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Fox, A.D., Madsen, J. & Stroud, D.A. (1983)
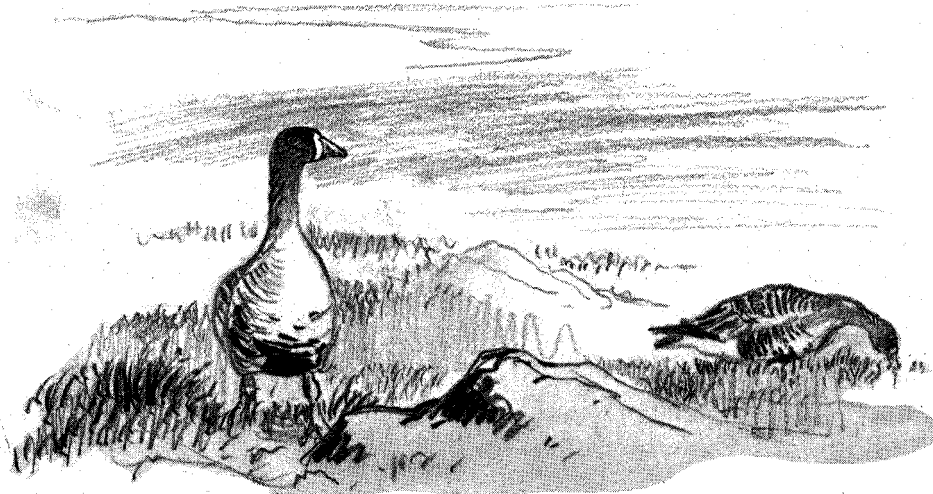
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A review of the summer ecology of the Greenland White-fronted Goose *Anser albifrons flavirostris*

A. D. FOX, J. MADSEN, and D. A. STROUD

(Med et dansk resumé: Sommerøkologien hos den Grønlandske Blisgås)

INTRODUCTION

The Greenland White-fronted Goose *Anser albifrons flavirostris* breeds in West Greenland and migrates through Iceland to winter exclusively in Ireland, Wales and Schotland. The current population size is estimated at between 14,300-16,600 birds, a decline from an estimated 17,500-23,000 in the 1950's (Ruttledge & Ogilvie 1979). In Greenland, the small population size, restricted breeding range and solitary nesting habits makes it one of the least studied of arctic nesting geese. Fencker (1950) and Salomonsen (1950) produced general accounts of the summer life of the geese, but other published information is scattered. In 1979 the Greenland White-fronted Goose Study organised a four month expedition to Eqalungmiut Nunât (67°30'N, 51°30'W), 750 km² of low arctic tundra more or less central in the breeding range. The results were published by Fox and Stroud (1981a) and the present paper reviews the current knowledge of the summer ecology of the goose, including information on its migration and staging in Iceland.

The breeding range extends from Nûk (64°N) to the Upernavik District (73°N) (Fig. 1), occurring in the inland 'continental' region near the ice-cap in the south, breeding closer to the coast further north reaching the seaboard in the Kangatsiaq District. Accounts of Whitefronts in Greenland (Salomonsen 1950, 1967, Fencker 1950) indicate that they are common around Disco Bay, Lersletten, Mudderbugten on Disco Ø and Sarqaqdalen on the Nugssuaq Peninsula. Until the middle of this century, the most northerly birds were found near Umanak, but since then a northward extension of the breeding range has occurred, breeding found on the Svartenhuk Peninsula (Salomonsen 1948, Joensen & Preuss 1972). In the absence of counts from the summer range,
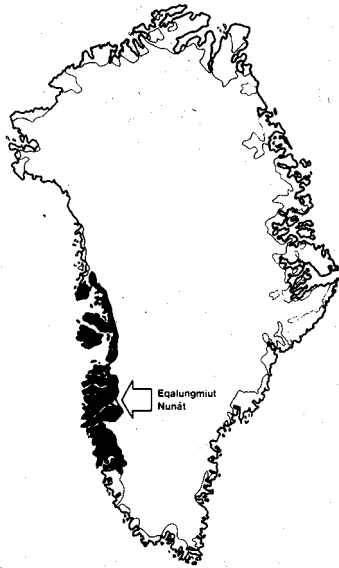
Fig. 1. World breeding distribution of the Greenland White-fronted Goose. Shading indicates current breeding range. The 1979 study area, Eqalungmiut Nunât is indicated adjacent to the ice-cap.
Yngleudbredelsen af den Grønlandske Blisgås. Sort angiver det nuværende yngleområde.
Undersøgelsesområdet i 1979, Eqalungmiut Nunât, er vist nær indlandsisen.

it is impossible to assess the proportions of the population breeding in different areas.

Eqalungmiut Nunât is thought typical of much of the goose breeding range, being adjacent to the ice-cap and experiencing a continental climate. The area is a plateau, 450-630 m a.s.l., cut by a few large lowland valleys (0-200 m a.s.l.). Large numbers of lakes are present although with low precipitation, few large watercourses are not associated with glacial meltwater. Marshes are present in valley bottoms (near glacial sandur valleys) and in the lowlands develop along the few streams that flow off the plateau. Detailed descriptions of the botanical communities of the lowland marshes and wetland margins of plateau lakes are given by Fox (1981) and Madsen & Fox (1981).

RESULTS

Spring migration through Iceland
On spring passage from Ireland, Scotland and Wales, Greenland Whitefronts occur in small scattered parties in Iceland, contrasting their major autumn occurence (Ruttledge & Ogilvie

1979, Gardarsson *in litt.,* Wilson *in litt.*). Peak passage occurs between 20-25 April and early May. Recoveries of ringed birds shot over many seasons are shown in Fig. 2. Björnsson (1976) records Whitefront passage in SE Iceland between 18-28 April, considering that they make first landfall on the south coast and then fly westwards without stopping. Observations made near Ingólfshöfdhi on 21 and 22 April 1965 recorded c. 1,000 passing west in two days in small flocks (mean 30 birds). Observations by J. Wilson *(in litt.)* tend to support this (mean flock size 35; 19 April-12 May) and show additional movement up the west coast between Reykjanes Peninsula and Snæfellsjökull from where most spring feeding records derive. Hjalmarsson (1979) records a regular spring passage through Snæfellsnes- and Hnappadalssyslu.

