7 (3 eggs), 8 (4 eggs), 3 (5 eggs), 1 (6 eggs) and 1 (7 eggs). This year ice from Selmaneset was separated from the mainland ice by only a few metres of water. It is possible that in some years with a complete ice bridge, the crossing of Arctic fox *Alopex lagopus* could upset breeding on this island. Very little vegetation is available on the island itself as on the nearby Vermlandryggen. Of this colony (28 breeding pairs), up to 30 birds at a time came over to Alkhornet for daily feeding.

The Daudmannsøyra area was almost snowfree (ca. 80%) when we were there (23–28 June). All goose nests seemed to have complete clutches. In contrast, Erdmannflya had an extensive snow cover, and only coastal areas and some milder sites on the south sides of rocks and mountains were open (29 June). On Bohemanflya (2 July) most of the snow had melted since we saw it two weeks earlier (about 90% snowfree tundra).

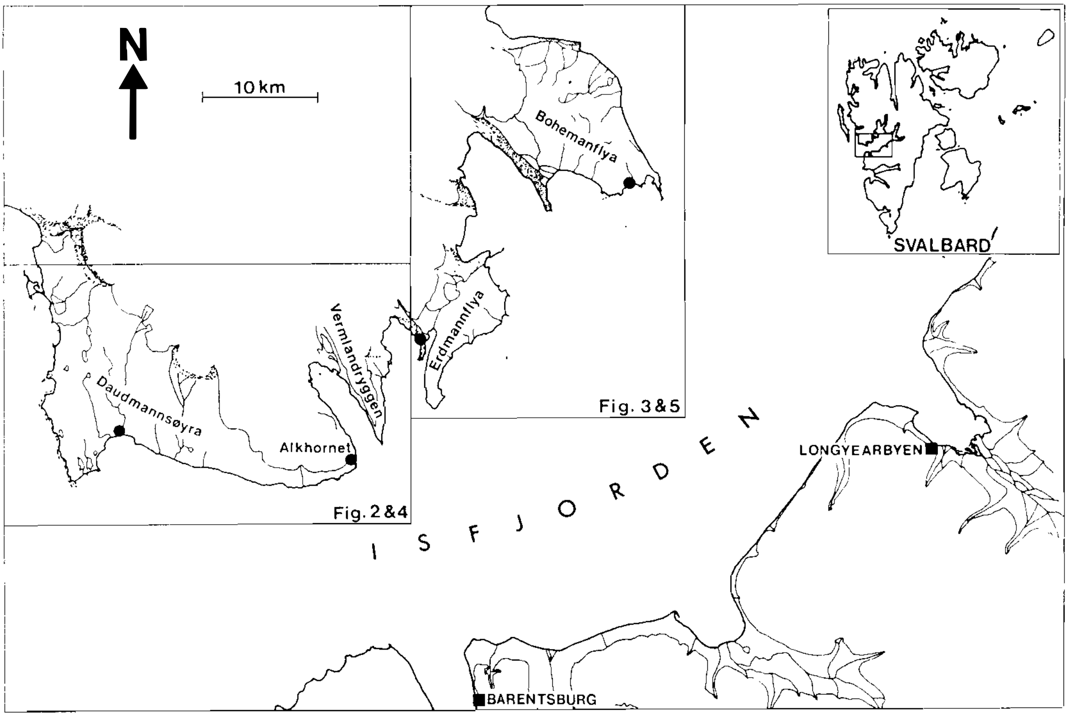


Fig. 1. Position of the study areas on the coast of Isfjorden, and location map of Svalbard (inset). Only the coastal lowlands are illustrated. Black dots: location of bases.

Numbers of geese

We found only two breeding species, the Pink-footed and the Barnacle Goose (Figs. 2–5, Table 1 and 2). Brent Geese were only seen twice: on 25 June 11 birds passed Daudmannsøyra heading towards inner Isfjorden, and on 26 June two adults (pair?) were sitting for a short time on an island in the Båkevatna lake, Daudmannsøyra (potential breeding site?; lake remained partly ice-covered).

The Daudmannsøyra/Alkhornet area proved to be the most important for the Pinkfoot and the Barnacle. The Selmaneset and Tvillingholmane islands also had significant numbers of Barnacle Geese. Erdmannflya and Bohemanflya had relatively sparse populations (Figs. 2–5, Tables 1 and 2).

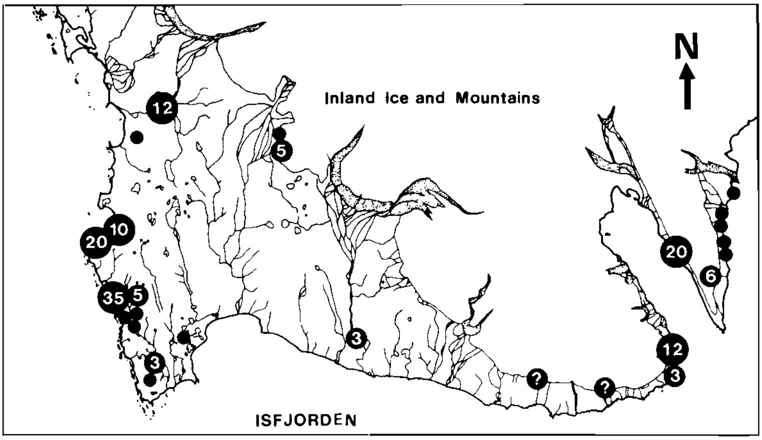


Fig. 2. Distribution of breeding Pink-footed Geese in the Daudmannsøyra/Alkhornet/Vermlandryggen area. Numbers of nests/colony are given.

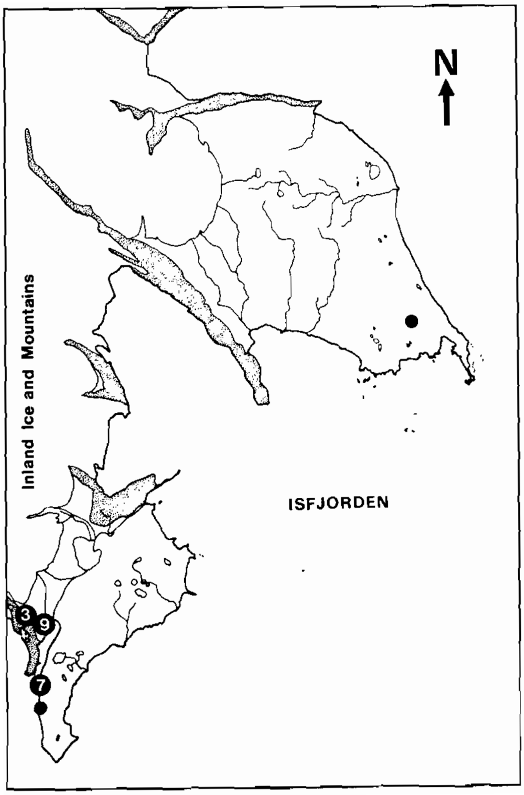


Fig. 3. Distribution of Pink-footed Geese in the Erdmannflya/Bohemanflya area. Numbers of nests/colony are given.

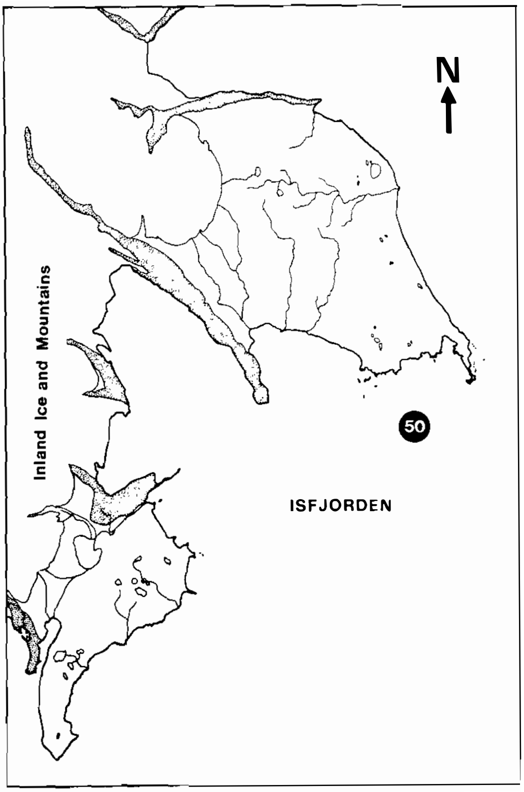


Fig. 5. Distribution of breeding Barnacle Geese in the Erdmannflya/Bohemanflya area.

Nesting sites

All Pink-footed Goose nests were found on the mainland, most of them within reach of the Arctic fox. Of 171 nests only two (1 %) were built on small islands in freshwater pools. Most were found on small rocks or rocky hills exposed on the tundra (95 nests, 56%). Forty-three pairs (25%) bred on rocky coastal edges, 15 (9%) on slopes of river gorges, 12 (7%) on inland mountain slopes (6 of them about 150 m above sea level), 3 (2%) in moraines, and 1 (1%) on a vegetated plain.

In contrast to the Pink-footed Geese, nearly all

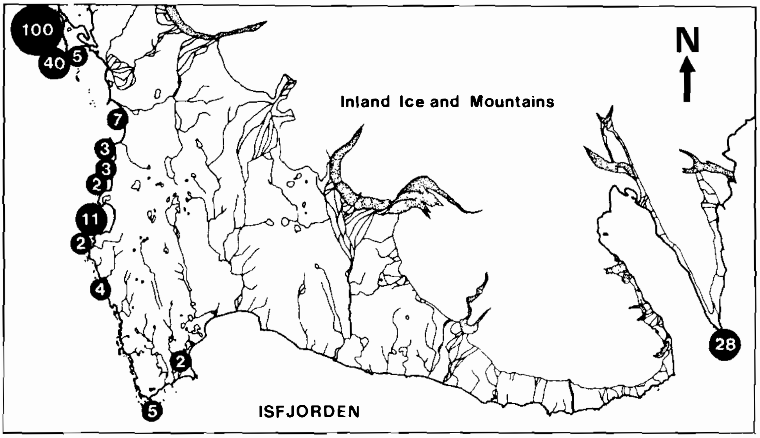


Fig. 4. Distribution of breeding Barnacle Geese in the Daudmannsøyra/Alkhornet/Vermlandryggen area. Numbers of nests/colony are given.

Table 1. *Numbers of Pink-footed Geese in the NW Isfjorden area June–July 1982.*

Area	*Nests found*	*Estimated pairs*	*Non-breeders*	*Total number of birds*
Daudmannsøyra	103	130	120	380
Alkhornet	15	20	100	140
Vermlandryggen	32	40	–	80
Erdmannflya	20	30	–	60
Bohemanflya	1	1	28	30
Total	171	221	248	690

Barnacle Geese nested on rocky islands in the sea, more or less close to the coast. Many islands on the west coast of Daudmannsøyra, which still had ice bridges to the mainland, were unpopulated, whereas similar islands without such ice bridges were occupied. Some of the larger islands (e.g. Marineholmane, Gudrunholmen, Tvillingholmane) have a vegetated plateau, others are completely rocky. On Hamnetangen five pairs bred on coastal cliffs on the mainland (the presence of many old feathers indicates that this peninsula may also be an important moulting area). Two pairs nested on an island in the centre of a lake (Båkevatna).

Discussion

This survey gives the most comprehensive picture to date of an important Svalbard goose region, which has been incompletely investigated in the past (Norderhaug 1970a, 1970b, 1970c, in litt, M. Owen, in litt.). We found more Pink-footed Geese in our surveyed section of the Isfjorden coast then were previously known to exist in the whole Isfjorden system (Norderhaug 1970c). However, our 690 birds represent only 2.5% of the last published population total (Madsen 1982) counted in Denmark in 1980. Consequently, it is clear that there is still much to learn about this species distribution in Svalbard (Ekker 1981).

We found nearly 8% of the Svalbard Barnacle Goose population, using the figure given for the autumn of 1981 by Owen (1982). The number of Barnacles on Daudmannsøyra seems to have

Table 2. *Numbers of Barnacle Geese in NW Isfjorden, June–July 1982.*

Area	*Locality*	*Breeding pairs*	*Non-breeders*	*Total (rounded)*	*Remarks*
	Marineholmane	100[1])			[1]) telescope watch from Hamnetangen: only 2/3 of these estimated breeding pairs actually seen (rest hidden on the other side of the island?)
	Gudrunholmen	40[1])			
	Snauodden	5			
	Tordenskjoldbukta	7			
	Between Marstrandodden and Kulpodden	8			
	Steinpyntvika	11			
	Between Steinpynten and Daudmannsodden	11			
	Båkevatna	2			
Daudmannsøyra		184	100	470	
Alkhornet		–	*[2])	*[2])	[2]) frequented regularly by birds from Selmaneset
Vermlandryggen	Selmaneset	28[3])	10	70	[3]) nests controlled
Erdmannflya		–	–	–	
Bohemanflya	Tvillingholmane	50[4])	?	100	[4]) telescope watch from 2 km distance: rough estimate as many birds may have been hidden. Flocks of 20–50 birds regulary came over to mainland
Total		262	110	640	

shown a marked increase since a British expedition was there in 1979 (M. Owen in litt.).

References

Ekker, Å.T. 1981: Svalbard-bestanden av kortnebbgås. *Vår Fuglefauna 4:* 104–107.

Madsen, J. 1982: Observations on the Svalbard population of *Anser brachyrhynchus* in Denmark. *Aquila 89:* 133–140.

Norderhaug, M. 1970a: The present status of the Brent Goose *(Branta bernicla hrota)* in Svalbard. *Nor. Polarinst. Årbok 1968:* 7–23.

