DARK-BELLIED BRENT GEESE **Branta bernicla bernicla**
FOREGO BREEDING WHEN ARCTIC FOXES **Alopec lagopus**
ARE PRESENT DURING NEST INITIATION

BERNARD SPAANS\(^1,3\), HARRY (J.) BLIJLEVEN\(^1\), IGOR U. POPOV\(^2\),
MARINA E. RYKHLIKova\(^2\) & BARWOLT S. EBBINGE\(^1\)


In an area north of the Pyasina delta in Taimyr (Russia), nest distribution, nest initiation and breeding success of Brent Geese *Branta bernicla bernicla* were studied in six successive summer seasons from 1990-1995 in relation to lemming and Arctic Fox *Alopex lagopus* abundance. Lemming abundance conformed to the well-known three-year cycle with peaks in 1991 and 1994. Wandering Arctic Foxes were numerous in 1992, one of the two years following a lemming peak. This was the only year in which foxes visited the small offshore island where Brent Geese used to nest. Although Brent Geese arrived in time that year, the majority did not even start to breed and disappeared. Thus the actual mechanism causing failure in 1992 was disturbance rather than predation and Brent Geese appeared to be able to forego breeding at the very last moment. In the unexpected absence of foxes in the second predator year 1995, Brent Geese incubated successfully on the small islands in our study area. However, they failed to raise their goslings as these were all predated, not by foxes but probably by gulls.

Key words: *Branta bernicla bernicla* - *Alopex lagopus* - lemming-cycle - fox predation - breeding success

\(^1\)Institute for Forestry and Nature Research (IBN-DLO), P.O. Box 167, 1790 AD Den Burg, Texel, The Netherlands; \(^2\)Institute of Ecology and Evolution, Russian Academy of Sciences, Leninsky Prospect 33, Moscow, Russia; \(^3\)Current address: Netherlands Institute for Sea Research (NIOZ), P.O. Box 59, 1790 AB Den Burg, Texel, The Netherlands, E-mail: Spaans@nioz.nl

**INTRODUCTION**

Breeding success in Dark-bellied Brent Geese *Branta bernicla bernicla*, nesting in arctic Taimyr, is characterised by large annual variations with a nearly complete breeding failure once every three years (Ebbingie 1989). Predation by Arctic Foxes *Alopex lagopus* is considered to be one of the main causes of this regular failure but field data are scarce (Summers & Underhill 1987; Ebbingie 1989). The abundance of Arctic Foxes in Taimyr and their predation pressure on birds is suggested to depend mainly on the availability of the Siberian Lemming *Lemmus sibiricus* and the Collared Lemming *Dicrostonyx torquatus*. Lemming abundance follows a three-year cycle. Lemming-predators such as Arctic Foxes, Snowy Owls *Nyctea scandiaca* and Pomarine Skuas *Stercorarius pomarinus* only reproduce during a lemming peak year (Maher 1974; Litvin & Ovsyanikov 1990). In this way, predator abundance follows a three-year cycle as well. In years after a lemming peak, the increased number of predators are expected to prey on the nests of arctic breed-
ing birds due to scarcity of lemmings as their main prey: the 'Roselaar-Summers hypothesis' (Roselaar 1979; Summers 1986). Indeed, over a period of more than 30 years, Brent Geese never bred successfully in the year following a lemming peak year, the so-called 'predator year' (Dhondt 1987; Ebbinge 1989). If the Roselaar-Summers hypothesis is right, breeding failure seems very predictable and the question arises why should Brent Geese make the effort to try and breed in such 'predator years'?

From 1990-95, Brent Geese were studied in the coastal area north of the Pyasina delta in Taimyr. Here we report on the relationship between the presence of Arctic Foxes and the occurrence of breeding by Brent Geese over six successive years, i.e. two complete lemming-cycles. We focus on the following four questions: Are the abundance and the behaviour of Arctic Foxes related to the lemming abundance as described above? Is the breeding failure in Brent Geese in the year after a lemming peak (the predator year) caused by predators? What mechanism causes this failure? Are there any indications that Brent Geese can assess their chances to breed successfully in advance?