Birds apparently feed in hill bogs and wet grassland areas in the southwest (Fig. 3); little is known of their habits at this time, but their food is thought to be young sedge (*Carex* ssp.) shoots and *Eriophorum* shoot bases (Gardarsson *in litt.*).

Little is known about the relative condition of the birds or their relationships in family or larger groups on arrival in Iceland or subsequently in Greenland. Observations in Eqalungmiut Nunât suggest that yearlings and possibly a substantial number of older nonbreeders generally arrive on the breeding grounds later than the adult, potentially breeding geese (Stroud 1981a). In Scotland, whole wintering flocks depart simultaneously, so if yearlings do separate from their parents before arrival in Greenland, this takes place after they leave the wintering area.

The importance of spring feeding in Iceland remains obscure; Lesser Snow Geese *Anser caerulescens caerulescens* feed at regular staging areas *en route* to the arctic which allows the female to intake the protein content equivalent to an extra egg (Wypkema & Ankney 1979). It is unlikely that the same position prevails with Greenland Whitefronts in Iceland as numbers seen in spring are small and the stopover time apparently brief, but with the present poor knowledge of spring distribution it would be premature to discount the possibility that for the small numbers of breeding pairs (c. 810 in an average year; Ruttledge & Ogilvie 1979) spring staging is of importance. Wilson *(in. litt.)* condiders that major spring sta-
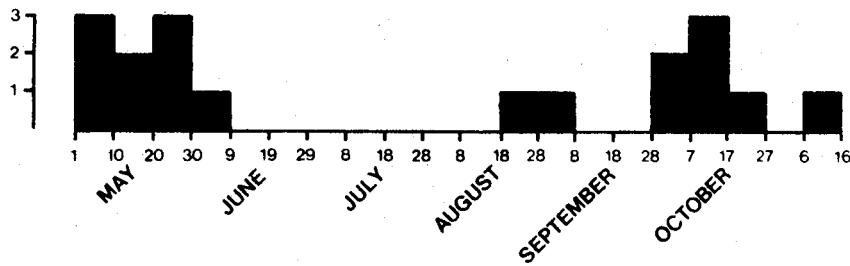
Fig. 2. Timing of passage of the Greenland White-fronted Goose through Iceland as indicated by dates of recovery of ringed birds from several years.
Trœktiderne for Grønlandsk Blisgås over Island udtrykt ved datoer for genmeldinger af ringmœrkede fugle fra flere år.

ging, if of short duration, cannot be ruled out in the grasslands south of Borgarfjördur.

Salomonsen (1950) has stated that most Whitefronts fly to Kap Farvel direct from Britain and then north through the interior of West Greenland. Although repeated by other authors, there seems no direct evidence to support this statement, it being rather based on the lack of spring sightings in Iceland. There are several spring records from the Tasiusaq (Angmagssalik) area of East Greenland (Stroud & Fox 1981) and the importance of the direct ice-cap route to the breeding grounds (Wilson 1981) has probably been underestimated. Salomonsen (1979) records a passage of Whitefronts observed from the ice-cap base DYE II during spring 1970. On four

consecutive days flocks of 6-8 geese passed flying in the direction of Søndre Strømfjord and one flock alighted on the ice to continue after a short rest.

Arrival in Greenland and pre-nesting phase
The earliest arrival in Greenland coincides with the first thaw at lowest altitudes, and forage at this time consists of subterranean perenating organs of plants restricted to the lowland mature sandur flats (Stroud 1981a). Whilst apparently sparse and poor in quality, such plant material contains its highest concentrations of protein, carbohydrate and mineral nutrients just prior to the onset of growth (Whitten & Cameron 1980, Thomas & Prevett 1980).
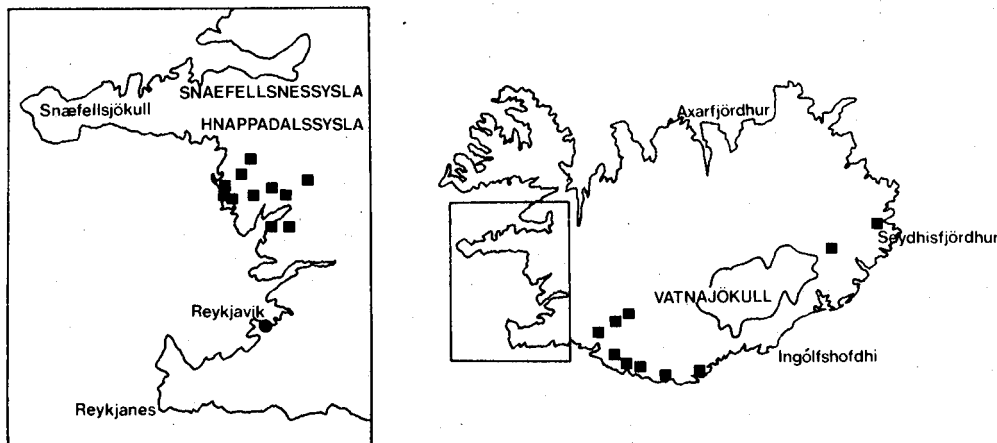