Norderhaug, M. 1970b: The present status of the Barnacle Goose *(Branta leucopsis)* in Svalbard. *Nor. Polarinst. Årbok 1968:* 24–35.

Norderhaug, M. 1970c: The present status of the Pink-footed Goose *(Anser brachyrhynchus)* in Svalbard. *Nor. Polarinst. Årbok 1969:* 55–69.

Owen, M. 1982: Population dynamics of Svalbard Barnacle Geese 1973–1980. *Aquila 89:* 229–247.

JESPER MADSEN:

Study of the possible impact of oil exploration on goose populations in Jameson Land, East Greenland. A progress report.

Madsen, J. 1984: Study of the possible impact of oil exploration on goose populations in Jameson Land, East Greenland. A progress report. *Nor. Polarinst. Skr. 181:* 141–151.

An extensive oil exploration in Jameson Land, East Greenland, is under preparation, and the Ministry of Greenland has brought about an environmental research programme in order to map and determine biological interests. Goose studies have been carried out since 1982. Aerial surveys and ground counts have revealed that up to 11,800 geese stay the summer and moult in the area (5600 Pink-footed Geese and 6200 Barnacle Geese). This report presents the approach to the goose studies and gives some preliminary results on behavioural and ecological investigations. A map of sensitive areas for moulting geese, where oil exploration should be avoided, is presented.

Jesper Madsen, Institut for Zoologi og Zoofysiologi, Zoologisk Laboratorium, Universitetsparken. B10 3, DK-8000 Aarhus C, Denmark.

Introduction

The effect of human disturbance on goose populations has primarily been studied in the wintering quarters of the geese in connection with habitat modifications, shooting, and the prevention of conflicts with agriculture. Knowledge on the breeding grounds is almost non-existent, although threats exist to certain moulting areas in Alaska posed by a developing oil exploration and industry (Derksen et al. 1979).

An extensive oil exploration in Jameson Land, East Greenland, is under preparation. Due to the possible impact on the environment, the Ministry of Greenland has decided to bring about an environmental research programme. The aim of these studies is to determine the areas of biological interest and to study the possible impact of increased human activity in this hitherto rather unexploited and sensitive area. In 1982 studies of the terrestrial populations of Musk Oxen *Ovibos moschatus* and geese as well as a vegetation survey were started, and studies of the marine environment will follow.

From earlier reports (e.g. Marris & Ogilvie 1962; Hall 1963; Hall & Waddingham 1966; Marris & Webbe 1969; Ferns & Green 1975; Meltofte 1976) Jameson Land is known as an important area for Barnacle Geese *Branta leucopsis* and Pink-footed Geese *Anser brachyrhynchus*. The Barnacle Geese are part of the East Greenland population wintering in Western Scotland and Ireland and numbering about 25,000 birds (spring 1983, Ogilvie 1983), while the Pinkfeet are part of the Iceland/East Greenland population wintering in Scotland and North England and numbering about 90,000 birds (autumn 1982, Ogilvie 1983). Part of the Pinkfoot population in Jameson Land consists of non-breeding birds undertaking a moult migration from Iceland to East Greenland (Christensen 1967).

The goose studies and the approach to the problems are presented in this paper. Preliminary results are given and the possible impact of the oil exploration on the goose populations discussed. A report on the results of the 1982 field season has been published (Madsen & Boertmann 1982).

Study area and field work

Jameson Land (71°N) is situated north of the Scoresby Sound Fjord (Fig. 1) and bordered by the Staunings Alps and King Oscars Fjord to the north and Liverpool Land to the east. The area consists of a large lowland tundra intersected by many rivers and dotted with lakes and pools in the south and west. To the north and east the tundra gradually slopes towards a plateau (generally 500–1000 m a.s.l.) cut by several valleys. The

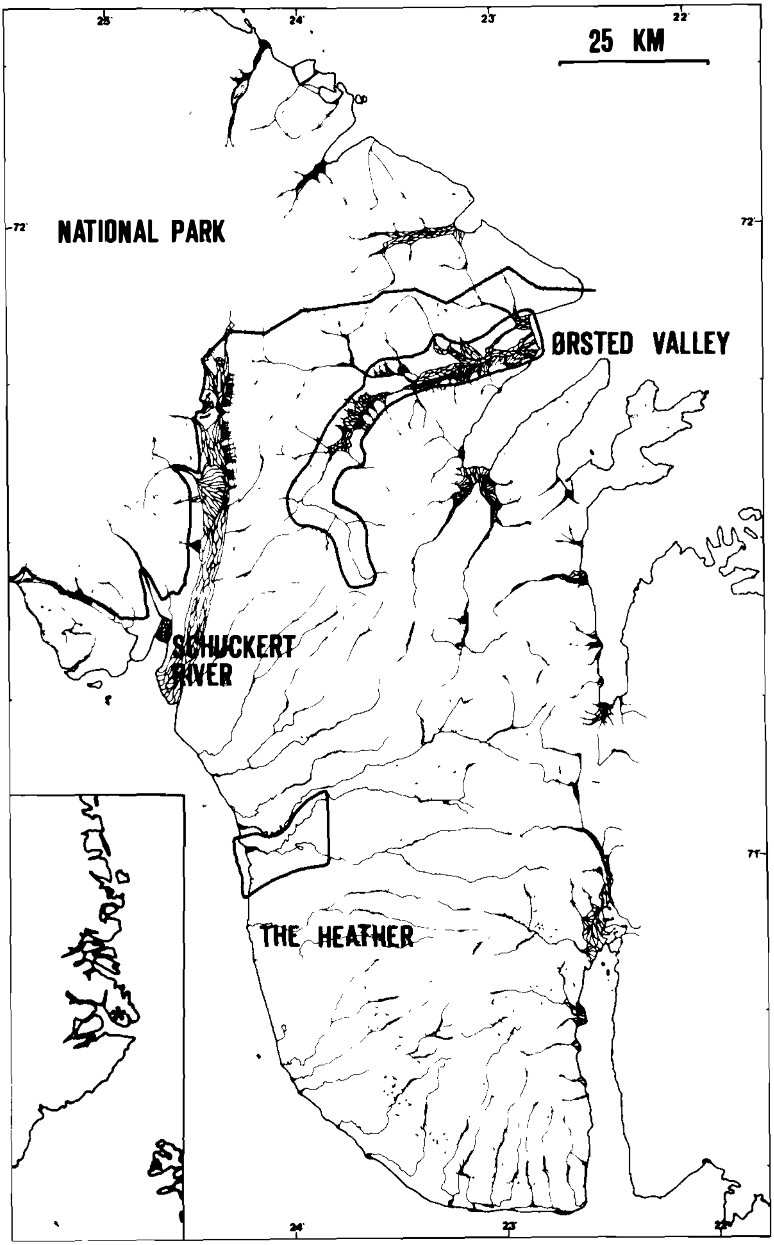


Fig. 1. Location map. Reference areas where ground counts are performed are framed. 200 m contour lines are shown.

vegetation on the plateau is sparse and patchy, while the lowland tundra is dominated by a dry fell heath *(Cassiope tetragona/Vaccinium uliginosum)*. Marshes, which are the most important goose habitats, are found along rivers and around lakes. Most are dominated by sedges and mosses, though in drier parts *Eriophorum* spp. sometimes dominate. Along some of the coastlines extensive salt marshes dominated by sedges are found. A full description of the plant communities is given by Fredskild et al. (1982).

In 1982 goose studies were carried out from 29 June to 3 August by D. Boertmann and the author. In 1983 the field season lasted from 29 June to 26 August, and the work was carried out by D. Boertmann (29 June–1 August), C.E. Mortensen (29 July–26 August), and the author (29 June–26 August). In 1984, which will be the final field season for the baseline studies of the geese, the field season is planned to cover June as well.

The approach

The aims of the goose studies are (1) to evaluate the importance of the area as a breeding and summering area of geese, and to point out the important (sensitive) goose areas, and (2) to analyse the sensitivity of the geese to various forms of disturbance, and possible consequences.

The study has been divided into three parts:

1. a population survey including an estimate of the population size and composition as well as a survey of the geographical and seasonal distribution of the population;
2. an investigation of the impact of human activities on behaviour and energy budgets of the geese; and
3. a study of the habitat ecology of the geese, including factors affecting habitat selection, habitat segregation of the two species, food selection, grazing intensities, and carrying capacity of the area.

In connection with the applied methods it is necessary to consider the forms of disturbances to be expected, as various forms will affect the goose populations differently. Thus two major human activity disturbance factors are expected: (1) human ground activities (camps, depots, airstrips, seismic transects in the terrain), and (2) aerial activities (supply and personnel transport with helicopters and small planes). In a preliminary assessment the oil company anticipates a daily flight capacity of eight helicopters and one Twin Otter, totalling 70–80 flight hours per day. The former will have a relatively limited distribution and will be a permanent directional disturbance factor, while the latter will be a non-directional disturbance factor of wide distribution.

Population survey

It has been possible to make a total census of the goose populations in Jameson Land by means of a small Cessna airplane. Three aerial counts have been made (a reconnaissance survey 29–30 June 1982; survey of the entire area 15–18 July and 22–25 August 1983). In addition, ground counts have been performed in two reference areas in both years (see Fig. 1), in Ørsted Valley and in an area around the Draba Sibirica River in the heath area. The ground counts have provided more precise information about the size of the breeding populations (families and goslings are often overlooked in aerial counts) and an opportunity to compare numbers between years. In 1983 Ørsted Valley was visited by a British goose expedition censusing this reference area (S. Newton and D. Cabot, pers. comm.).

The results of the aerial surveys in 1983 are summarized in Table 1 and the distribution of geese in July is shown in Fig. 2. In short, the surveys combined with the censuses in the reference areas, have revealed that the breeding populations are generally small and scattered. Only in Ørsted Valley and adjacent valleys are high concentrations of breeding Barnacle Geese and Pinkfeet found, and the numbers of breeding pairs are highly variable in different years. Jameson Land has its major importance as a summering and moulting area of non-breeding flocks of geese. In July 1983, 25% of the entire East Greenland population of Barnacle Geese and around 6% of the Iceland/East Greenland population of Pinkfeet were gathered in the area.

The Barnacle Geese seem to utilize Jameson Land for a short period. It is still unknown when they arrive (this will be examined in 1984), while the major part of the July population in 1983 had abandoned the area by 22–25 August, and our impression is that they left the area as soon as the moulting was over (in both 1982 and 1983 flightless non-breeding Barnacle Geese were seen in the period 5 July to 2 August).

The non-breeding Pinkfeet undertaking the moult migration from Iceland to East Greenland arrive from mid to late June (Meltofte 1976; Hansen 1979). After the moult (flightless non-breeding Pinkfeet were observed from 10 July to 10 August both years) the geese apparently stay

Table 1. *Total number of adult geese counted by the aerial censuses in 1983.*

Census	*Pink-footed Goose*	*Barnacle Goose*	*Total*
15–18 July	5561	6144	11705
22–25 August	5500	1336	6836

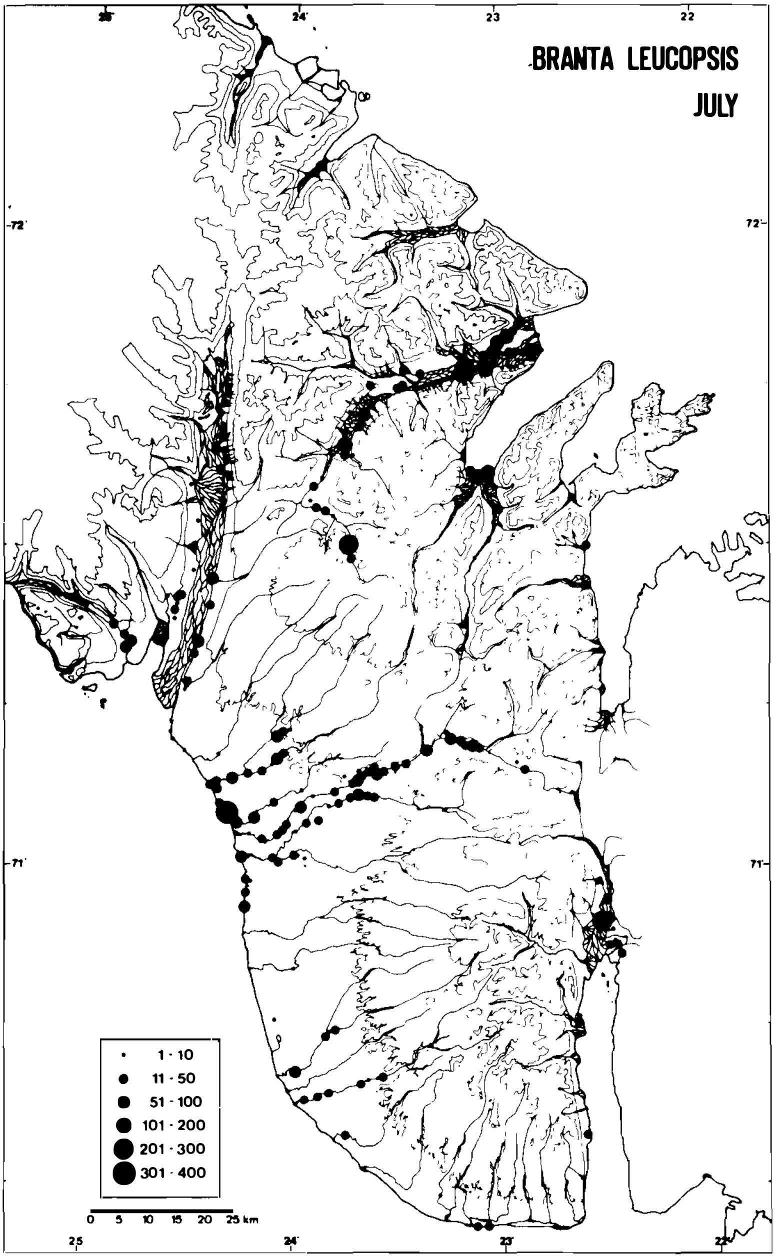


Fig. 2. The distribution of adult geese in Jameson Land by the aerial census in July 1983.

in the area until the departure from East Greenland which for both species takes place from late August to mid September (Meltofte 1976).