**STUDY AREA AND METHODS**

The study was carried out in the coastal area north of the Pyasina delta, about 200 km ENE of Dickson, Taimyr, Russia (74°07'N, 86°50'E; Fig. 1). The coastal mainland and the island Farwaternie consist of low, undulating arctic tundra traversed by a number of small rivers. The tundra vegetation is dominated by mosses, lichens, sedges and grasses. Offshore there are a number of small islands: the Bird Islands and the Beacon Islands. The 16 ha Big Bird Island (BBI) is rather flat with mainly tundra vegetation comparable to the mainland. The other Bird Islands are rocky with bare patches, some areas of tundra vegetation, and a richer grassy vegetation around colonies of the Taimyr Gull *Larus (argentatus) taimyrensis* (Spaans et al. 1993). The Beacon Islands are very flat and low, mainly covered with a mossy vegetation in which young monocots emerge in the course of the summer.

From 1990 to 1995, we arrived in the study area on 1, 10, 5, 8, 9 and 8 June respectively, always before arrival of the Brent Geese. Most of the behavioural observations of geese and foxes were made on BBI. In 1990, BBI was observed from a hide on the adjacent island (# 2). In 1991, 1993, 1994 and 1995 two observers lived permanently in a small hut on BBI from our arrival in...
the beginning of June until hatching of the geese in the second half of July. In 1992, observations from this hut were made from 5 June to 3 July. From the hut, it was possible to overlook most of the island. Human activity around the hut was restricted to avoid disturbance. The research in the rest of the study area was carried out from a base camp situated at Cape East on the mainland.

Daily minimum and maximum air temperatures were recorded as well as the condition of the ice between BBI, the mainland and Farwaternie. Lemming abundance was measured by systematically checking a large number (150-200) of live-traps and snap traps along a transect and in a number of permanent plots on the mainland, each year by the same system. The results of trapping are expressed as the number of lemmings caught per 100 traps 24 h⁻¹ and we use this measure to compare the abundance of lemmings between years.

In June, all Brent Geese migrating over the study area were counted and the size of the migrating flocks was determined. In 1990 we did not record the settlement of the breeding birds on BBI consistently (settled geese are pairs that are present and defending a territory). From 1991 to 1995, the daily number of geese present on BBI (observations for at least 16 hours per day) were recorded. The entire study area was surveyed for breeding geese after the first females had started to incubate and clutch-size was noted. Mainland Brent Geese nests were checked regularly (from >200 m distance) to assess possible predation by foxes. Except for 1992, the laying date of the first egg was calculated from the date of the first observation of a gosling, by subtracting the length of the incubation period (24 days) and the average clutch-size (1 egg per day). In 1992, we checked the locations where we had observed 'sitting' female Brent Geese to assess the date of the first egg. The entire study area was surveyed for inhabited fox dens and the presence or absence of young foxes was checked when a den was found. Number and duration of fox-visits to BBI were recorded as well as the behaviour of foxes during visits. Daily observations averaged 16 h (mainly 11.00h - 03.00h local time).

RESULTS

Weather and ice conditions

The cumulative daily maximum air temperature from 11 June-3 July (23 days) and the dates of disappearance of the sea ice each year are given in Table 1. Spring (June) was mild in 1990 (Spaans et al. 1993) and 1994, while 1992 and 1995 were relatively cold. The weather conditions in spring in the study area showed no obvious correlation with the disappearance of the sea ice; the ice disappeared late in 1990, the warmest spring. Except for 1991, BBI was within easy reach of foxes over the ice in Lidia Bay until the first week of July. In 1991 the ice had already disappeared by 19 June. In all six years there were sufficient snow-free patches on BBI in the second half of June to allow the geese to start nesting.