Fig. 3. Distribution of recoveries of Greenland White-fronted Geese from Iceland. Exploded western area shows areas referred to in the text. There is no obvious difference between spring and autumn patterns of recovery.
Fordelingen af genmeldte Grønlandske Blisgœs fra Island. Det forstørrede vestlige område viser de områder, som der er refereret til i teksten. Der er ingen tydelig forskel mellem mønstret for forårs- og efterårsgenmeldinger.
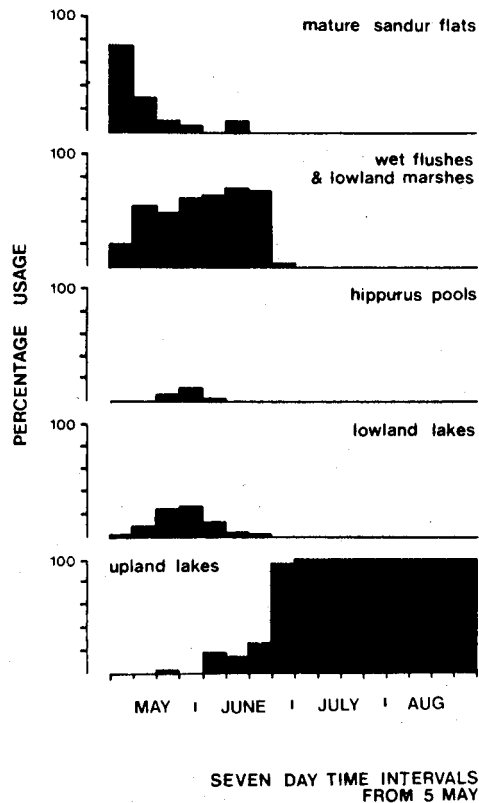
Fig. 4. Usage of feeding habitats by Greenland White-fronted Geese in Eqalungmiut Nunât during the summer of 1979.
Udnyttelsen af habitater til fødesøgning hos de Grønlandske Blisgæs i Eqalungmiut Nunât i sommeren 1979.

Observations suggested an interaction between the constraints of optimal feeding in flocks and in solitary pairs. The high threat of predation (Fowles 1981) favoured shared vigilance within a large group and thus a social feeding strategy, whilst agonistic behaviour between pairs resulting from the defence of mobile feeding territories and the patchy nature of the food resource appeared to favour solitary feeding. The result was a comprimise, with limited food supplies tending to concentrate birds into small areas, with social feeding and shared alertness, to the advantage of the ganders which were thus able to feed for longer periods (Fox & Madsen 1981). However, many birds fed as solitary pairs and this became more common as May progressed leading eventually to the departure of breeding pairs away from the sandur areas in mid-May

to feed in other lowland and mid-altitude marshes as they became progressively freed by the thaw (Stroud 1981a; Fig. 4).

The concentrations of early arrivals at a small number of traditional lowland sites seems a common phenomenon throughout the range and conditions at Kuk Marshes are probably similar at other sites (e.g. Søndre Strømfjord, and Tasserssuaq, 67°00'N, 52°20'W), with birds feeding on nutrient-rich over-wintering parts of *Triglochin palustre* and *Puccinellia deschampsioides*. These areas may be important in allowing the female to maintain or increase her nutrient reserves between arrival and nesting (Fox & Madsen 1981).

Prospecting for nest sites commenced in mid-May, and those selected were near lowland and mid-altitude *Sphagnum – Eriophorum* dominated marshes, providing the gander with suitable feeding close to a nest which gave the female a view of the surrounding terrain (Stroud 1981b, Fencker 1950). There seemed abundant suitable marshes, and this habitat is also of importance for arriving non-breeders before they move to the plateau in search of prime forage.

Nesting phase

As breeding pairs settled around lowland and mid-altitude marshes (⟨300 m), non-breding geese and presumably also failed breeders moved to higher altitudes to benefit from the later initiation of plant production there (Stroud 1981a, Madsen & Fox 1981). The margins of upland plateau lakes form an even larger expanse of suitable feeding than that previously exploited in the lowland marshes. Geese began to graze leaves of *Carex rariflora*, gradually neglecting under-ground storage organs which previously dominated the diet (Madsen & Fox 1981). Further investigation is required to investigate the hypothesis that the geese are able to optimise energy intake by positional means (moving with the thaw) and social means (feeding in flocks). Initially, non-breeding groups were small, gradually aggregating into larger flocks with social advantages. This probably minimises predation later when flightless during moult.

The phenology of breeding is shown in Tab. 1 based on a sample of 7 nests found in 1979. All these were near *Eriophorum angustifolium*-dominated marshes, providing a food

Table 1. Timing of major events observed during 1979 in Eqalungmiut Nunât.
Tidspunktet for større begivenheder hos Grønlandsk Blisgås igennem 1979 i Eqalungmiut Nunât.

Event *Begivenhed*	Date *Dato*
Arrival of first Whitefronts	7 May
Ankomst af de første Blisgæs	*7. maj*
Passage largely complete	17 May
Størstedelen af trækket overstået	*17. maj*
Laying of first egg (peak)	19-27 May (22 May)
Lægning af første æg (top)	*19.-27. maj (22. maj)*
Hatching	22-27 June
Klækning	*22.-27. juni*
Moult of non- or failed-breeders	1st week July – 4th week July
Fældning hos ikke-ynglende/mislykket ynglende	*1.-4. uge af juli*
Moult of breeders	3rd week July – 2nd week August
Fældning hos ynglende	*3. uge af juli – 2. uge af august*

supply for the female during her short recesses (Stroud 1981b, 1981c). There was little evidence of territorial aggression by the gander despite solitary nesting habits; the male apparently tolerated other breeding ganders and occasional groups of non-breeding birds on the marsh. In areas of suitable nesting habitat, breeding densities were estimated to be less than one pair per 2 km², and in all Eqalungmiut Nunât only 16 families were seen during late summer (Stroud 1981a).