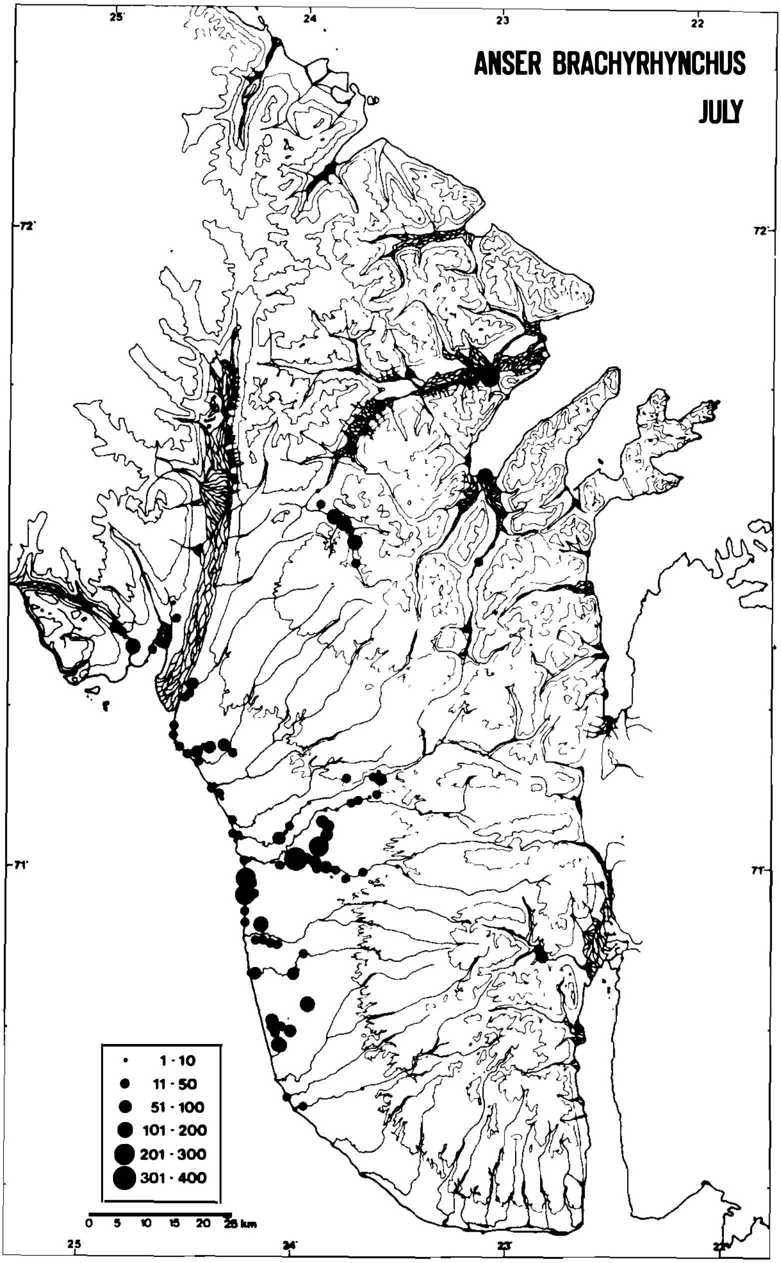
Behavioural and energetic studies

As the great majority of the geese were found to be non-breeders, the behavioural and energetic studies were concentrated on these. The analysis of disturbance effects of human activity attempts to express the acute, direct behavioural response of the geese as well as the effect on time and energy budgets (condition).

(a) The direct response

Helicopters

In both years daily helicopter flights were observed, and at every opportunity an attempt was made to describe the sequence of events when a



B

helicopter passed over an area with moulting geese. The distance to the helicopter was estimated using either fixed points of known distances in the vicinity or by measuring the time lapse on a stop watch (velocity of helicopters known). The reaction of the observed geese was standardized in an index:

Index 0: no reaction, grazing or rest continued undisturbed,

Index I: the flock runs a short distance but stays on land,

Index II: the flock runs to the bank of the river/lake and swims out on the water,

Index III: the flock runs to the bank, swims out on the water and the birds aggregate in panic.

The results (Table 2) show that the geese are extremely shy and wary when moulting even to the noise of helicopters many kilometres away. A significant interspecific difference exists in both the distance of reaction and in the intensity of the response. In certain situations the Pinkfeet react to helicopters 20 km away, in general swimming out on open water at 10 km's distance, and clumping in panic at 4 km's distance from the helicopter. The Barnacle Geese are less shy and react only moderately to helicopters even 1–2 km away; in general they do not react to helicopters at 4 km's distance.

Ground activity

By our own experience it has been demonstrated that when we walk past a lake with moulting geese, they will often be driven off (especially the Pinkfeet) and are forced to cross the tundra with the risk of predation by the Arctic fox *Alopex lagopus*. If the lake is connected with a river or a coast, the geese may return later in the moulting period, but remote lakes will not be recolonized. The period preceding moult seems to be especially sensitive. The geese seem to arrive at the moulting place some time before the moult is started (maybe to evaluate the suitability – carrying capacity and peace). Twice during this period we drove geese off a lake, and it was ascertained that they only returned to one of the lakes later during moult.

(b) The consequence of disturbance on time and energy budgets

Until now, efforts have been concentrated on the establishment of an expression of a time and energy budget of moulting geese in a situation without human interference. This has almost been achieved for the Pinkfeet, whilst the data on the Barnacle Geese are still incomplete. Thus, in the following, only the results on Pinkfeet will be presented. In 1984, the plan is to carry out a series of experimental studies on the effect of various human activities on the energy budgets of the geese. The question is whether they will be able to compensate for lost feeding time when exposed to the disturbance pressure that can be expected from oil exploration activities.

Table 2. *Reaction expressed by index (see text) of moulting geese to overflying helicopters. A cross indicates one observation in the given interval.*

Distance (km)	*Index 0*	*Index I*	*Index II*	*Index III*
Pink-footed Goose:				
0–2				xxxxx
				xxxx
2–4				xxxx
				xxxx
4–6				xxxxx
			x	xxxx
6–8	xx		xxx	xx
8–10	xxx		xxx	
10–12	xxxxx	x		
12–14	xxxxx	x		
14–16	xxxx			
	xx	xx	xx	
16–18	xxxxx	x		
18–20	xxxxx	x		
> 20	xxxx			
	xx			
Barnacle Goose				
0–2	xxxx	xxxxx		
	xxx	xxxx	xxxxx	xx
2–4	xxxx			
	xx	xx	x	
4–6	xxxxx			
	xxxx	x	x	
6–8	xxxx			
	xxxx			
8–10	xxxx			
	xxxx			
> 10	xxx			

Time budget studies are carried out from hides. The activity of the flock under observation is scanned through a telescope (20–45x) every 5 or 10 minutes depending on flock size, and observations are preferably run 24 h or more uninterrupted.

Daily food and energy intake is estimated using the 'marker substance method' developed on geese in the wintering areas (Ebbinge et al. 1975; Drent et al. 1978/79). The method appears to be especially applicable to the situation during moult in Jameson Land. The geese feed on a uniform food supply (in the study area a preliminary faecal analysis had revealed that 80–90% of the diet is made up of *Carex subspathacea)*, and during continuous daylight they spread their activity over all 24 hours without any

Table 3. *Estimate of food and energy intake of Pinkfeet grazing on sedge-dominated marshes during moult (undisturbed conditions).*

Daily defaecation (droppings/24 h)[a]	139 (n = 37239 sec.)
Dry weight of droppings (g)	0.86 (n = 84)
Organic content (g ash-free)	0.74
Retention rate[b]	0.31
Daily intake (g.o.m.)	149
Energy content food (kJ/g.o.m.)	21.01
Energy content droppings (kJ/g.o.m.)	18.75
Energy retention rate	0.38
Daily energy intake (kJ/24 h)	1200

[a] measured by the number of defaecated droppings during an intensive observation of the abdomen of a goose, [b] ash was used as tracer substance, and the silica fraction has been subtracted.

Table 4. *Estimation of time and energy expenditure of Pinkfeet during moult (undisturbed conditions).*

Time budget (%): (n = 79 h)	Grazing	40.9
	Roosting	38.1
	Preening	7.8
	Walking	4.0
	Swimming	9.2
Mean weight of geese during moult (kg)[a]		2.470
Basal metabolic rate (kJ/24 h)[b]		702
Energy coast of activities (kJ/24 h)[c]		1058
Energy cost of moulting (kJ/24 h)[d]		293
Daily energy expenditure (kJ/24 h)		1351

[a] from Beer & Boyd (1962), [b] calculated from equation in Aschoff & Pohl (1970), [c] multiples of BMR taken from Wooley & Owen (1978), [d] estimate for Barnacle Goose given in Owen & Ogilvie (1979).

definite rhythm, thus defaecating at a relatively constant rate.

The estimates of daily energy intake and energy expenditure are shown in Tables 3 and 4. Confidence limits on estimates of both intake and expenditure have not yet been calculated, but there seems to be an approximate balance between intake and expenditure, perhaps with a small deficit in food intake. Investigations on the weight development during moult (see Owen & Ogilvie 1979) have shown that most geese go through moult without loss of weight, which is in accordance with the calculated energy balance of Pinkfeet under undisturbed conditions in Jameson Land.

Habitat ecological correlates to disturbance

Our investigation of the habitat ecology has been concerned with a description of the habitat selection and segregation of the species throughout the season, food selection, an analysis of grazing intensity, and carrying capacity.

One of the crucial questions in connection with oil exploration and the disturbance effect is what effect a consequent displacement of parts of the goose populations will have. Are there alternative sites or is the area (the optimal habitat) saturated with geese? Furthermore, exact knowledge of the habitats utilized by the geese is essential, when it comes to regulation of oil exploration activities.

(a) Habitat selection

The habitat selection and segregation of the species during moult are analysed by a multiple factor anlysis (described by Fjeldså (1981)), but the data still await computation, and only some of the results are presented here.

During moult the geese have only a narrow ecological amplitude, as they are dependent on a safe escape and a sufficient food supply in direct connection to this. Both species graze exclusively on marshes dominated by sedges. In Fig. 3 the

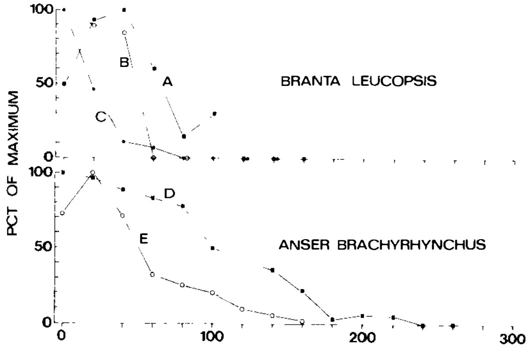


Fig. 3. Habitat utilization during moult in relation to proximity to open water in sedge dominated marshes (five sites, A–E), expressed by dropping densities (each point represents at least 8 squares of 4 m^2 each). Densities have been expressed as percentage of the maximum density.

relationship between habitat utilization and the proximity to open water is demonstrated. Barnacle Geese only exploit a narrow zone (less than 100 m from the water) while the Pinkfeet dare to walk further away into the marshes (some 200 m from the water's edge). Dropping counts, which have been used in this analysis, do not quite reflect grazing pressure, as it has been noticed that especially the Pinkfeet graze at a faster rate when they walk away from the open water (at the same time they are far more alert and wary).

In 1983 it was observed that as soon as the moult was finished, the geese totally abandoned the moulting habitats. Most of the Barnacle Geese left the area entirely as described above, while the Pinkfeet moved to the fell heath, feeding on berries, and to marshes which had not been visited earlier in the season.

(b) Grazing intensity and carrying capacity

As the habitat selection of the geese during moult is so well defined, it has been possible to make some estimates of grazing intensity by the calculation of goose days spent per unit grazed area. Of great value to this analysis has been aerial photography of the entire area with false-colour infra-red film undertaken by the botanical investigators in order to map the vegetation zones (S. Holt and C. Bay). From these photographs various habitats can be identified by colour, and in the reference areas, where the number of geese within well defined sites is known, the goose grazed habitats have been mapped from the photographs. From the study of their habitat selection (Fig. 3) it is known which parts of the marshes are available to the geese.

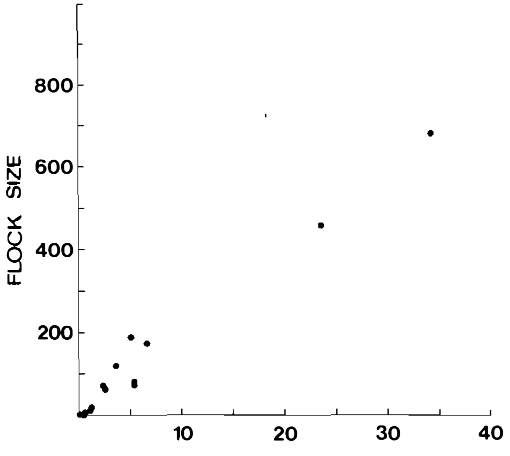


Fig. 4. Relationship between size of moulting flocks of geese (both species included) and food supplies (sedge dominated marshes).