Lemming and fox abundance

Lemmings were very numerous in 1991 and 1994, very scarce in 1990 and 1995 and rather scarce in 1992 and 1993 (Table 1). This pattern fits a three-year cycle. Therefore we call 1991 and 1994, by definition, the peak years, 1992 and 1995 the predator years and 1990 and 1993 the intermediate years. In 1990, the first intermediate year, no foxes were seen in the study area (Spaans et al. 1993). Two fox dens found on top of the Wisoka Hill were unoccupied. In the lemming peak years 1991 and 1994, there were at least two occupied fox dens: on top of Wisoka Hill and on the large island Farwaternie. Young foxes were successfully raised in these years. In the den on Wisoka Hill for instance, we found 12 young cubs in 1991. There was one inhabited fox den on Wisoka Hill in the second intermediate year 1993, despite the rather low lemming density. In the two predator years no fox dens with cubs were found. In the first predator year (1992) there were a lot of wandering foxes everywhere in the study area. We only saw a few wandering foxes on the mainland in the second predator year (1995). However, foxes had been numerous after the lemming peak in 1994: the local fisherman had caught many (125) foxes during the 94/95 winter and we found...
Table 1. Weather conditions, lemming, fox and Brent Goose abundance, timing of Brent Goose migration, start of egg laying and fox predation on Brent Goose nests in the study area, 1990-95.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cum. max. temperature</th>
<th>Break up of ice</th>
<th>Lemming abundance</th>
<th>Number of fox dens</th>
<th>Definition year</th>
<th>Fox visits to BBI</th>
<th>First migrating Brent Geese</th>
<th>First day with mass migration</th>
<th>Flock size migrating geese</th>
<th>Date of first egg</th>
<th>Nests on mainland (Farwatermie)</th>
<th>% predated (mainl. and Farw.)</th>
<th>Nests on BBI</th>
<th>% predated (BBI)</th>
<th>Nests on offshore islands</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>185</td>
<td>7 July</td>
<td>0.3</td>
<td>0</td>
<td>interim. predator</td>
<td>0</td>
<td>10 June</td>
<td>14 June</td>
<td>9 ±1 (77)</td>
<td>15 June</td>
<td>10 (2)</td>
<td>0</td>
<td>90</td>
<td>0</td>
<td>252</td>
</tr>
<tr>
<td>1991</td>
<td>113</td>
<td>19 June</td>
<td>10.4</td>
<td>≥2</td>
<td>peak predator</td>
<td>0</td>
<td>10 June</td>
<td>13 June</td>
<td>32 ± 10 (71)</td>
<td>15 June</td>
<td>8 (1)</td>
<td>100</td>
<td>83</td>
<td>2</td>
<td>291</td>
</tr>
<tr>
<td>1992</td>
<td>28</td>
<td>2 July</td>
<td>1.2</td>
<td>0</td>
<td>interim. predator</td>
<td>0</td>
<td>13 June</td>
<td>14 June</td>
<td>11 ± 1 (75)</td>
<td>2 July</td>
<td>0 (0)</td>
<td>-</td>
<td>2</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>1993</td>
<td>96</td>
<td>1 July</td>
<td>1.7</td>
<td>≥1</td>
<td>peak predator</td>
<td>0</td>
<td>21 June</td>
<td>10 June</td>
<td>7 ± 1 (142)</td>
<td>13 June</td>
<td>3 (12)</td>
<td>20</td>
<td>89</td>
<td>2</td>
<td>251</td>
</tr>
<tr>
<td>1994</td>
<td>165</td>
<td>2 July</td>
<td>10.0</td>
<td>≥2</td>
<td>peak predator</td>
<td>0</td>
<td>19 June</td>
<td>20 June</td>
<td>34 ± 8 (41)</td>
<td>21 June</td>
<td>5 (1)</td>
<td>67</td>
<td>63</td>
<td>0</td>
<td>243</td>
</tr>
<tr>
<td>1995</td>
<td>60</td>
<td>5 July</td>
<td>0.4</td>
<td>0</td>
<td>predator</td>
<td>0</td>
<td>11 June</td>
<td>11 June</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>381</td>
</tr>
</tbody>
</table>