Aggressive interactions were more common between breeding males than with non-breeding geese. Despite his absence from the nest area, the gander apparently fulfils a limited protective role during incubation, although he has sufficient time to feed during most of the day, and thus to maintain or improve his physiological condition prior to the assumption of the dominant role within the family (Stroud 1981c, Madsen 1981).

During the 26 day incubation (Stroud 1981d), the overall alertness of the pair progressively increased (Stroud 1981c). The gander positioned himself close to the nest during egg-laying, but except for short periods during incubation, he remained some distance away feeding on the marsh, returning just prior to hatching. Both sexes showed diurnal rhythms of activity correlated with changes in environmental variables and predator abundance. It is thought that diurnal vigilance patterns maximised chances of predator detection (Fig. 5) although it was not possible to establish causality. The physiological stress of incubation was reflected by the increased frequency and duration of feeding recesses of the female. The

gander accompanied her when feeding and most recesses occurred in the late evening when there was least predator activity (Fig. 5, Stroud 1981c).

At one nest a young bird (probably a yearling), was seen at the nest at the end of incubation. This, and other observations of yearlings accompanying parents with goslings (Madsen 1981), suggest that Greenland Whitefronts exhibit a degree of alloparental care such that young stay with their parents in an extended family relationship and assist in caring for young of the year by sharing vigilant behaviour with the gander. Such behaviour has previously been noted for Pacific Whitefronted Geese *A. a. frontalis* by Ely (1979) and may be a common feature of Whitefront breeding biology.

Non-breeding birds follow the thaw onto the plateau in early to mid-June, while breeding birds remained on nesting marshes until late June. Once goslings hatch, they are taken onto the plateau to find forage (Stroud 1981c).

Post-hatching phase
Immediately after hatching the gander assumes a sentinel role in the family, giving female and goslings maximal opportunity to feed. Vigilance is maintained at the expense of all other non-alert activities, and directly benefit gosling feeding in a fashion similar to the protective role with the female during pre-nesting feeding (Madsen 1981, Fox & Madsen 1981, Stroud 1981c).

Gosling diet differs from that of the adults despite similar feeding sites, but as they grew, time spent feeding decreased (Madsen 1981)

associated with a gradual change in diet which increasingly resembled that of the adults (Madsen & Fox 1981), whilst parental vigilance declined during the same period (Madsen 1981).

The mean brood size of 16 families seen in 1979 was 3.50 (range 1-6).

Moult period

Increasing flock size amongst non-breeding birds from June onwards (Stroud 1981a) reflected the advantage to moulting birds in offsetting increased susceptibility to predation. Similarly, it was of advantage to family parties to come together thus sharing the burden of vigilance amongst more birds and increasing efficiency of forage utilisation.

Non-breeders and family parties flocked seperately throughout the summer, probably as a result of different timing of moult (Belman 1981) and a conflict of interests – non-breeders not sharing vigilance yet competing for food (Madsen 1981). Throughout the summer geese probably continued to optimise nutrient intake by following thaw on a microtopographical level, selecting young growth stages of plants, progressively moving from early-thawing south-facing lake margins around to north-facing lake edges. Eventually they fed close to semi-permanent snow patches – the very last areas to thaw (Madsen & Fox 1981).

Non-breeders moulted two weeks earlier than breeding birds, but there was no apparent difference in their diets.

Two attempts were made to census parts of Eqalungmiut Nunât, covering 250 km² of the 750 km² region. Details are given by Stroud (1981a), but the following were the estimated totals for the whole of Eqalungmiut Nunât: non-breeders 300-340, 16 families totaling 90-100 individuals thus a total population of 390-440 birds. Problems with the counts and extrapolations are discussed by Stroud (1981a).

Autumn aggregations and migration

Flocking continues during late summer and by early September, families probably join non-breeders for migration. Whitefronts seen arriving in Iceland from the west or north-west are in moderate size flocks (mean number 57; 29 August–27 September: J. Wilson *in litt.*, Glue 1972). Large aggregations soon develop with flock sizes exceeding numbers encountered in
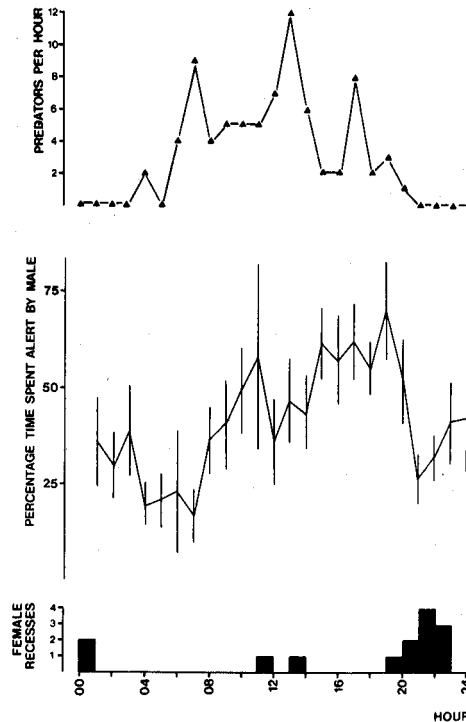

Fig. 5. Diurnal abundance of predator sightings (of Raven, Arctic Fox *Alopex lagopus* and Gyrfalcon *Falco rusticolus* combined) over or near to the nest of a Greenland White-fronted Goose, with respect to the diurnal pattern of time spent by the attendant male in the head-up posture and the timing of departures from the nest by the female to feed. *Hyppigheden af observationer af predatorer i løbet af døgnet (af Ravn, Polarræv og Jagtfalk kombineret) over eller i nærheden af reden af Grønlandsk Blisgås, i sammenhæng med døgnvariationen i gasens agtsomhed (oprejst-hovedpositur) og tiderne for, hvornår gåsen forlod reden for at søge føde.*

summer and winter quarters. Autumn feeding and roosting sites seem of more traditional importance than in spring, with Gardarsson (1976) recording 4,000 roosting on Lake Frakkavatn in Safamýri, up to 900 on Skúmsstadavatn and 1,200 at Ferjubakkaflói-Nordura. An aerial survey in 1974 recorded a total of 7,000 -8,000 Whitefronts (Gardarsson 1975) so probably the entire population passes through in autumn. As in spring, the major route to Iceland is probably over the Greenland ice-cap (Salomonsen 1967, Stroud & Fox 1981) and birds have been seen approaching north-west Iceland, apparently regularly in the Axarfjördur area (Griffiths 1973) and there are ringing

recoveries from near Seydhistfjördur (Fig. 3). It is likely that a small proportion of the population passes through Iceland west of Vatnajö-kull.