In Fig. 4 the relationship between the available area of marsh at a site and the size of the moulting goose flock has been depicted (there are still more data to come). The linear correlation indicates that the sites are exploited according to the available food resource, and the slope of the regression (preliminary regression: $Y = 20X + 4$) indicates a similar grazing pressure on all sites.

The impression of these patterns is furthermore confirmed by the constancy in number of geese per locality in the two seasons (Fig. 5).

In 1983 an exclosure experiment was made on a marsh dominated by *Carex subspathacea* and mosses, and grazed by up to 230 Pinkfeet during the moult. Four fenced areas of 1 m^2 each were erected on 5 July and the vegetation clipped around the exclosures. By that time the area had already been grazed. On 4 August, when the majority of the geese had finished the moult and abandoned the area, the vegetation was clipped inside and outside the exclosures.

The results are shown in Table 5. No difference in standing crop between the fenced and unfenced area was found, and since 5 July the green above-ground biomass had decreased. The experiment indicates that the primary production had taken place in the period before the erection of exclosures (before moult), and there had been no significant growth, nor grazing of the vegetation since.

In 1984 the primary production is planned to be followed at two sites from early June to August in order to elucidate the nature and dynamics of the primary production. The preliminary results, however, give some indications of a situation where the moulting geese graze on a resource which is not replenished, but gradually depleted.

If the period the geese stay in the moulting places is set to 30 days, the grazing pressure can be calculated from the regression in Fig. 4. Thus a grazing pressure of 607 goose days/ha is calculated, equivalent to 17 m^2 per goose per day (no differentiation between species). The daily

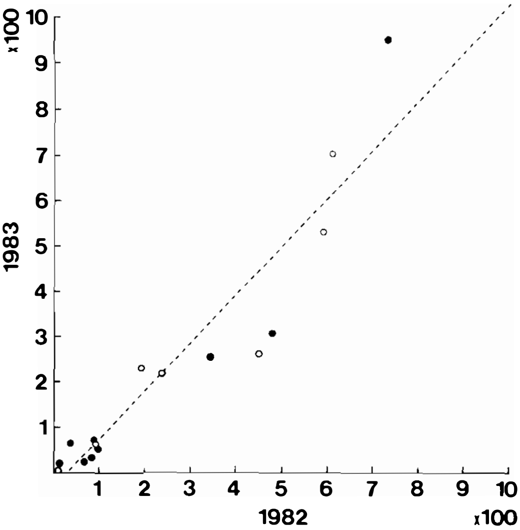


Fig. 5. Comparison of numbers of moulting geese per site in the reference areas in 1982 and 1983. Circles: Pinkfeet; filled circles: Barnacle Geese. The regression is Y = 1.1X − 32.5; r = 0.94; $p < 0.001$. One set of data is omitted, as the site was probably disturbed by human activity just prior to moult.

food intake of a Pinkfoot was estimated at 149 g organic matter (Table 3). With an estimated availability of 17 m^2 per day, a Pinkfoot will remove 9 g biomass/m^2 (organic matter) per day. Although we do not know the exact primary growth preceding the erection of the exclosures on 5 July, it is believed that the geese have minimal scope for further grazing, if any at all.

In summary, it is indicated by a number of findings that the carrying capacity has been almost, if not completely, reached:

(1) all suitable sites (salt marshes, lakes and rivers above a certain width) are utilized if a food supply is available;
(2) the geese seem to remove all primary growth above a height of ca. 1/2 cm; and
(3) the geese abandon the moulting areas as soon as possible after flight has been regained.

Furthermore, during the time budget studies of a flock of 170 Pinkfeet and 6 Barnacle Geese, the Pinkfeet were observed to graze 43% of the time (n = 48 h), while the Barnacle Geese spent 61% of the time grazing. The Pinkfeet primarily grazed in a zone 50–200 m from the lake while the Barnacle Geese grazed exclusively in a zone 0–50 m from the lake. The latter zone had probably already been grazed by Pinkfeet, and has possibly been only a profitable resource to the smaller billed and faster pecking Barnacle Goose, but at the cost of a longer feeding period (and a higher energy expenditure).

Owen (1980) hypothezised that some arctic breeding geese, including the Iceland/East Greenland population of Pinkfeet, may be regulated by the carrying capacity of the nesting areas. The implication of the above findings is that the hypothesis may also be extended to the moulting areas of this population.

Discussion

The surveys in 1983 revealed that Jameson Land is a very important moulting area for Barnacle Geese and Pinkfeet, and is probably the most important area for moulting geese in all East and Northeast Greenland. It should be noted that the Barnacle Goose population has been declining recently (Ogilvie 1983). Although the effect of the oil exploration in Jameson Land is still unknown (will be known by the termination) it poses a potential threat to the population, which might additionally affect the population development.

From the distribution maps (Fig. 2) and based on experience with the extreme shyness of the moulting geese, a map showing sensitive and

Table 5. *Standing crop before and after moult (inside and outside exclosures) in a* Carex subspathacea *dominated marsh grazed by Pinkfeet. Sample size: 0.11* m^2. *There is no significant difference between biomass outside and inside exclosures on 4 August (t-test), while there is a significant drop in biomass from 5 July to 4 August (F-test,* $p < 0.01$*).*

	Carex subspathacea	*Poa pratensis*
5 July 1983		
Biomass (g d.w./m^2)	9.09	0.57
s.d. (n = 6)	4.14	0.58
4 August 1983		
Outside exclosures		
Biomass (g d.w./m^2)	6.94	0.19
s.d. (n = 6)	0.64	0.14
Inside exclosures		
Biomass (g d.w./m^2)	8.23	0.50
s.d. (n = 6)	3.15	0.49

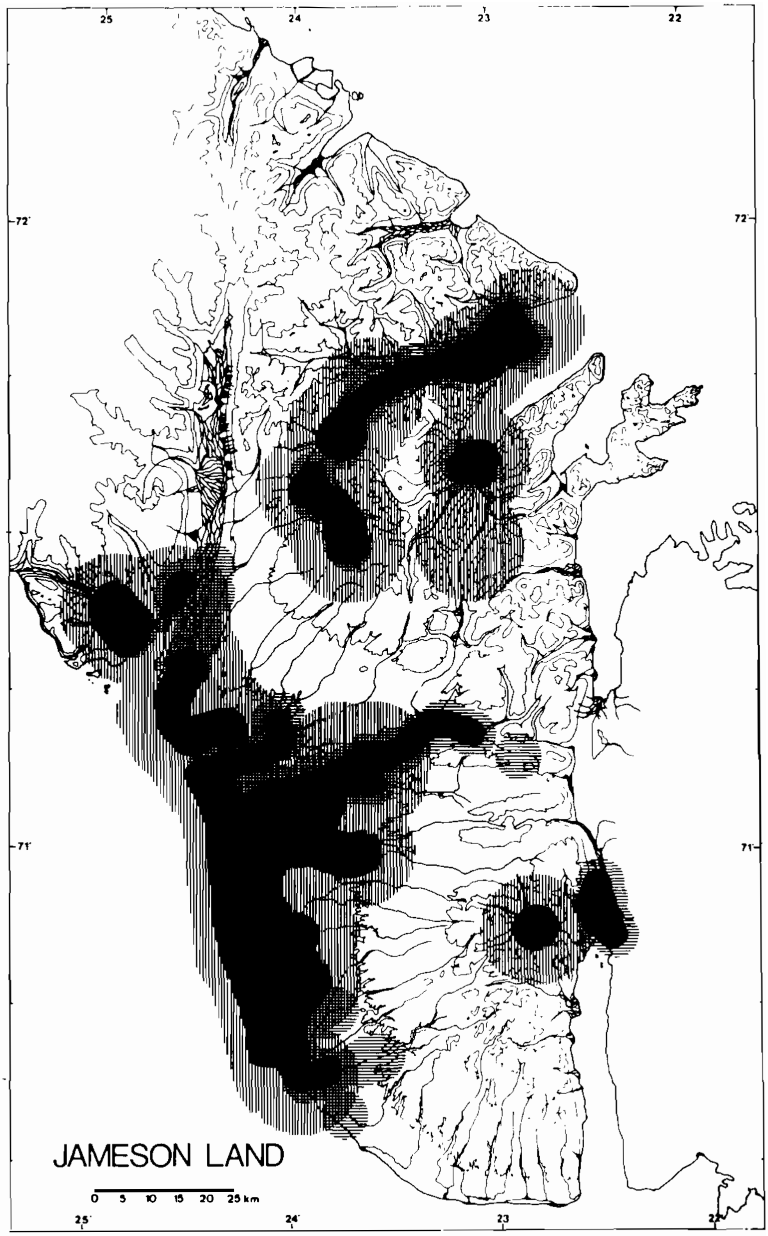


Fig. 6. Location of sensitive and highly sensitive areas with concentrations of moulting geese. Hatching indicates the sensitive areas (a buffer zone of 10 km in radius around a flock of Pinkfeet, and 4 km around a flock of Barnacle Geese, and a flock size of 50 as the lowest criterion); black areas indicate the highly sensitive areas (a buffer zone of 6 km radius around a flock of Pinkfeet, and 2 km around a flock of Barnacle Geese, and a flock size of 100 as the lowest criterion). Vertical hatching indicates buffer zones of Pinkfeet, and horizontal hatching buffer zones of Barnacle Geese.

highly sensitive areas has been prepared (Fig. 6). Its purpose is to point out areas where human activity ought to be regulated, e.g. by aerial corridors, during the moulting period and the preceding weeks. By these means it is hoped that the most damaging impacts to the goose populations can be circumvented.

Acknowledgements

The goose studies are performed by the Zoological Museum, Copenhagen as consultants to the Greenland Fisheries Investigations. Jon Fjeldså, Hanne Petersen, David Boertmann and Chr. Ebbe Mortensen are thanked for fruitful discussion and for commenting on this paper. Sune Holt and Christian Bay are thanked for help in the preparation of maps of goose habitats. Poul Lassen drew the basic map.

References

Aschoff, J.H. & Pohl, H. 1970: Der Ruheumsats von Vögeln als Funktion der Tageszeit und der Körpergrösse. *J. Orn. 111:* 38–47.

Beer, J.V. & Boyd, H. 1962: Weights of Pink-footed Geese in autumn. *Bird Study 9:* 91–99.

Christensen, N.H. 1967: Moult migration of Pink-footed Geese *(Anser fabalis brachyrhynchus)* from Iceland to Greenland. *Dansk orn. Foren. Tidsskr. 61:* 56–66.

Derksen, D.V., Weller, M.W. & Eldridge, W.D. 1979: Distributional ecology of geese molting near Teshekpuk Lake, National Petroleum Reserve-Alaska. Pp. 189-207 *in* Jarvis, R.L. & Bartonek J.C. (eds.): *Management and biology of Pacific Flyway Geese.* Corvallis, Oregon State Univ. Book Stores.

Drent, R., Ebbinge B. & Weijand B. 1978/79: Balancing the energy budgets of arctic-breeding geese throughout the annual cycle: a progress report. *Verh. orn. Ges. Bayern 23:* 239–264.

Ebbinge, B., Canters, K. & Drent, R. 1975: Foraging routines and estimated food intake in Barnacle Geese wintering in the Northern Netherlands. *Wildfowl 26:* 5–19.

Ferns, P.N. & Green, G.H. 1975: Observations of Pink-footed and Barnacle Geese in the King Oscar Fjord region of north-east Greenland. *Wildfowl 26:* 131–138.

Fjeldså, J. 1981: Comparative ecology of Peruvian grebes – a study of the mechanisms of evolution of ecological isolation. *Vidensk. Meddr. dansk naturh. Foren. 143:* 125–249.

Fredskild, B., Bay, C. & Holt, S. 1982: *Botaniske undersøgelser på Jameson Land 1982.* Botanical Museum, Copenhagen.

Hall, A.B. 1963: Goose observations from Scoresby Land, 1962. *Wildfowl Trust Ann. Rep. 14:* 94–97.

Hall, A.B. & Waddingham, R.N. 1966: The breeding birds of Ørsted Dal, East Greenland, 1963. *Dansk orn. Foren. Tidskr. 60:* 186–197.

Hansen, J.M. 1979: *Hurry Fjord ekspeditionen 1979. Avifaunistical survey.* Photocopied report.

Madsen, J. & Boertmann, D. 1982: *Undersøgelser af gæs i Jameson Land 1982.* Zoological Museum, Copenhagen. Greenland Fisheries Investigations.

Marris, R. & Ogilvie, M.A. 1962: The ringing of Barnacle Geese in Greenland in 1961. *Wildfowl Trust Ann. Rep. 13:* 53–64.

Marris, R. & Webbe, A.H.F. 1969: Observations of birds in East Greenland, 1966. *Dansk orn. Foren. Tidsskr. 63:* 161–170.

Meltofte, H. 1976: Ornithological observations from the Scoresby Sund area, East Greenland, 1974. *Dansk orn. For. Tidsskr. 70:* 107–122.

Ogilvie, M.A. 1983: Numbers of geese in Britain and Ireland, 1982–1983. *Wildfowl 34:* 172.

Ogilvie, M.A. 1983: The numbers of Greenland Barnacle Geese in Britain and Ireland. *Wildfowl 34:* 77–88.

Owen, M. 1980: *Wild geese of the world.* Batsford, London.

Owen, M. & Ogilvie, M.A. 1979: Wing molt and weights of Barnacle Geese in Spitsbergen. *Condor 81:* 42–52.

Wooley, J.B. & Owen, R.B. 1978: Energy costs of activity and daily energy expenditure in the Black Duck. *J. Wildl. Manage. 42:* 739–745.

PALLE UHD JEPSEN:

Protection and management of arctic goose populations in Denmark

Jepsen, P.U. 1984: Protection and management of arctic goose populations in Denmark. *Nor. Polarinst. Skr. 181:* 153–160.