1 The cumulative daily maximum air temperature in °C from 11 June - 3 July (23 days), 2 Dates of disappearance of the sea ice, 3 Number of lemmings caught per 100 traps 24 h-1, 4 Number of inhabited fox dens, 5 Definition according to the lemming cycle, 6 Number of observed fox visits to BBI from arrival of the first Brent Geese, 7 Number of Brent Goose nests on the mainland and, between brackets, on Farwaternie, 8 Percentage of mainland plus Farwaternie nests predated by foxes, 9 Number of Brent Goose nests on BBI, 10 Percentage of nests on BBI predated by foxes, 11 Total number of Brent Goose nests on the Bird- and Beacon Islands.

several dead foxes, probably having died from starvation, around our camp in 1995. Apparently few of the foxes survived the preceding winter. The only year in which foxes visited BBI after arrival of the geese was 1992 (Table 1).

Arrival of the Brent Geese, settlement and start of egg-laying
In each of the years, we observed the first migrating Brent Geese in our study area between 10 and 16 June. Daily totals of 200 or more Brent Geese migrating over the study area (‘mass migration’) were always recorded within 0-4 days after the observation of the first geese (Table 1). Brent Geese migrated in small flocks (10 or fewer individuals per flock) in 1990, 1991, 1993 and 1994 and in larger flocks in 1992 and 1995. As soon as Brent Geese migration had begun, the first breeding birds arrived at BBI (Figs. 2 & 3). Except for 1992, the majority of the BBI breeding population settled on the island within 10 days after the first migration peak (Fig. 2). In 1990 we did not consistently record the settlement of the breeding birds on BBI. The observation on BBI of
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Fig. 2. Arrival of Brent Geese on BBI in 1991 and 1993-95. The number of Brent Geese present is expressed as the percentage of the BBI-breeding population. The arrows indicate the date of the first egg.

74 pairs (or 82% of the 1990 breeding population) of which 59 individuals were 'sitting' (egg-laying or incubating females) on 21 June 1990, indicates that the timing of the settlement of Brent Geese in 1990 was comparable with 1991 and 1993-95. In 1992, the first Brent Geese arrived on BBI on the same day as the first migrating geese were seen but numbers dropped in the course of June (Fig. 3). Foxes visited BBI in this period almost every day, from one to six visits per daily observation period of 16 hours (Fig. 3). The last fox visit was recorded on 1 July and this animal had to swim more than 200 m to reach the island. In 1990, 1991, 1993 and 1994, the geese started nesting very soon after arrival and the first egg was laid within three days after the first day with mass migration. In 1995 this period was eight days, and in 1992 it was 18 days after the first day with mass migration before we found the first egg (Table 1 and Figs. 2 & 3).

Behaviour of geese and foxes on BBI

In five of the six years, foxes did not visit BBI after arrival of the geese. In the lemming peak and intermediate years, Brent Geese arrived in small flocks and in the first days after arrival, these flocks split up into territory-defending pairs. In 1991 for instance, we observed the first copulations 4 days after the arrival of the first geese. In the predator year 1992, Brent Geese arrived in large flocks. The newly arrived geese behaved in a similar way as in the lemming peak and intermediate years: flocks split up into pairs, territories were defended, mates displayed and copulations were observed. The first copulation was seen four days after arrival of the first geese. In contrast with the other years, foxes visited the island regularly in 1992 (Fig. 3). It was easy to notice a visiting fox because of the numerous alarm-calling and mobbing gulls above it. As soon as a fox appeared on the island, the goose pairs formed flocks until the fox had disappeared. It was obvious that the fox was searching for nests and sometimes it chased the geese themselves, forcing them to take wing. After such an incident, the geese usually landed elsewhere on the island but sometimes they flew to feeding areas on the mainland or Farwatermie. We never saw a fox catch a goose. The geese never attempted to drive the fox away. Foxes visited the island almost daily and...
often several times per day and during this period the total number of geese on the island decreased. After 26 observed fox-visits since the arrival of the first geese, on 24 June there were few geese left (Fig. 3).