Although shooting commences in late August, and geese can be shot throughout the autumn migration, there were only 600 waterfowl hunters in Iceland in 1974 and little tradition of goose-shooting (Lampio 1974, Ruttledge & Ogilvie 1979). There are few conflicts with farmers at present, and autumn food consists mainly of *Polygonum* rhizomes and *Carex* seedheads (Gardarsson in litt.).

Winter segregation and dispersal

In 1979, 96 geese were caught during moult and ringed with large white Darvic rings. In three subsequent winters, 53 geese have been seen in the British Isles at a number of sites scatterd throughout the winter range (Fig. 6a). Belman (1981) considers that the results show that birds from Eqalungmiut Nunât are more or less evenly distributed throughout Scotland (when sightings are expressed as a proportion of the birds present at a location). However, »ring-reading effort was greater in Scotland than Ireland and the 8:1 ratio of shot birds is the only estimate of dispersal between Scotland and Ireland« (Belman 1981).

The results of previous Greenland Whitefront ringing shows that the dispersal of birds from one ringing site to many winter sites is normal. Figures 6b and 6c present recoveries in the British Isles of geese ringed at two sites in Greenland: Sarqaqdalen, Nugssuaq (70°06'N, 52°08'W) and Ikamiut, Qasigianguit (Christianshaab) (68°38'N, 51°51'W) respectively. Geese from both sites were recovered from a large number of winter sites, though mainly in Ireland.

While the most northerly breeding geese tend to winter in the most southerly part of the winter range (Salomonsen 1967, Owen *in prep.*), it is obviously no longer valid to regard each winter flock of Greenland Whitefronts as a breeding unit from any one part of Greenland. This has implications for the conservation and management of the population, since, as suggested by Abraham (1981) for Brents *Branta bernicla hrota,* no one nesting area would be disproportionately affected by high winter mortality at one site and differences in productivity on a local scale in summer will

not unduly affect aggregations in any one wintering area.

Greenland Whitefronts exhibit low productivity, and with this sort of dispersal system, continued shooting at a number of sites (e.g. Eire) may influence the population in most of the breeding range; never catastrophically, but enough to keep the population at its current small size.

The simple model of explaining differences in breeding success from different parts of the summer range, by corresponding differences in winter forage quality in different parts of the wintering grounds (Ruttledge & Ogilvie 1979) will have to be revised in the light of this information. Although concentrated in Scotland, geese from Eqalungmiut Nunât have been found throughout the entire winter range in the British Isles, from Caithness to Wexford, and forage condition can be expected to vary considerably over six degrees of latitude.

GENERAL DISCUSSION

Evolution

It is thought that *flavirostris* was one of the earliest races to evolve from ancestral *Anser albifrons* (see Fox & Stroud 1981c), and their morphological differences from other races, small population size and isolated breeding area implies that Greenland Whitefront ecology may significantly differ from other Whitefront races. Certainly, they show many differences in winter food and feeding habits compared to *A. a. albifrons,* with a tendency to feed on upland bog and rough pasture (Madsen & Fox 1981, Owen *in prep.*). Nesting sites in Eqalungmiut Nunât were very different from those used by *frontalis* in Alaska (Ely 1979), so it is not likely that Greenland Whitefront summer ecology is the same in all aspect as that of other races.

Productivity

Concern has been expressed as to the decline in numbers of Greenland White-fronted Geese (Owen 1978, Ruttledge & Ogilvie 1979, Fox & Stroud 1981b). While our results cannot categorically point to the reasons responsible, it is possible to discuss some of the factors affecting breeding success.