This report deals with the protection of the populations of Pink-footed Goose *Anser brachyrhynchus* and Light-bellied Brent Goose *Branta bernicla hrota* in Danish haunts in relation to damage to field crops caused by Pink-footed Goose, shooting, nature conservation, and establishment of reserves for geese. It is suggested that the arctic goose populations which during migration and the winter stay in haunts in Northwest Europe should be managed in such a way that the mortality factors which may contribute to the fact that the populations cannot achieve a high survival rate are reduced to a minimum. These factors are primarily shooting, disturbances in the haunts, and reduced food resources.

Palle Uhd Jepsen, Wildlife Administration of the Ministry of Agriculture, Wildlife Reserve Bureau, Strandvejen 4, DK-8410 Rønde, Denmark.

Introduction

The breeding populations of the Pink-footed Goose *Anser brachyrhynchus* and the Light-bellied Brent Goose *Branta bernicla hrota* of Svalbard stay in Denmark during migration and are sometimes wintering in haunts there. The number of geese as well as annual fluctuations during the last approximately 20 years are well documented in regular counts by the Game Biology Station, Kalø, the National Agency for the Protection of Nature, Monuments and Sites, and the Danish Ornithological Society (Salomonsen 1958; Fog 1967, 1972, 1977; Madsen & Lund 1982).

The number of haunts for both these arctic goose populations has been reduced to very few localities, all in Jutland (Fig 1 A and B). More details concerning migration, numbers, and habitat usage have been given by Madsen (1984).

In 1972 the Brent Goose was totally protected in Denmark; an increase in the population during the last ten years may be due to this protection. The Pink-footed Goose has an open hunting season and may be shot within the period 1 September to 31 December.

Other measures than regulation of the shooting are necessary however in the management of the goose populations. Increasing problems of damage to field crops caused by Pink-footed Geese make it necessary to discuss a strategy for a long-term management of the geese populations, such as for instance protection of the geese in the haunts. In Denmark no field damage caused by the Light-bellied Brent Goose has been documented.

In this report these problems will be mentioned and attention called to possible solutions.

Pink-footed goose

During migration and stay in Denmark the Pink-footed Goose is exclusively attached to haunts along the west coast of Jutland (Fig. 1 A), and the most important areas in the spring months are the areas at the Waddensea, Filsø, Tipperne-Værnengene, Vest Stadil Fjord, Nissum Fjord, and Harboøre Tange. In the autumn the haunts are limited to Vest Stadil Fjord, Tipperne, and Filsø, probably first and foremost because of disturbances caused by shooting.

In the autumn of 1980, 91% of the total goose-days were spent at two localities with no or very limited shooting, whereas the same numbers of goose-days the following spring were spent at seven different localities (Madsen 1982).

The significant increase in the population of Pink-footed Geese during the latest years (Fog 1981; Madsen 1984) has had the effect that the geese forage in cultivated fields in greater numbers causing damage to the crops, primarily by eating newly sown cereals. At the same time they

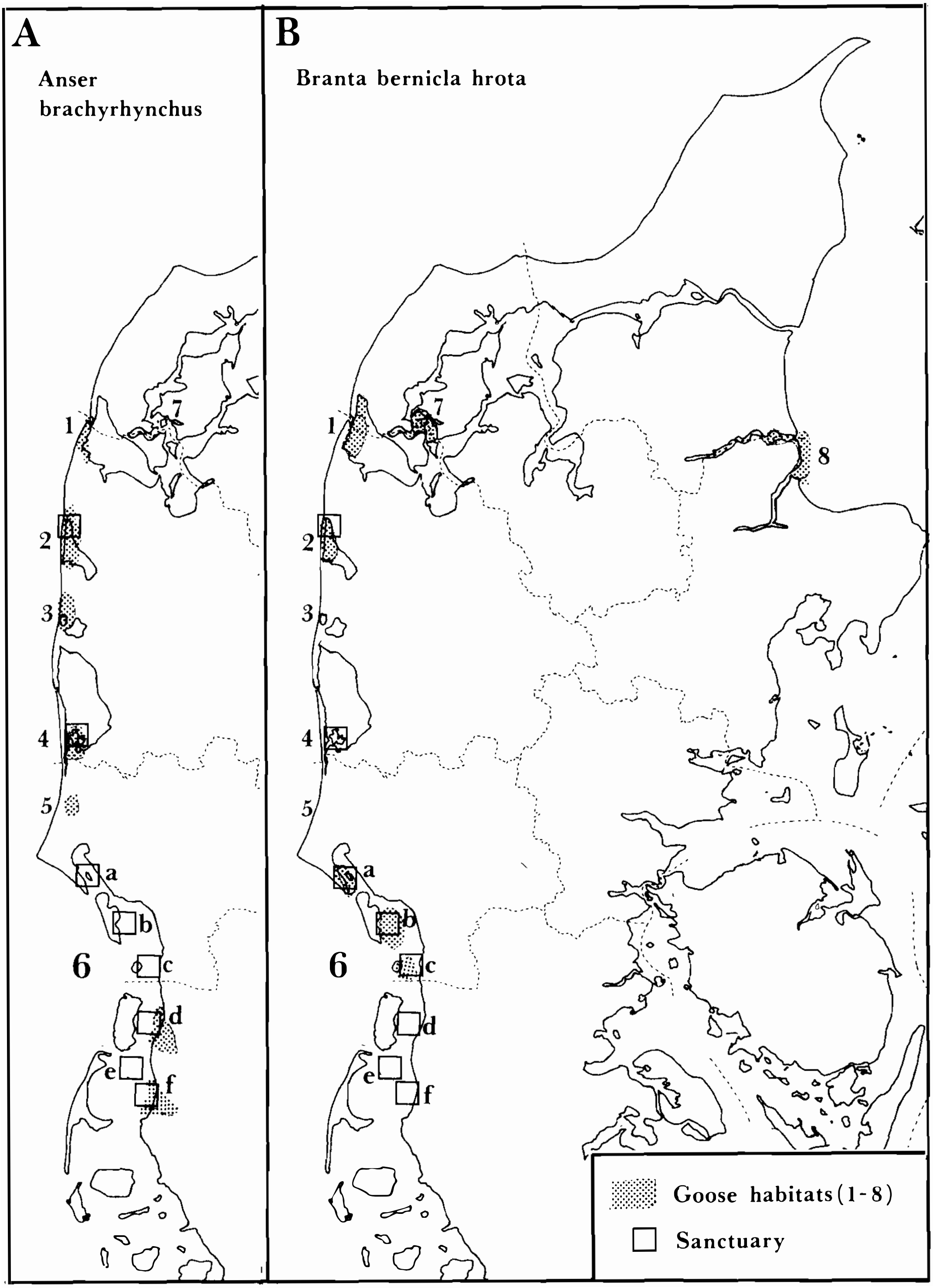


Fig. 1. Habitats for Pink-footed Geese (A) and Light-bellied Brent Geese (B) during migration and wintering in Denmark. 1. Nissum Bredning and the isthmus by Thyborøn; 2. Nissum Fjord; 3. Vest Stadil Fjord; 4. Tipperne and Klægbanken; 5. Filsø; 6. the Waddensea (a. the deep between Skallingen and Langli, b. Albuebugten east of Fanø, c. Mandø, d. the Rømø-dam, e. the island of Jordsand, and f. diked marsh-land near Højer); 7. Agerø; and 8. Mariager and Randers Fjords.

become accustomed to a higher degree to feeding on agricultural cereals. The problem is thus greatest during spring migration, whereas in the autumn they primarily eat cereals wasted in stubble fields and grass fields without causing considerable damage (Fog 1981).

The areas in which the geese mainly damage the field crops are in and in close proximity to larger homogeneous agricultural areas laid out on the bottom of drained wetlands in Vest Stadil Fjord and Filsø. These areas attract the geese because of 1) the size of the areas, 2) the view, 3) the reduced disturbance, 4) the access to food, and 5) the possibility of overnight stay close by.

The conflict between geese and agriculture

The most important reasons why problems with geese and field crops arise are the high number of geese, and the drainage and cultivation of original grass areas in salt meadows and in marshland. The recent change in the agricultural structure which has resulted in a drastic decrease in the number of herds of cattle and thus in grass areas in favour of larger areas with cereals, has probably also resulted in the geese getting accustomed to foraging cereals (J. Madsen, pers. comm.). Together with the economic stagnation in the agricultural industry this has resulted in a smaller tolerance to the presence of geese.

The Danish legislation does not allow for compensation to be paid for game damage to crops, and generally speaking it is thus left to each single farmer to solve the problems himself.

In Denmark we have only recently started research on feeding habitats (Fruzinski 1977; Madsen 1980), and the extent of damage to field crops caused by Pink-footed Geese.

In one single locality, Vest Stadil Fjord, the Game Biology Station has for a number of years tried to prevent damage caused by geese by feeding them with barley in a selected area laid out with grass. This measure has a good effect on the surrounding small farms, and it has been possible to keep the geese away from them, but when some weeks later the large areas on the earlier fiord bottom are sown, it is extremely difficult to keep the geese away from the newly sown fields (Fog 1981; 1982 a).

In the Netherlands where geese have caused extensive field damage, as according to Rooth et al. (1981) up to 400,000 geese of several species rest and winter there, they have not yet been able to find efficient solutions. They have, however, temporarily managed the problems, partly by paying damages to the farmers affected, partly by purchasing or hiring areas for the birds (Fog 1982 b). In Britain several scientists have dealt with geese and damage to agricultural areas caused by geese (Kear 1970; Newton & Campbell 1973; Owen 1977; St. Joseph 1979). Newton & Campbell among other things pointed out that it may be very difficult to reduce the number of geese in a suitable goose locality and that the farmers must therefore show understanding of the problem and to a certain degree adapt the farming to the geese.

Management of the population

St. Joseph (1979) has pointed out that protection of field crops against geese, for instance by scaring, is only possible if the geese have alternative feeding possibilities in undisturbed areas. Observations in Danish goose localities seem to confirm this theory.

The management of the population of the Pink-footed Goose in Denmark should aim partly to give the best possible protection of the geese as there will continue to be suitable haunts, and partly to reduce the conflicts between geese and farmers.

As mentioned earlier, during migration along the Jutland west coast the geese are concentrated in very few haunts where on the other hand they appear in great numbers. In some of these areas the geese are subject to hunting, but in total no more than 1,500 Pink-footed Geese are bagged per year (M. Fog, pers. comm.). A bag of this size can hardly have a negative effect on the population. The possibility of shooting Pink-footed Geese may give the farmers a certain financial compensation for any damage, which has to be tolerated in the spring months, and besides it increases the threshold of tolerance towards the geese. Therefore, shooting should continue to be permitted on the condition that it is within the frames of the natural population surplus.

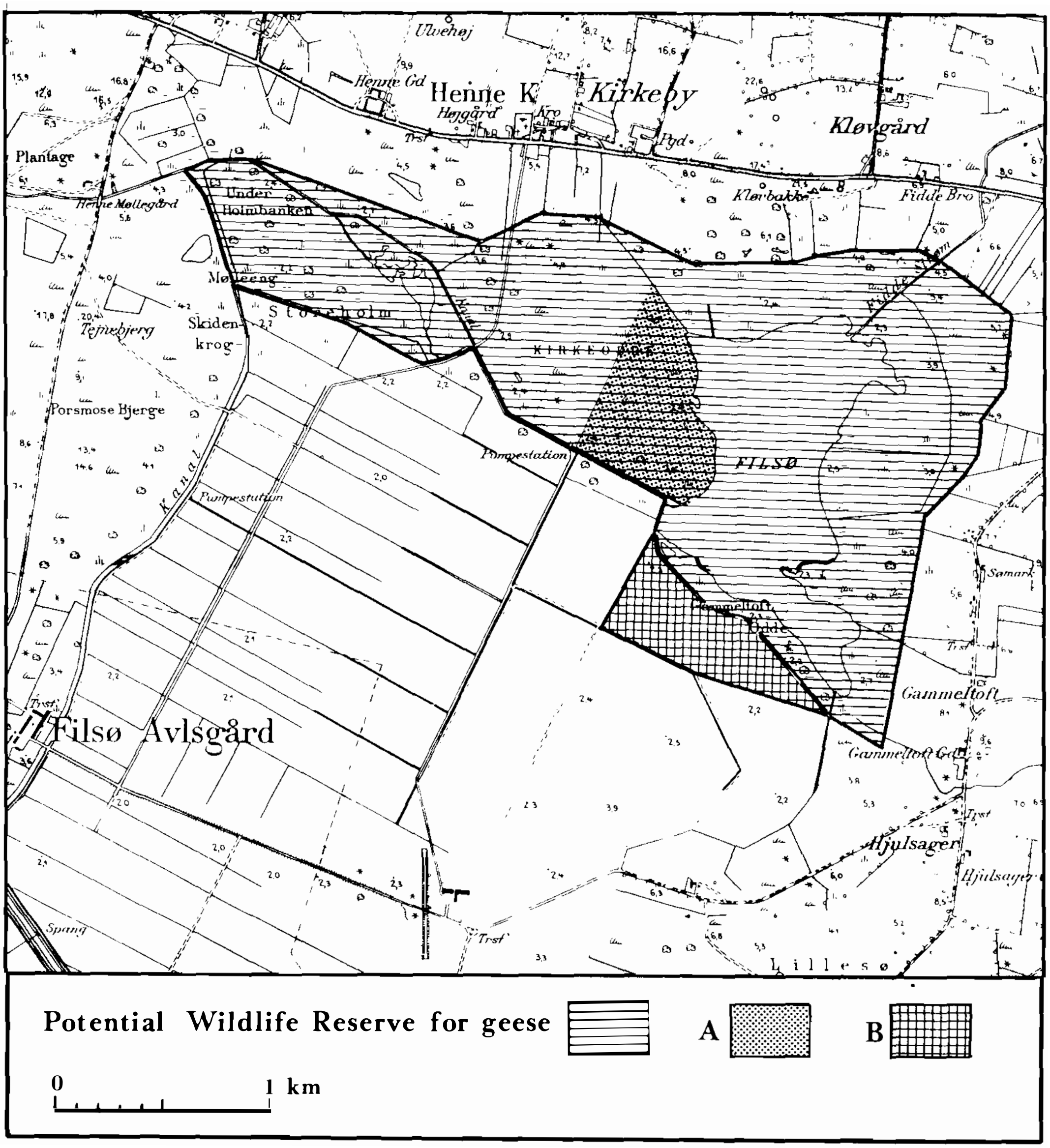


Fig. 2. Potential goose-reserve in a nature protected area at Filsø. A: grassland after removing of Willow-scrub, B: feeding area for geese.