In 1995, the second predator year, Brent Geese also arrived in relatively large flocks, though not as large as in 1992 (Table 1). In contrast with 1992, the island was not visited by foxes. After arrival, the geese behaved in a similar way as in the lemming peak and intermediate years, and started nesting. However, the first egg was laid relatively late: 8 days after the first day with mass migration. Most nests hatched success­fully but after hatching the families stayed on the island to moult instead of swimming to the food­rich riversides and coastal areas on the mainland as they did in all lemming and intermediate years (Spaans et al. 1993). One week after hatching we left BBI. When we visited the island two weeks later, the adult geese were still present but almost all the goslings had disappeared. Predation by gulls is the most probable explanation for this.

Foxes visited BBI in 1992 in search for eggs

On 25 June 1992 we observed for the first time a fox finding an egg on BBI. It was an egg of a Taimyr Gull, the commonest breeding bird on the island with a maximum of 450 individuals present in 1992. This egg was buried on the island by the fox. In the following 6 days we observed for 16 hours per day and we recorded 37 gull-eggs taken by a fox during 17 visits averaging 69 minutes each. Two of these 37 eggs were eaten on the spot, whereas 32 eggs were buried on the island. The first egg found by a fox on 25 June was probably the first gull-egg of the season, indicating that the gulls started laying late in 1992. In 1990 for instance, we had already counted 88 incubating Taimyr Gulls on BBI on 23 June, and in 1991 we checked one of the gull-colonies on BBI on 17 June and found eggs in 31 out of the 33 gull-nests.

It was possible to identify some foxes by differences in the colour pattern caused by the state of moult. Although we saw at least three different foxes on the island, it was clear that the one which took the gull-eggs was the same individual. This fox came from Farwaternie and probably knew BBI very well. During every visit by this fox the gull colonies on the island were searched systematically for eggs. It was obvious that the fox had problems with swimming in the cold water. A lot of time (up to 20 minutes) was spent finding the narrowest part of the channel that had to be crossed. When the fox had reached the other side, it immediately started to run very fast, jumped in the air and rolled in the snow. Once we observed how a fox tried to swim with a gull-egg in its mouth to the adjacent island Farwaternie. Halfway across the channel the fox took a rest on an ice-floe and decided to swim the second part without the egg, leaving the egg on the ice-floe. These observations illustrate that most of the disturbance on BBI was caused by one fox and that this fox took great pains to find eggs. Only two pairs of the Brent Geese that were left on BBI in the beginning of July (Fig. 3) started to nest, on 1 July. At 03.10h in the morning that day, we observed the last visit of a fox to the island. The surrounding channel had probably become too wide.

Predation of Brent Goose nests by foxes

In all years of our study, the majority of Brent Geese bred on the small offshore islands. No predation by foxes was recorded in the first intermediate year 1990 because foxes were absent from our study area. That year, ten pairs of Brent Geese bred successfully on the mainland. Some or all the mainland nests were predated by foxes in both lemming peak years and in the second intermediate year 1993. The breeding gOOSE on BBI were not visited by a fox in these years although it was possible to reach the island over the ice in the first week(s) after arrival of the goose. In the two predator years, Brent Geese did not try to nest on the mainland. The few pairs that were left on BBI in 1992 started nesting late, after the fast ice around the island had disappeared. So that in 1992 no fox predation of (the two) Brent Goose nests on BBI was recorded. Similarly there was no fox predation in 1995 because foxes did not visit BBI during the breeding season in that predator year.
DISCUSSION

Lemming abundance in our study area from 1990-1995 fits the predicted three-year cycle. Arctic Foxes reproduced only in the lemming peak years and in one of the intermediate years. In these years the foxes operated within a limited range from their den and did not cross the sea ice to visit BBI. Foxes were very numerous in the first predator year 1992. In this year, the foxes wandered and crossed the fast ice frequently. These observations are in accordance with the Roselaar-Summers hypothesis. In the second predator year (1995), however, foxes were scarce and BBI was not visited by a single fox.