Counts in the British Isles show Greenland Whitefronts to have consistently lower levels of productivity but larger brood sizes than the
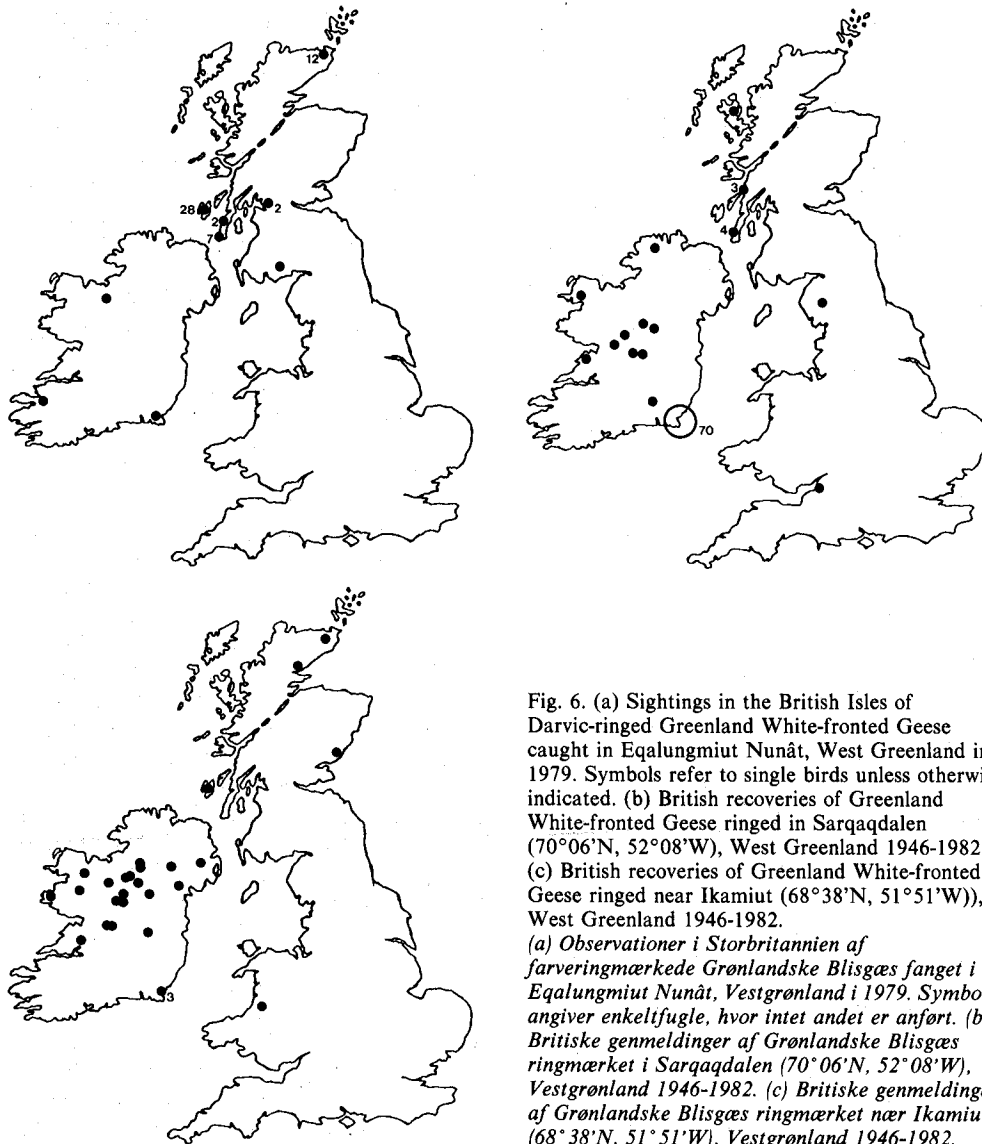
Fig. 6. (a) Sightings in the British Isles of Darvic-ringed Greenland White-fronted Geese caught in Eqalungmiut Nunât, West Greenland in 1979. Symbols refer to single birds unless otherwise indicated. (b) British recoveries of Greenland White-fronted Geese ringed in Sarqaqdalen (70°06'N, 52°08'W), West Greenland 1946-1982, (c) British recoveries of Greenland White-fronted Geese ringed near Ikamiut (68°38'N, 51°51'W)), West Greenland 1946-1982.

(a) Observationer i Storbritannien af farveringmærkede Grønlandske Blisgæs fanget i Eqalungmiut Nunât, Vestgrønland i 1979. Symboler angiver enkeltfugle, hvor intet andet er anført. (b) Britiske genmeldinger af Grønlandske Blisgæs ringmærket i Sarqaqdalen (70°06'N, 52°08'W), Vestgrønland 1946-1982. (c) Britiske genmeldinger af Grønlandske Blisgæs ringmærket nær Ikamiut (68°38'N, 51°51'W), Vestgrønland 1946-1982.

Siberian nesting race (Ruttledge & Ogilvie 1979). These demographic features were observed in 1979, with a low proportion of breeding birds (*c.* 14% of arrivals in May successfully bred) and large brood size (mean 3.50, compared with 11 year means at Islay of 2.6 and Wexford of 3.6; Stroud 1981a). There was a high proportion of predated or deserted nests within the study area (57% of nests found) but the part played by our disturbance remains obscure (Fowles 1981). Each of the likely factors involved in nest failure in a wider context is discussed below:

(i) *Human Predation.* There is little human disturbance of geese during the summer (Fowles 1981) with the increased standard of living in Greenland, traditional hunting practices in larger settlements have been neglected and legislation has also protected the geese (Salomonsen 1970, Ministeriet for Grønland). Fattening of captive goslings has been outlawed and a general lack of interest in geese in the presence of more 'profitable' game ensures adherence to these laws. The period when Greenlanders are in the interior regions hunting Caribou *Rangifer tarandus,* is when the geese are

most difficult to locate, so this also protects the birds. Traditional hunting of Whitefronts in some smaller settlements in the Disko Bay region (e.g. Ikamiut) over many years may have a severe local impact (Higgs 1981). The main mortality is undoubtedly shooting at large migratory flocks on arrival i May, as occurs near Søndre Strømfjord Air Base. If older birds arrive before immature birds, as suggested by Stroud (1981a), shooting of first arrivals early in the season might result in a disproportinate kill of breeding adults. Thus, protection of geese from disturbance on the pre-nesting feeding areas may be an effective way of increasing breeding success.

Sub-fossil remains of Whitefront bones in a midden site in Eqalungmiut Nunât (Stroud 1981e) indicate that geese have been killed by past Inuit cultures. The wide distribution of camps through the interior regions could have resulted in severe local mortality in some areas.

(ii) *Other Predation*. Potential predators in Eqalungmiut Nunât are less numerous than experienced by many other arctic nesting geese. It is not known how typical the area is in this respect, but coastal regions probably have higher numbers of predators, gulls and skuas being especially important. Nest predation is complicated by active and passive forms (i.e. following desertion), and although we have no information on the cause of failure of many of the nests we found (Tab. 2), these many stem from inexperience of nesting geese or for physiological reasons rather than from predator abundance.