Reserves for geese

Protected haunts, i.e. reserves without shooting and other disturbance where there are food resources, as alternatives to agricultural areas, must be an important element of the management of the population. Today only one reserve, Tipperne in Ringkøbing Fjord, is of a suitable size for the geese. An increase in the number of suitable goose reserves is necessary, however, if we are to avoid essential conflicts between geese and farmers in the future. But at the same time attention must be called to the fact that reserves can be so attractive, that the geese appear in such large numbers that damage to surrounding fields cannot be avoided (Owen 1977; Fog 1981).

This is why alternative foraging possibilities in natural habitats are of crucial importance, combined with measures, such as scaring, which make cultivated areas less attractive to geese.

A proposal for a solution of the goose problems in one of the most exposed areas in Denmark, Filsø, might be to establish a wildlife reserve on the remaining part of the former large lake and to start management of the area closest to the lake, making the necessary allowance for the conservation status of the area. Willow scrub and other bushes should be removed to recreate an open connection to the lake, which is used by the geese as an overnight roost. The grass vegetation in the area should then be cut and later kept low by grazing cattle or sheep. In the spring period it may be necessary to feed the geese in the reserve, and an adjoining area in the fields of Filsø might be grown with crops for the geese. In order to keep the geese away from the cereal fields scaring techniques should be used as soon as the birds arrive in the early spring. This may force them to stay in the reserve. In the summer of 1983 the Wildlife Administration started provisional negotiations with the owner of Filsø about the proposal.

Along the Jutland west coast, in areas presently owned by the Government or in areas which might be purchased by it (for instance the earlier wetland Vest Stadil Fjord), similar measures might be initiated in order to start experiments with particular crops for the geese (among other things grass as alternative to cereals) to ensure intact salt meadows. These were originally the natural foraging areas for the geese. Establishment of wetlands should also be initiated.

Light-bellied Brent Goose

During migration in Denmark the Light-bellied Brent Goose primarily appears in a few localities in Jutland, in the Nissum Fjord, and in Limfjorden at Agerø, and in the Nissum Bredning in the spring. From November and, in mild winters, sometimes until March, the Light-bellied Brent Goose stays in the fiords of Mariager and Randers and in the northern part of the Waddensea (Fig. 1 B).

The number of Light-bellied Brent Geese in Danish haunts has increased during recent years. One reason for this may be the total protection of the Brent Goose in 1972 (Madsen 1984).

In the haunts in Nissum Fjord and at Agerø the geese are mainly seen foraging in the vegetation belts and on mud-flats in the fiord. In the Nissum Fjord only approximately 16% of the population forage in adjacent grass areas (Madsen 1984). The possibilities for the geese to seek food on land in the Nissum Fjord area have been reduced in recent years, partly due to the increased cultivation of the salt meadows, partly to the fact that cattle grazing has been given up. The result is that the meadow vegetation changes its character as either *Phragmites communis* appears or the grass grows long and becomes unsuitable for the geese. At the same time a drastic reduction of areas with growth of eel grass *Zostera sp.* has occurred in the Nissum Fjord since the mid-1960s, when the distribution of eel grass was surveyed (Jepsen 1967), showing occurrence of dense growth in the western parts of the fiord (Figure 3 A). In the late summer of 1983 sampling of the bottom vegetation showed that eel grass only occurs in the northern part of the fiord (Fig. 3 B). This development has probably contributed to the number of Light-bellied Brent Geese in the Nissum Fjord remaining stable during recent years even though the population is increasing.

Disturbance and shooting

Since the total protection of the Brent Goose in 1972 it has repeatedly been discussed whether an open season should be reintroduced following the very large increase in the population of Dark-bellied Brent Geese *Branta bernicla bernicla.* This debate will not be resumed here. It must be emphasized, however, that if at some time in the future an open season should become a reality, it must be ensured that the conservation of the Light-bellied Brent Goose continues. Such conservation can hardly be effected in any other way than to continue the total protection of the Brent Goose in the counties where the light-bellied subspecies has its haunts, as it will be difficult or impossible in practice for hunters to distinguish between the two kinds.

As far as the light-bellied subspecies is concerned, conservation through protection alone is not sufficient. Disturbance in the autumn haunts of the geese in connection with shooting of other game species, increasing disturbance in connection with navigation, fishery, etc. in general, and

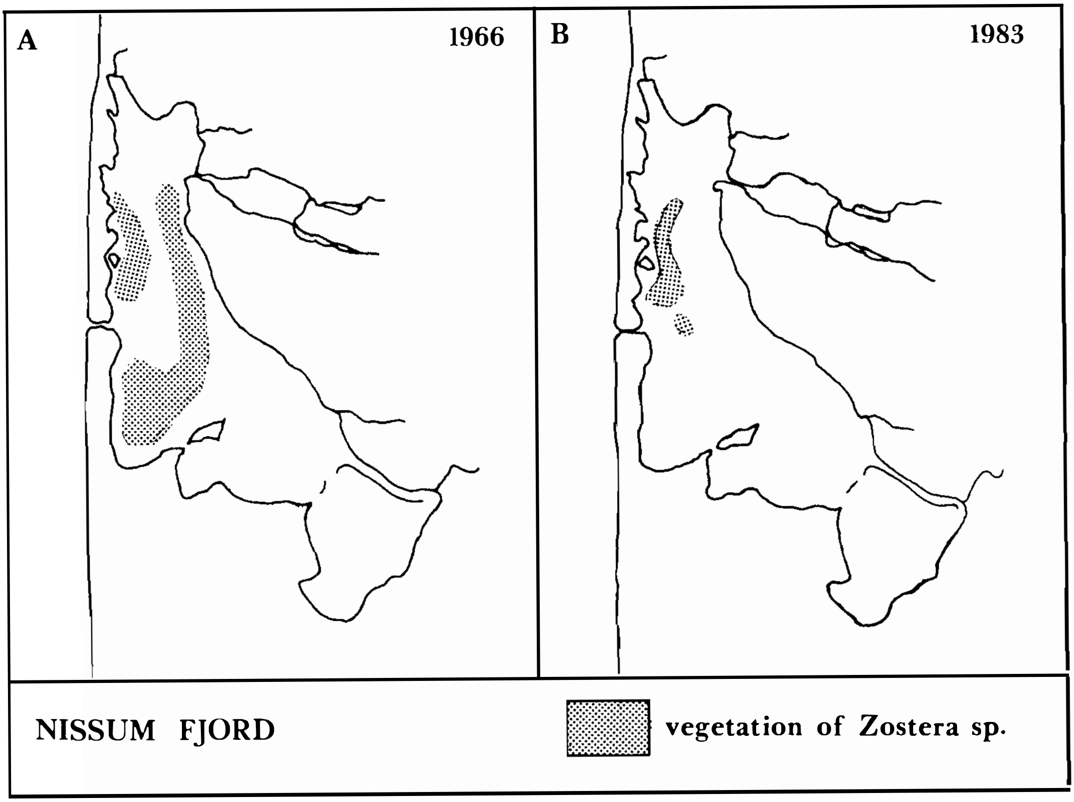


Fig. 3. The distribution of *Zostera* sp. in the Nissum Fjord (Loc. 2 in Fig. 1) autumn 1966 (A) and 1983 (B).

the earlier mentioned changed exploitation of nearfiord salt meadows, contribute to deterioration of the haunts.

Conservation of haunts

On several occasions biologists and conservationists have discussed the conditions for the Light-bellied Brent Goose in Denmark. I will point out here the establishment of reserves in the most important haunts, in which shooting is prohibited or restricted in the part of the year when the geese are there. At the same time it is important to ensure intact salt meadows through suitable management and also to reduce the increasing supply of organic material to the Danish fiord areas, which stimulates the algae vegetation, thus reducing the transparency and oxygen content of the water with consequent lower production of food plants for the geese.

There are only few areas with reserve status covering the important haunts for Light-bellied Brent Geese. In the northern part of Nissum Fjord, Bøvling Fjord has been laid out as reserve where shooting and traffic are prohibited. The area between Skallingen and Langli in the Waddensea has also been given shooting and traffic prohibition, and in Albuebugten at the east coast of Fanø shooting is prohibited (Fig. 1). Important haunts at Agerø in Limfjorden and also in and at the fiords of Randers and Mariager have, however, not been given regulations to protect the geese. Also in the northern part of the Waddensea it might be necessary to protect the Light-bellied Brent Goose to a larger extent than is the case today.

In Fig. 4 a proposal is outlined for reserve areas in the localities mentioned.

Acknowledgements

Thanks are due to Mette Fog and Jesper Madsen for discussions and criticism of the manuscript.

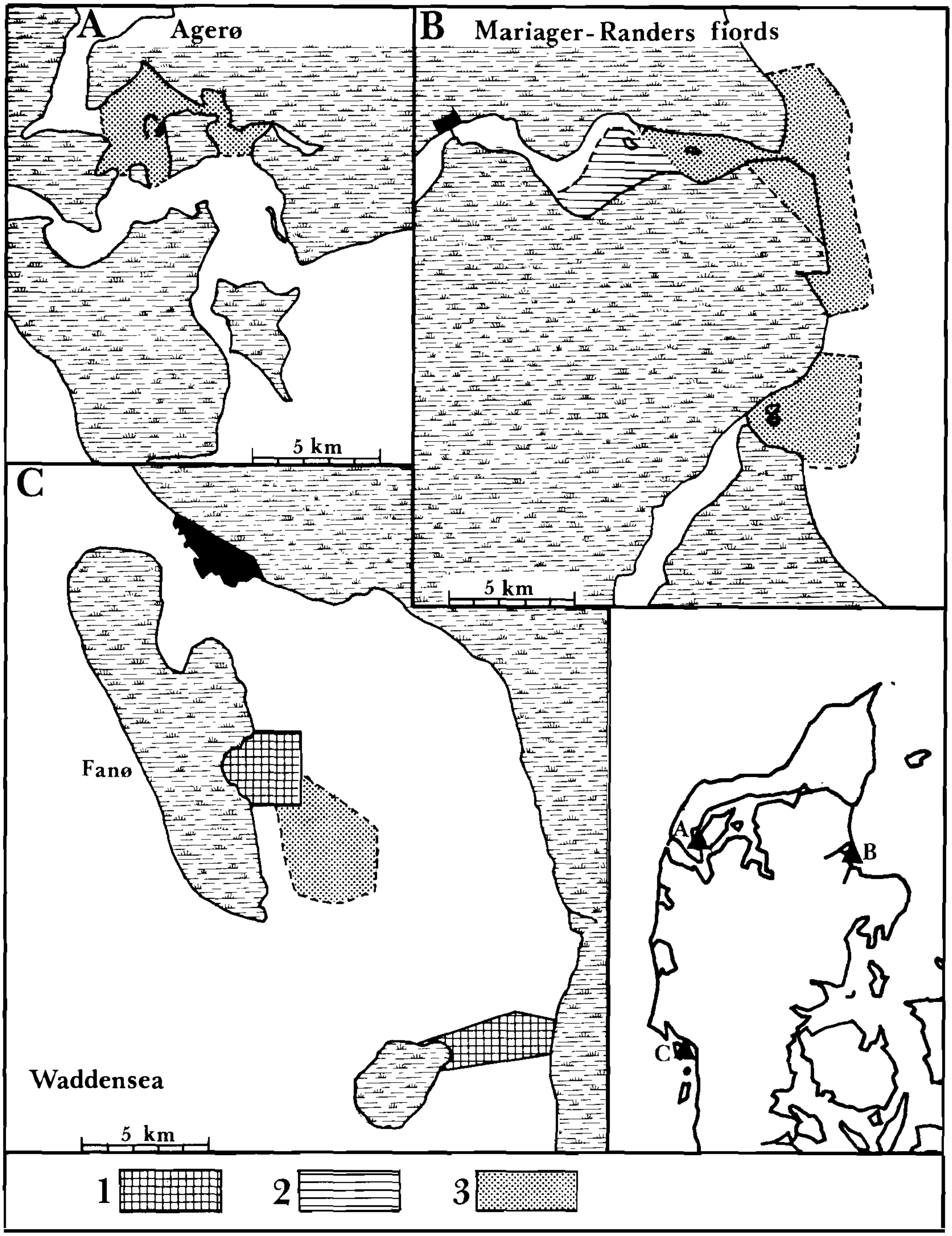


Fig. 4. Recommendation of sanctuaries for Light-bellied Brent in A. The Limfjord by Agerø, B. Mariager- and Randers fjords, and C. area in the Waddensea near Fanø. 1. present sanctuaries, 2. proposed full protected area, and 3. areas where restrictions on shooting and traffic are recommended in the period when the geese use the area.