From our observations on BBI in 1992 we conclude that the frequent presence of foxes forced the geese to refrain from even trying to breed. This supports the main idea of the Roselaar-Summers hypothesis: breeding failure of Brent Geese was caused by foxes in the year after a lemming peak. The actual mechanism causing breeding failure in our study area in 1992 appeared to be disturbance rather than predation. Such a mechanism has already been suggested by Madsen et al. (1992) who supposed that fox presence on small islands in Spitsbergen in 1989 caused the breeding failure of Light-bellied Brent Geese Branta b. hrota by disturbance of nesting attempts. We do not think that the geese refrained from laying eggs in 1992 because of the cold weather conditions in that year. Brent Geese are known to breed at higher latitudes where summer temperatures are on average considerably lower than those in our study area. On the Island Troynoy, situated about 250 km NNW of our study area, Brent Geese bred numerous and successfully in 1994 when June temperatures were comparable with June temperatures in our study area in 1992 (Bangjord et al. 1994).

It is striking that Brent Geese appear to be capable of foregoing egg-laying when foxes are present at the breeding islands. In contrast, their neighbours, the gulls, did not refrain from laying eggs in 1992. This resulted in predation of their clutches, whereas the majority of the geese did not spend energy on eggs. The fact that egg-laying of the gulls started late in 1992 might have been caused by the visiting foxes, but a poor food-situation (cold spring, and few lemmings) could be an alternative explanation.

We do not think that geese from our study area started to breed elsewhere after they left our area in 1992. Assuming that lemming and fox abundance were synchronized in Taimyr in 1992 (Underhill et al. 1993, see below), it would have been hard to find fox-free breeding sites in Taimyr, and geese will have met the same kind of problems elsewhere. Moreover, the energy needed for migration to another site would have reduced the body stores which are so important for egg-laying and incubation (Ebbinge & Spaans 1995; B. Spaans et al. unpublished data). Finally, a delay of at least 2 weeks is probably too long to complete the breeding-cycle within the short arctic summer at this latitude.

The overall breeding success of the Dark-bellied Brent Goose population, recorded in the subsequent autumn in western Europe was 21% juveniles in 1990, 31% in 1991, <1% in 1992, 20% in 1993, 8% in 1994 and 0.5% in 1995 (IWRB Goose Research Group 1994, 1995; B. Spaans unpublished data). Once again, total breeding failure occurred in the years after the lemming peak. This means that Brent Geese failed to breed not only in our study area but in their whole breeding range. Observations by Underhill et al. (1993) show that lemming and fox abundance were indeed synchronized in Taimyr in 1991 and 1992. In their mainland study area in northeastern Taimyr (760 km east of our study area) lemmings occurred at high densities in 1991 and densities were substantially lower in 1992. Three fox dens with young were found in this area in 1991 and one in 1992 whereas wandering foxes were more often seen in 1992, intensively searching for food. Brent Geese nested here successfully in 1991, while in 1992 only 2 nests of Brent Geese were found and both were depredated by foxes.

The situation in the other predator year (1995), when most nests of our geese hatched successfully, shows that reproduction can fail at a
later stage, as hardly any juveniles were observed three weeks after hatching on BBI and later in autumn in western Europe. Predation by Taimyr Gulls probably was the direct cause of the failure in our study area but this only occurred because the geese did not leave the island after hatching. The mainland areas where the geese usually moult and raise their goslings offer the geese a much better food supply than BBI in the period after hatching. Thus the predation by gulls could well be the result of a poor condition of the goslings caused by scarcity of food. The reason why the geese refused to leave the island after hatching in 1995 remains obscure. Fear for hungry predators on the mainland could be an explanation. We did indeed establish the presence of Snowy Owl and Arctic Fox on the mainland in the second half of July.