The increase in Raven *Corvus corax* numbers in continental West Greenland over the last 20 years due to winter feeding at the Søndre Strømfjord Air Base rubbish dump (S. Malmquist *pers. comm.*) is roughly coincident with the decrease in Greenland Whitefronts noted in the British Isles. Since egg predation by Ravens is likely to be more successful at nests of young, inexperienced breeders, the result will be that only older, experienced birds will succesfully incubate whole, large clutches. The consequence will be the small number of large broods seen in winter (Owen 1978, Fowles 1981).

(iii) *Climate*. Meteorological data from Søndre Strømfjord shows that continental areas of West Greenland have a more stable and predictable climate compared with the coastal areas which have larger between-year variations in weather. In the south of their range, Greenland Whitefronts are only found nesting close to the ice-cap in highly continental areas east of Nûk (Salomonsen 1950). This, with suggestion of higher densities in continental regions further north where the range extends to the coast (Holthe in Stroud 1981a), implies an advantage in nesting in a predictable climate. For the majority of the population there is no meteorological reason for the large scale fluctuations in breeding success so typical of hig arctic goose populations, and indeed, the annual production figures have been relatively consistent. However, a few days difference in the thaw of the lowland marshes important for pre-nesting feeding may have a profound effect on local breeding success.

(iv) *Nest site limitation*. In Eqalungmiut Nunât there seemed ample wetland sites at suitable altitudes (50-300 m) to support many more breeding pairs than were actually found (Stroud 1981b), and there was no shortage of upland feeding areas for families to move to after hatching, although these areas may be-

Table 2. Details of nest fates of breeding Greenland White-fronted Geese, 1979.
Syv reders skæbne hos ynglende Grønlandske Blisgæs i 1979.

Date cluth started *Dato for første æg*	Eggs laid *Lagte æg*	Date of failure *Dato for fejlslagning*	Date of hatch (number) *Dato for klækning (antal)*
19 May	1	20 May	– (0)
22 May	6	–	22 June (5)
22 May	6	1 June	– (0)
24 May	6	31 May – 3 June	– (0)
?	1	–	? (?)
?	6	–	? (?)
27 May	6	–	27 June (5)

come over-grazed towards the end of the summer. However, the successful nests were both on large marshes, and it may be that the surfeit of suitable marshes is more apparent than real if size is an important factor.

(v) *Inexperience.* Raveling (1981) has shown the relationship between age and nesting success in Canada Geese *Branta canadensis.* Recent recruitment to breeding age classes of Greenland Whitefronts may have been reduced, resulting in few older, more experienced pairs hatching larger broods and many novice inexperienced birds with very low success rates. In the absence of a population of marked birds, there is nothing to support this hypothesis apart from the demographic features mentioned above and the observed high nest failure rate. Ruttledge & Ogilvie (1979) showed that Greenland Whitefronts had undergone a recent marked decline in numbers in many areas, particularly in Ireland. At the same time, there has been a spontaneous change in winter habits, with traditional *Eriophorum angustifolium* – dominated bogs being neglected for improved or rough pasture. The combination of change in diet and local habitat loss during the last few years may well have contributed to poor breeding success over at fairly long time span, now being reflected in reduced recruitment of mature birds into breeding age classes (Reed 1976).

(vi) *Condition.* The physiological condition of geese at the commencement of nesting is of crucial importance for nesting success (Ankney & MacInnes 1978), and depends on food quality in spring, especially on the staging areas between wintering and breeding grounds. Greenland Whitefronts are possibly unique amongst arctic nesting geese in having no major spring staging areas (but see above), and in this case it is possible that pre-nesting feeding after arrival in Greenland is unusually important (Fox & Madsen 1981).

Brent Geese *B. b. hrota* need to attain a body weight of *c.* 1.6 kg in April for subsequent breeding success. Thus conditions in spring determine whether they attain this threshold (Ebbinge 1979). A similar effect could operate in Greenland White-fronted Geese, although as stated above, additional feeding in Greenland may also be of considerable importance to breeding females. Condition can also

be expected to act with the other effects mentioned above, particularly predation. Higher losses to predators will probably ensue if the female is energetically deficient and having to spend long periods off the nest feeding during incubation.

The effects of condition on Greenland White-fronted Geese and its relationship to their subsequent breeding success is probably of prime importance in understanding the curious demography of this race, although the subject will remain cloaked in mystery until detailed energetic studies are undertaken throughout the year and on large numbers of birds from different parts of the wintering and breeding ranges.
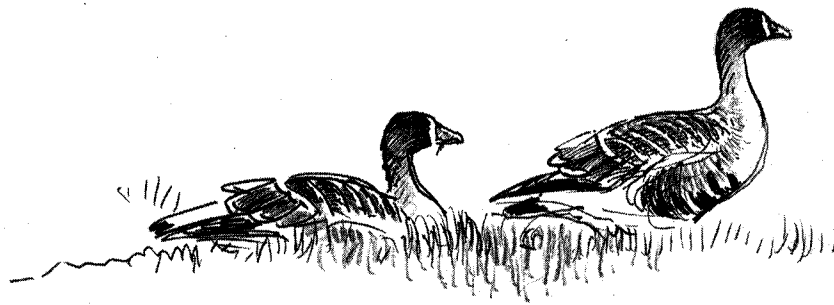
ACKNOWLEDGEMENTS

DANSK RESUMÉ

Sommerøkologien hos den Grønlandske Blisgås
Artiklen giver en oversigt over resultaterne af en fire måneders undersøgelse af sommerøkologien hos den Grønlandske Blisgås i sammenhæng med tidligere oplysninger om racens ynglebiologi. Den Grønlandske Blisgås yngler i Vestgrønland fra Nuuk til Svartenhuk Halvøen (Fig. 1), og undersøgelsesområdet i 1979, Eqalungmiut Nunât, var placeret i den centrale del af yngleområdet, tæt op ad indlandsisen. Området er en lavarktisk tundra; 750 km² stort plateau gennemskåret af flere store dale og med mange søer og kær.