References

Fog, M. 1967: An investigation on the Brent Goose *(Branta bernicla)* in Denmark. *Danish Rev. of Game Biol. 5(1):* 1–40.

Fog, M. 1972: *Status for Knortegåsen (Branta bernicla).* Game Biology Station, Kalø, 104 pp.

Fog, M. 1977: Gänse, Gänseforschung und Gänseprobleme Dänemarks. *Die Vogelwelt 98:* 121–141.

Fog, M. 1981: Vildgæssene søger føde på landmandens marker. *Dansk Vildtforskning 1981:* 15–19.

Fog, M. 1982a: Baiting as a means of preventing crop damage by Pink-footed Geese, *Anser brachyrhynchus* at Vest Stadil Fjord, Danmark. *Managing Wetlands and their Birds IWRB:* 233–234.

Fog, M. 1982b: Internationale erfaringer med hensyn til gåseskader og forebyggelse deraf. *Vår Fågelv. Suppl. 9:* 63–70.

Fruzinski, B. 1977: Feeding Habits of Pink-footed Geese *(Anser fabalis brachyrhynchus)* in Denmark during the Spring Passage in April 1975. *Danish Rev. of Game Biol. 10(6):* 1–11.

Jepsen, P.U. 1967: Fuglelivet ved Nissum Fjord. *Dansk ornith. Foren. Tidsskr. 61:* 1–29.

Kear, J. 1970: The experimental Assessment and Goose Damage to Agricultural Crops. *Cons. 2(3):* 206–212.

Madsen, J. 1980: Forekomst, habitatudvalg og overnatning hos kortnæbbet gås *(Anser brachyrhynchus)* på Tipperne 1972–1978. *Dansk orn. Foren. Tidsskr. 74:* 45–58.

Madsen, J. 1982: Observations on the Svalbard population of *Anser brachyrhynchus* in Denmark. *Aquila 89:* 133–140.

Madsen, J. 1984: Numbers, distribution, and habitat utilization of Pink-footed Geese *Anser brachyrhynchus* in Denmark 1980–1983. *Nor. Polarinst. Skr. 181* (this volume).

Madsen, J. & Lund, T. (eds.) 1982: *Årsrapport 1981. Dansk ornithologisk Forenings Gåsegruppe.* – National Agency for the Protection of Nature, Monuments and Sites, 62 pp.

Newton, I. & Campbell, C.R.G. 1973: Feeding of geese in Eastcentral Scotland. *J. Appl. Ecol. 10:* 781–801.

Owen, M. 1977: The role of wildfowl refuges on agricultural land in lessening the conflict between farmers and geese in Britain. *Biol. Cons. 11:* 209–222.

Rooth, J., Ebbinge, B., van Haperen, A., Lok, M., Timmerman, A., Philippona, J., van den Bergh, L. et. al. 1981: Numbers and distribution of wild geese in the Netherlands, 1974–1979. *Wildfowl 32:* 146-155.

Salomonsen, F. 1958: The present status of the Brent Goose *(Branta bernicla* (L)) in Western Europe. *Vidensk. Medd. dansk naturhist. Foren. 120:* 43–80.

St. Joseph, A. 1979: The development of inland feeding by *Branta bernicla bernicla* in Southeastern England. Appendix I: Brent Geese and Agriculture, appendix 2: Brent Geese and scaring Techniques 1977–1978. *Proc. First Technical Meeting on Western Palearctic Migratory Bird Management:* 132–145.

MAGNAR NORDERHAUG:

Captive breeding and reintroduction of northern geese

Norderhaug, M. 1984: Captive breeding and reintroduction of northern geese. *Nor. Polarinst. Skr. 181:* 161–164.

Experience from two different reintroduction programmes related to the Svalbard population of the Light-bellied Brent Goose *Branta bernicla hrota* and the Fennoscandian population of the Lesser White-fronted Goose *Anser erythropus* is summarized. The Light-bellied Brent Goose project was a pilot study conducted in 1974 to investigate possibilities for captive breeding and reintroduction in Svalbard to prevent further population decline. The project on the Lesser White-fronted Goose was initiated in Sweden in 1979. Reintroduction started in 1981 with the release of 14–37 young birds per year in Lappland 1981–1983. Manipulation with the traditional migratory route is a part of this conservation programme. Details are further described.

Magnar Norderhaug, Norwegian Ministry of the Environment, Oslo 1, Norway.

Introduction

In connection with this symposium, I have been asked to summarize experience from two quite different reintroduction programmes related to northern geese.

The first one is a preparatory study conducted in 1974 on the Light-bellied Brent Goose *Branta bernicla hrota* in Svalbard. The second one is an ongoing project in Sweden to reintroduce the Lesser White-fronted Goose *Anser erythropus* in Fennoscandia.

Pilot study on captive breeding of Light-bellied Brent geese in Svalbard

From 1955 to 1973 available figures for the Svalbard population showed a continuous decline from approximately 4000 to less than 2000 birds (Salomonsen 1958; Norderhaug 1974a).

If this decline continued, it was estimated that the population might well approach extinction by 1990. On this basis WWF/Norway initiated a preliminary study on a possible captive breeding programme for this Svalbard species.

Based on discussions with the staff of the Wildfowl Trust in October 1974, a report was prepared (Norderhaug 1974b).

An outline of a possible captive breeding and reintroduction programme was supposed to include 12 integrated steps:

1. Transport of an egg collection team to Longyearbyen, Svalbard.
2. Transport of the team from Longyearbyen to selected collection sites.
3. Collection of eggs for hatching in captivity.
4. Transport of eggs to Longyearbyen.
5. Transport of eggs from Longyearbyen to the selected incubation centre.
6. Incubation in captivity.
7. Hatching.
8. Raising of goslings.
9. Breeding in captivity.
10. Building up of a captive breeding population.
11. Transport of breeding surplus (yearly) from the breeding centre to Longyearbyen.
12. Reintroduction on traditional Brent Goose breeding grounds.

It soon became evident that one of the key problems would be the running of a sufficient large-scale breeding programme in captivity. At the Wildfowl Trust, the Dark-bellied Brents are regularly bred in captivity, but experience with Light-bellied Brents was lacking. One of the basic problems of captive breeding of high arctic waterfowl is probably related to the photoperiodic control of reproduction. Apparently their reproduction is connected with a gradual increase in the amount of daylight during spring migration, followed by 24 hours of daylight in the breeding areas. It was therefore suggested that the most suitable site for captive breeding would not be Slimbridge, but a locality further north, for instance Tromsø.

Another problem related to captive breeding of endangered species was also underlined. Individuals able to survive and reproduce in captivity may produce offspring genetically less fit for survival and reproduction in the wild.

Apart from this rather theoretical, but also important, problem, the following technical solutions were suggested:

1. Hatching success of eggs from the wild would probably be best if well incubated eggs (18–19 days) were used.
2. Transport methods needed attention, but these problems could be solved.
3. The first phase of the hatching and rearing programme might best be organized at the Wildfowl Trust.
4. Breeding attempts (after two years) could be organized in North Norway where light conditions were more suitable.
5. After six years, the first generation of captive Brents would reach their maximum breeding capacity.
6. If 15 wild eggs produced 12 goslings in year 1, it would be possible to build up a captive breeding population of 200 birds in year 15. In other words it would take approximately the same time to build up 10% of the wild population (1973/74) as it would take the wild population to reach extinction level if the population decline in the 1955–1973 period continued.

It was suggested that a possible captive breeding programme should be a joint British/Danish/Norwegian project. Fortunately, the population showed some encouraging signs of recovery in 1974. On this basis, advice was given to WWF/Norway not to invest funds in a follow-up operation, unless a new, serious decline became evident. Since then a more stable and even positive increasing trend has characterized this population and no further steps have therefore been taken.

In recent years a few requests from private breeders have been received by the Norwegian Ministry of the Environment to obtain eggs from Svalbard for captive breeding. These requests have been turned down, however, based on the preliminary study conducted in 1974 and the slightly changed population trend in recent years. Today it seems reasonable to conclude that all efforts should be concentrated on the increase of reproduction and survival rates in the wild, and no time or money should be spent on captive breeding operations, as long as the population does not suffer another significant decline.

Captive breeding and reintroduction of the Lesser White-fronted Goose in Fennoscandia

Studies during the 1970s have shown that the Lesser White-fronted Goose today is one of the most endangered bird species in Fennoscandia. The present population level in Finland, Norway, and Sweden is probably well below 4–500 birds (Norderhaug & Norderhaug 1982). On this basis WWF/Sweden and the Swedish Hunters Association in 1979 organized a special project to breed and raise Lesser White-fronted Geese in captivity. The project has been gradually developed during 1979–1983 and is now funded by WWF in Sweden and Norway (v. Essen 1982). The Lesser White-fronted Goose is fairly easy to breed in captivity and the present population of captive breeders numbers 40–50 adult birds. Unfortunately, the project was organized too late to be based on genetic material from Fennoscandian birds. The present captive breeding population is in fact composed of birds with a genetically mixed origin.

In the preparatory phase it was concluded that one of the basic problems facing the Lesser White-fronted Goose was probably loss of habitats combined with human disturbance along its southeastern migratory route and in the supposed wintering quarters in SE Europe. After lengthy considerations it was concluded, probably for the first time in the history of wildlife conservation, that manipulation of a species' migratory pattern should be tested as a conservation tool. The basic idea was to lead reintroduced birds into a new and supposedly safer migratory route.

Without going into details, the project strategy could be described as shown in Fig. 1.

The results so far are as follows:

- The first goslings hatched in captivity in 1980.
- In 1981, 14 goslings were released in Lappland together with their Barnacle foster parents.

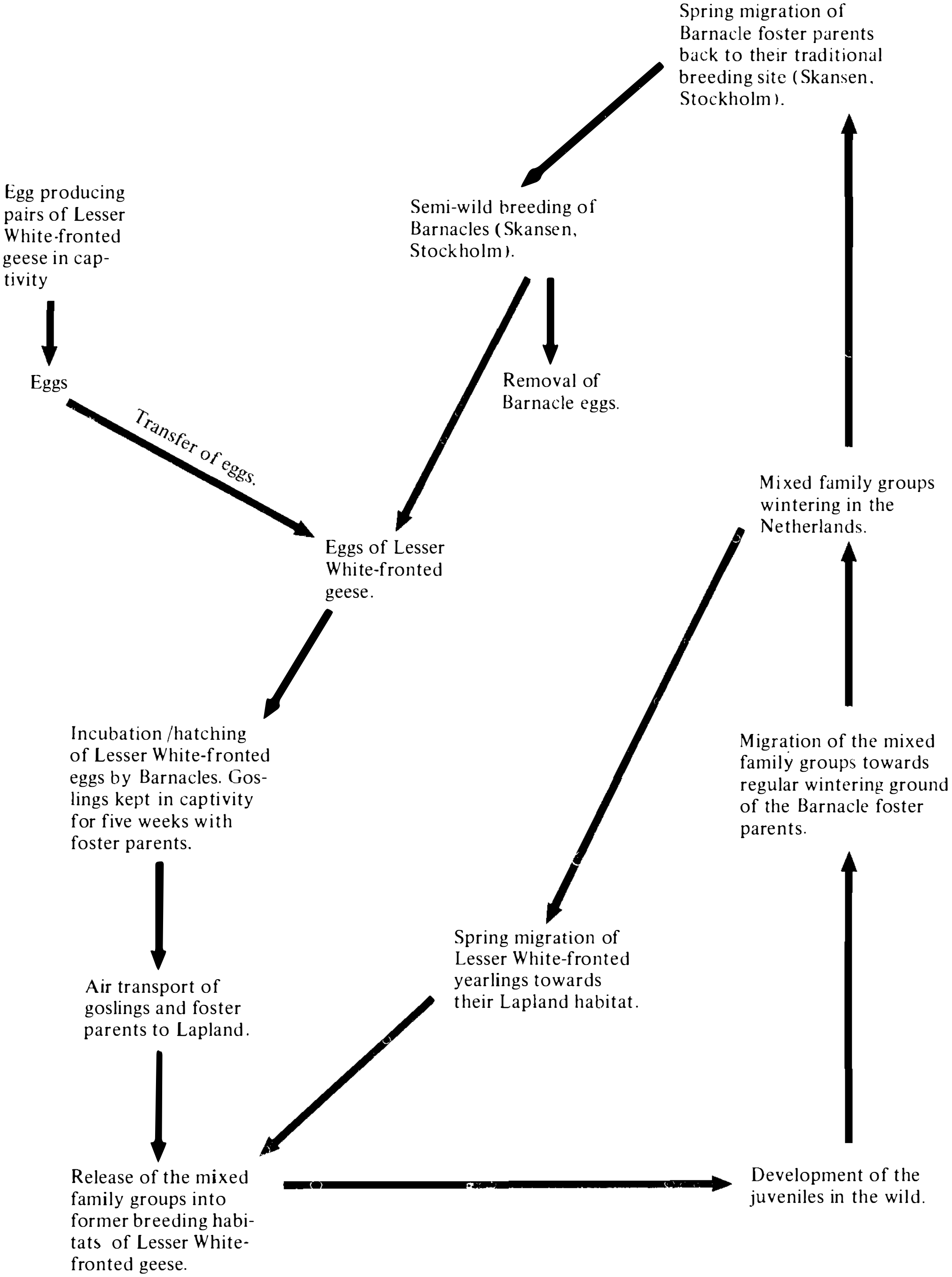

Spring migration of Barnacle foster parents back to their traditional breeding site (Skansen, Stockholm).
Egg producing pairs of Lesser White-fronted geese in captivity
Semi-wild breeding of Barnacles (Skansen, Stockholm).
Eggs
Removal of Barnacle eggs.
Transfer of eggs.
Mixed family groups wintering in the Netherlands.
Eggs of Lesser White-fronted geese.
Incubation /hatching of Lesser White-fronted eggs by Barnacles. Goslings kept in captivity for five weeks with foster parents.
Migration of the mixed family groups towards regular wintering ground of the Barnacle foster parents.
Spring migration of Lesser White-fronted yearlings towards their Lapland habitat.
Air transport of goslings and foster parents to Lapland.
Release of the mixed family groups into former breeding habitats of Lesser White-fronted geese.
Development of the juveniles in the wild.