Our findings in 1995 show that disturbance by foxes does not have to be the only mechanism behind breeding failure in predator years. Predation of eggs and/or goslings by Arctic Foxes is often reported (Bousfield & Syroechkovskiy 1985; Ravelling 1989; Anthony et al. 1991; Stickney 1991; Syroechkovskiy et al. 1991; Madsen et al. 1992; Underhill et al. 1993). The goslings in our area in 1995 however, were probably depredated by gulls and this predation was possible by the fact that the geese did not dare to go to the usual post-hatching feeding areas on the mainland. Our study shows that the relationships between lemmings, predators and geese are more complex than suggested in the Roselaar-Summers hypothesis. In case of disturbance by foxes during the nest initiation period, Brent Geese appear to be able to forego breeding. Such behaviour results in a total failure of the breeding season, as effectively as does predation.

**Risk of predation determines nest distribution**

Roselaar (1979) and Summers (1986) suggested that the absence of fox-predation in lemming peak years would enable the geese to breed successfully. During our study, however, predation of goose-eggs by foxes occurred mainly in the lemming peak years 1991 and 1994 when there were plenty of lemmings (Table 1). In these years, the foxes did not disturb nest initiation of the mainland-breeders but the nests were depredated in a later stage. Thus lemming abundance as such does not stop foxes from preying on eggs. However, the BBI and the other small offshore islands, where most of the local Brent Geese breed, were not visited by foxes in these years. Apparently the abundance of food (lemmings) on the mainland tundra made trips on the ice in search for food unnecessary. The density of lemmings seemed to determine the radius of action of the foxes and their willingness to take risks (visiting islands during the period of melting ice). This explains why small islands are preferred by geese as breeding sites. Even in 1990, when not a single fox was observed in our study area, the majority of Brent Geese bred on the small offshore islands, although the food situation on these islands is poor compared to suitable breeding locations on the mainland (Spaans et al. 1993).

In lemming peak years Brent Geese often breed close to nests of Snowy Owls on the mainland and on large islands (Litvin et al. 1985; Doro­goi 1990; Underhill et al. 1993; Summers et al. 1994). In such a case the owls act as ‘defenders’ against Arctic Foxes by chasing every fox that comes to close to their nest. This also shows the effect of foxes on the nest distribution of Brent Geese in years when food for foxes is abundant. Thus the successful breeding of Dark-bellied Brent Geese in lemming peak years might well be the result of an enlargement of the otherwise limited breeding area (small islands) with fox-free ‘islands’ around Snowy Owl nests on the mainland and on large islands. However, the poor breeding result in the lemming peak year 1994 (8% juveniles observed in western Europe), indicates that favourable conditions on the breeding grounds are not a guarantee of successful breeding.

**Can Brent Geese assess their chances of breeding successfully?**

Brent Geese arrived in larger flocks in the two predator years than in the other years (Table 1).
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Apparently the flocks had already partly split up into pairs during migration in the non-predator years. After the first day with mass migration, it took 18 days before the first egg was laid in 1992, 8 days in 1995 but only 1-3 days in the other years. These findings suggest that in the predator years the geese arrive at the breeding grounds less well prepared for breeding, although they did not arrive later in those years. We think that the latter indicates that also in predator years the geese leave their migration areas prepared to start breeding. During the last part of their migration however, between the White Sea and Taimyr, they might become aware of the situation on the breeding area, for instance by encounters with Arctic Foxes and Snowy Owls. Therefore pairs may stay in flocks instead of already leaving the flocks during the migration to prepare for breeding. In 1992, with many foxes around, this process was more pronounced than in 1995 when most foxes near our study area had not survived the preceding winter. The fact that many nests hatched successfully in 1995 shows that it can pay to come to the breeding area in time and to start breeding in a predator year. With an annual survival rate of 0.86 (Ebbinge 1992), the mean life span of a Brent Goose is only 6.4 years and they do not start breeding before their third year (B. Spaans unpublished data). This implies that they cannot afford to miss a chance to reproduce. Only when they arrive in their breeding area are the geese able to reliably assess their chances of breeding successfully. Our observations in 1992 show that Brent Geese can decide to forego breeding at a very late stage when the likelihood of successful reproduction appears to be negligible.

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