Fra yngleområdet trækker bestanden via Island til overvintringsområderne i Irland, Skotland og Wales (trækkets tidsforløb over Island er vist på Fig. 2 og genmeldingssteder på Island på Fig. 3). Bestanden tæller idag mellem 14.300 og 16.600 individer og er aftaget de sidste 30-40 år fra 17.500-23.000. Bestan-

den har lavere ynglesucces, men større kuldstørrelser end den sibiriske bestand af racen *Anser albifrons albifrons.*

Tidspunkterne for de vigtigste begivenheder i yngle- og fældningscyklus i 1979 er givet i Tab. 1. De fleste ynglefugle ankom 2-3 uger forud for æglægning og fouragerede især på underjordiske planteorganer i lavlandet (Fig. 4). Redehabitaterne var kærområder længere oppe i dalene (rederne solitære) og i rugeperioden var gasernes vigtigste føde Smalbladet Kæruld. Rugeperioden estimeredes til 26 dage og bortset fra æglægningsperioden og dagene umiddelbart før klækning holdt gasen sig på afstand af reden. Gåsen forlod reden 0-1 gang dagligt for at fouragere, ledsaget af gasen og på tidspunkter, hvor risikoen for predation var mindst (Fig. 5). Ved én rede sås en ung gås (formentlig 2. års fugl) mod slutningen af rugeperioden og efter klækning sås flere yngre fugle i følgeskab med familierne. De yngre gæs deltog i visse tilfælde i agtsomhed, hvilket tyder på, at de optrådte som 'hjælpere' for forældrene.

Ikke-ynglende fugle flokkedes på søer på plateauet fra juni. Efter ægklækning førtes gæslingerne også til plateausøerne, men familierne holdt sig separat fra de ikke-ynglende. Ikke-ynglende fugle fældede svingfjer to uger før forældrefugle. I ungeføringsperioden varetog gasen agtsomheden over familien, mens gåsen og ungerne havde maksimal fourageringstid. I løbet af ungernes tilvækstperiode faldt gasens agtsomhed. Ungeføden var forskellig fra forældrenes lige efter klækning, men lignede senere forældrenes. Gæssenes vigtigste føde var Starer og græsser.

Bestanden i området estimeredes til 300-340 ikke-ynglende fugle. I alt sås 16 familier med en gennemsnitlig kuldstørrelse på 3,50 unge/par, og totalbestanden estimeredes til 390-440 fugle.

96 Blisgæs blev ringmærket med farveringe (benringe). 53 fugle er hidtil aflæst på overvintringspladserne fordelt på en række lokaliteter (Fig. 6a). Genmeldinger af fugle ringmærket forskellige steder i yngleområdet i perioden 1946-1982 tyder på, at nordligt ynglende fugle trækker længst mod syd på overvintringsområdet, mens det modsatte er tilfældet for sydligt ynglende fugle (Fig. 6b, c), men aflæsninger af Eqalungmiut Nunât fuglene tyder på en del udveksling mellem områderne.

Årsagerne til bestandens tilbagegang og lave produktivitet diskuteres. Mulige årsager på yngpepladserne er (1) menneskelig forfølgelse i ankomstperioden, hvor gæssene er begrænsede til få lokaliteter, (2) redepredation af Ravne og Ræve, (3) klimatiske forandringer, (4) begrænset antal egnede redesteder, (5) den fysiologiske kondition ved starten på æglægningen.

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Mindre meddelelser

NON-MAGNETIC ORIENTATION IN PIED FLYCATCHERS *FICEDULA HYPOLEUCA*

Beck and Wiltschko (Z. Tierpsychol. 60 (1982): 41-46) have demonstrated magnetic North as a primary genetically fixed compass reference for the southwesterly standard direction in the Pied Flycatcher. However, this finding does not exclude that the standard direction could also be fixed genetically in relation to other compass references than magnetic North.

In the summer and autumn of 1982 we carried out some preliminary orientation experiments with juvenile Pied Flycatchers, to find out whether the autumn standard direction could be established in the abscence of appropriate magnetic information.

On June 20 and 22 5 nestlings were taken from their boxes at Strødam, North Zealand and handraised. The age was about 7-8 days. After one week and hence foreward the birds were transferred to wire cages (30×30×30 cm), each applied with two bar magnets fixed in the middle and lower part of two opposite sides in the level of the two perches. The magnets produced a strong vertical field within the cage (magnetic North pointed downwards). The strength was not measured exactly but exceeded the normal field intensity about 4 to 5 times in all parts of the cage.

The strong vertical field was heterogenous, and small but varying horisontal components were found within the cage. As the cages were turned about every second day, there should be no possibility for the birds to establish the standard direction in relation to magnetic North.

On 11 nights between July 4 and August 3 the birds were placed outdoors 3 to 5 hours in their cages under the starry sky.

During August 14 to 29 the birds spent 7 nights under a starry sky in Emlen-funnels. The orientation was registrered as described by Rabøl (Dansk Orn. Foren. Tidsskr. 75 (1981): 97-104).

Bird no. 1 failed to show any migratory activity. The remaining 4 birds showed a total of 16 unimodal orientations. The no. of the birds and their mean directions are denoted at the figure. The mean vector is directed towards 191° (»S-SSW«), and the concentration is 0.53 (0.01⟨P⟨0.02, Raleigh-test). In the remaining 12 experiments the activity was dis-oriented, weakly bimodal or zero.

The conclusion is that the flycatchers are oriented approximately in the standard direction.

The strong and vertical magnetic field in the cages and funnels made it impossible for the birds to evolve and establish migratory orientation using magnetic North as a compass reference. Furthermore, a star compass could not evolve as a secondary compass calibrated by the magnetic compass.