Fig. 1.

- In 1982, another 28 goslings were released, and 37 followed in 1983.
- In the autumn of 1981 flying Lesser White-fronted Geese were observed in the reintroduction area. Later in the autumn one of the juveniles was killed by a power line in Scania, S. Sweden.
- In December 1981 another juvenile was found dead in the delta of Loire, France.
- In October 1982, five of the released goslings were observed in Southern Sweden. In addition one was shot the same autumn in Western Finland, along the traditional migratory route.

It should be added that the project has met with some criticism from Danish ornithologists, for manipulation of a supposedly genetically fixed migration pattern and for possible loss of important behavioural adaptions. Without going into further detail, it should be stressed that a thorough discussion took place in the steering committee before the project was actually initiated. The basic problem was that no realistic alternative to the present project existed, apart from passivity and risk of further population decline, which might rapidly lead to extinction.

This is, however, a pilot project. It is anticipated that a Nordic meeting will take place in the mid 1980's to review results and draw conclusions on its future.

So far, the project should be considered as a rather interesting and also encouraging conservation programme. But it is, still too early to draw final conclusions about its practical value in maintaining a wild population of Lesser White-fronted Geese in Fennoscandia in the future.

References

Essen v.L. 1982: An effort to reintroduce the Lesser White-fronted Goose (*Anser erythropus*) into Scandinavian mountains. *Aquila* 89:103–105.

Norderhaug, M. 1974 a: Utryddes ringgåsa? *Norsk Natur* 1: 14–15.

Norderhaug, M. 1974 b: *Rapport vedrørende drøftelser ved The Wildfowl Trust om formering av Svalbards ringgjess (Branta bernicla hrot* i fangenskap. *Report to WWF/Norway. Mimeo* 5p.

Norderhaug, M. 1983: Prosjekt dverggås. *Vår Fuglefauna 3:* 215–219.

Norderhaug, A. & Norderhaug M. 1982:*Anser erythropus* in Fennoscandia. *Aquila 89:* 93–101.

Salomonsen, F. 1958: The Present Status of the Brent Goose (*Branta bernicla* (L.)) in Western Europe. *IWRB Bull 4:* 1-80.

MALCOLM A. OGILVIE:

Summary and conclusions at Arctic Geese Symposium in Oslo, Norway, 24–26 October 1983

Ogilvie, M.A. 1984: Summary and conclusions at Arctic Geese Symposium in Oslo, Norway, 24–26 October 1983. *Nor. Polarinst. Skr. 181:* 165–168.

Malcolm A. Ogilvie, Wildfowl Trust, Slimbridge, Gloucester GL2 7BT, United Kingdom.

This Symposium has clearly demonstrated the great value of international cooperation in scientific research. The work carried out on the three species of geese breeding in Svalbard has involved ever closer links between biologists in different countries. It has also highlighted the need for international cooperation in conservation and management. While the three populations of geese currently have at least a reasonably satisfactory status and prospects, until very recently this has come about mainly through uncoordinated actions in the different countries which they visit, and not through concerted international action. The future well-being of all three will be best served by the greatest possible coordination of effort in conservation and management, as well as in research.

The most useful basic information for any understanding of one of the goose populations must be knowledge of their numbers and distribution. The potential for instability in arctic-breeding goose populations, with the relatively large natural influences on their annual breeding cycle coupled with the capability of man to make massive changes to their wintering grounds, demands that there must be regular (i.e. at least annual) monitoring of their population size, breeding success, and where possible, their use of the many different haunts throughout the range. With this regularly augmented store of information available it is possible to plan detailed research programmes, realistic conservation measures, and where necessary active management. Ideally all three of these should be as closely integrated as possible.

With the benefit of this collection of papers reviewing the current state of our knowledge of the three species of Svalbard geese, we can now briefly consider each species to see how closely the ideal monitoring is being achieved, what research is currently being undertaken, while highlighting gaps which need to be filled.

Pink-footed Goose *Anser brachyrhynchus*

Whilst the status of this population is undoubtedly healthy, having shown substantial increases in recent years, it is nevertheless apparent that knowledge of the species' distribution through the year is very patchy. The population counts come from brief periods in autumn and spring when the birds are all gathered in Denmark. The Symposium papers have shown only too well how incomplete is our knowledge of the whereabouts of the birds at other times of the year. Mid-winter surveys are producing two-thirds or less of the known total. The very full cooperation between workers in the recognised winter range is so far failing to locate all the birds, with a consequent loss in ability to provide any needed protection or management. The recent increase in numbers does, however, suggest that the present level of hunting throughout the range is not excessive. Indeed a drop in mortality is one of the main reasons suggested for the population increase. On the other hand there are some wintering areas which are being under-used, or have lost their birds altogether, probably through excessive hunting and disturbance.

The species is very widespread in Svalbard and for this reason alone may not require any special conservation measures there. However, as important breeding and/or moulting areas are identified, their conservation status should be reviewed. There are no known important autumn staging areas between Svalbard and Denmark, but this probably requires further checking. Similarly, there is not yet a complete picture available for the vital spring staging areas, though recent work suggests that for some at least of the geese these lie in Denmark.

A recognition of the need for continued cooperative surveys on the winter numbers and, particularly, distribution of the Pinkfeet is one of the more obvious conclusions to be drawn from the Symposium. It is certainly planned that they should continue, while routine monitoring of breeding success, only started relatively recently, is an essential part of this work.

In common with many other goose populations wintering in western Europe, there has been a growing conflict between the Svalbard Pinkfeet and agricultural interests on the wintering grounds. This is presently confined to Denmark where the problem has been exacerbated by changes in farming practice. Measures to alleviate it have included baiting the birds away from vulnerable crops, but increasingly the need is to provide feeding reserves for the geese where natural food is readily available, or crops can be specially grown. This is particularly necessary in the critical spring period.

Turning to research, the Pinkfoot presents a considerable number of opportunities. The only ringing being undertaken is relatively small in scale and confined to standard metal rings. Detailed work has taken place in the last few years on feeding and habitat utilisation in Denmark, but almost all other aspects of Pinkfoot biology and behaviour throughout the range await study. Research in Svalbard has not extended beyond some ringing in the 1950s, and a more recent small-scale project on breeding biology.

While the Svalbard Pink-footed Goose population is larger and more widespread than the Barnacle Goose stock, it would nevertheless seem to offer great scope for detailed research along some of the same lines and based on similar individual marking.

Barnacle Goose *Branta leucopsis*

The sheer breadth of research that has developed in recent years on this population almost makes it easier to point out the gaps in knowledge, rather than review what has been discovered and what is in progress. Taking full advantage of the circumscribed winter range it is possible to obtain extremely accurate population counts and measurements of breeding success every autumn. The present quite healthy size of the population compares with its parlous state just thirty years ago. Protection is now total throughout its range, if not entirely effective at least in winter, though this came about through national actions in each country, rather than through coordinated international effort.

The distribution within Svalbard breeding grounds is comparatively well known, perhaps 80–90% of the breeding pairs being located. The majority are on existing bird sanctuaries, whose effectiveness is in process of being monitored. There seems little doubt as to their value, nor to their ever-present vulnerability to disturbance. It is hoped that summer surveys will be possible at regular intervals. Spring staging areas have been identified off the coast of Helgeland, North Norway. Here, although the birds are adequately protected, recent changes in human land management practices threaten the habitat and therefore the well-being of the geese. Proposals were put forward in the Symposium to rectify this potentially very serious situation. The last gap in annual travels of these geese, knowledge of the autumn staging area, is in the course of being filled, by the very recent work on Bjørnøya.

Protection throughout the year, and management of the wintering grounds to improve the food supply and reduce disturbance, have resulted in the considerable population growth of recent years. The predicted upper level has yet to be reached, but it is considered that the ultimate limitation on numbers will be set on the breeding grounds.

The detailed knowledge already gained on breeding biology and behaviour, factors affecting individual and population performance, and food, feeding and energy budgets through the year, coupled with the ability to maintain the level of individually marked birds at around 1 in 5 or even better, make this goose population one of the best studied in the world, as well as one with the highest potential rewarding further study. The answers emanating from the research have not only provided direct benefit for these geese but also many results with wider applications.

Just two of the particular aspects now under investigation are the distribution of mortality through the annual cycle, including losses of young between hatching and arrival on the wintering grounds, and possible losses of adults on migration, and the long-term breeding performance of individual birds and thus the importance of individual contributions to the population. This latter aspect is of wide interest as several European goose populations share with the Svalbard Barnacle Goose the common factor of an increasing segment of mature yet non-productive birds. To what extent the same birds remain productive or non-productive over a period of years, and if so why, are questions of considerable importance, the answers to which are more likely to come from this study than other currently in progress.

Light-Bellied Brent Goose *Branta bernicla hrota*

This population, one of the smallest clearly identifiable goose populations in the world, has very recently shown some welcome signs of increase. There is no cause for complacency, however, as both our state of knowledge and the conservation prospects for the goose are a long way from being satisfactory.

The population total can be assessed reasonably well each winter, though there are problems related to the mobility of the birds and the size of some of their haunts. Except in periods of very severe weather it is believed that all their regular major haunts are known and counted. Breeding success has only been routinely monitored in the last few years, but this must certainly be continued. It is capable of providing a useful additional check on the apparent completeness of the population counts. The Light-bellied Brent Goose is protected throughout its range, with the exception of those few that stray into Germany. It seems highly probable that the recent increase has come about through reduced mortality following the cessation of Brent shooting in Denmark in 1972. That action was principally aimed at benefiting the Dark-bellied Brent Goose *B.b. bernicla* and undoubtedly contributed to that population's dramatic increase. It is now vital that any change in the latter's protection status, and there is much lobbying by hunters in several north-west European countries to be allowed to shoot it again, should take very full account of the continued need for total protection for the Light-bellied Brent. Even with total protection there is evidence that the disturbance from shooting of other species is having an adverse effect on the geese, as are other kinds of disturbance, from fishing and boating, as well as degradation of saltings. There is a considerable need for more reserves for this population of geese in addition to better management of those that exist already.

The breeding distribution of the Light-bellied Brent Goose in Svalbard has changed quite markedly in recent decades, though to what extent this has been associated with the earlier population decline, and how if at all the increasing Barnacle Goose population has competed for nest sites, is unknown. Rather few pairs seem to breed on the established bird sanctuaries, though such other colonies as are known are mostly safeguarded by their very remoteness and inaccessibility. There is an obvious need for more summer surveys, to be used as a basis for effective conservation measures when these seem required.

The timing of arrival and departure from Denmark would seem to preclude the existence of any other spring or autumn staging areas, making the Danish haunts of even greater importance to the geese than if they were just wintering sites.

There is even less available knowledge of other aspects of the Light-bellied Brent Goose than there is of the Pinkfoot, though the need for information is certainly no less. Experience with other goose populations suggests that the spring feeding sites are of critical importance and it is perhaps here that any study should commence, particularly as it has been suggested that the carrying capacity of one of the two sites may have been reached, with the saltings being cultivated and so denied to the geese. Marking with individually coded rings would quite quickly provide much useful information on movements between haunts as well as answers to some of the many outstanding questions concerning this highly vulnerable population.

Conclusions

There is little doubt that taking just the raw population data, the last ten years have provided a considerable success story for the three populations of geese breeding in Svalbard, all of which have roughly doubled their numbers. These, and the earlier increases of particularly the Barnacle Goose, have at least partly come about through deliberate acts of man seeking to benefit the geese, even if, as already mentioned, these acts were mostly carried out unilaterally in different countries, and not through some coordinated international plan. Examples of such acts include the establishment of a reserve for the Barnacle Geese on the Solway, and its subsequent expansion and management, and the setting up of the breeding bird sanctuaries in Svalbard. However the geese have also benefited from changes brought about by man in ways which could not, or at any rate were not, foreseen. For example the shooting of Brent Geese in Denmark was primarily halted to benefit the Dark-bellied Brent, but undoubtedly helped the Light-bellied Brent too. And the changes in farming practices on the wintering grounds of the Pinkfeet provided the geese with more and better feeding, though this process may have begun to be reversed. It has to be constantly borne in mind that some apparently quite unrelated event, perhaps the alteration of a particular farming subsidy, can have profound effects on the well-being of these, and other, goose populations.

From a purely conservation stand-point it is indeed fortunate that efforts to find oil or other new minerals in Svalbard have so far proved unsuccessful, or at any rate uneconomic. The Symposium was very usefully able to look beyond Svalbard to East Greenland where a major oil exploration programme is about to begin. It was particularly welcome to learn of detailed environmental impact assessments being carried out before such a programme actually gets under way, a procedure that ought to be, but too often is not, followed universally. The detailed studies being done on the likely impact on the Pink-footed and Barnacle Goose populations of the area were of direct relevance to the main subject matter of the Symposium, as well as further afield.

The Arctic Goose Symposium in Oslo was not just a meeting at which these published papers were read and discussed. It was also, for the participants, a most stimulating three days of new and renewed contacts, which constantly served to emphasise the value of a cooperative approach to research and conservation. Our hope is that this will indeed be the main way forward as we seek to uncover the facts that will enable us properly to understand and conserve Svalbard's geese.

A.S JOHN GRIEG