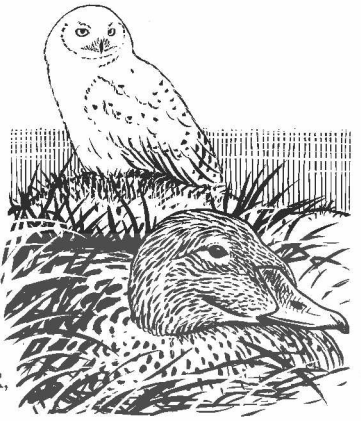
The breeding biology of Dark-bellied Brent Geese *Branta b. bernicla* and King Eiders *Somateria spectabilis* on the northeastern Taimyr Peninsula, especially in relation to Snowy Owl *Nyctea scandiaca* nests



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It was established that Brent Geese nesting in the northeastern Taimyr Peninsula belong to the nominate race Branta bernicla bernicla. Brent Geese and King Eiders were found nesting close to Snowy Owl nests during the lemming peak of 1991. All nested successfully. It is believed that the waterfowl benefited from the aggressive nature of the Snowy Owls which exclude predators such as Arctic Foxes from hunting close to their nests. This situation was first described for B. b. nigricans which breeds exclusively near Snowy Owl nests on Wrangel Island. As Snowy Owls breed primarily when lemmings are abundant, the Brent Geese on Wrangel Island and the mainland of the northeastern Taimyr Peninsula are indirectly dependent on the lemmings.

Keywords: Brent Geese, King Eiders, Snowy Owl, Tundra, Breeding Association, Predation

Dark-bellied Brent Geese *Branta bernicla bernicla* breed almost entirely on the Taimyr Peninsula (Martynov 1986, Rogacheva 1992, Syroechkovski in press) and winter in western Europe (Cramp & Simmons 1977). Their biology in winter and spring has been the subject of many studies but relatively little is known about their breeding biology. This subspecies has large annual variations in breeding success (Ogilvie & St Joseph 1976, Summers & Underhill 1987). Hypotheses to explain this variation include spring feeding conditions (Ebbinge 1989), weather on the breeding grounds (Boyd 1987) and predation mediated by the abundance of lemmings *Lemmus sibiricus* and *Dicrostonyx torquatus* (Roselaar 1979, Summers 1986, Summers & Underhill 1987, Syroechkovskiy *et al.* 1991, Underhill *et al.* 1993). There is now experimental evidence supporting the latter hypothesis; removal of Arctic Foxes *Alpoex lagopus* in the vicinity of a Black Brant *B. b. nigricans* colony improved nesting success over a control colony (Anthony *et al.* 1991).

The circumpolar King Eider *Somateria spectabilis* breeds both on the coast and inland on the tundra, nesting near water and on islands (Cramp & Simmons 1977, Rogacheva 1992). Data on its breeding biology have been collected largely on a casual basis and there are no detailed investigations.

In 1990, an expedition was mounted by the Institute of Evolutionary Morphology and Animal Ecology enabling Dutch and German biologists to study Brent Geese on the Taimyr Peninsula (Ebbinge 1991), followed in 1991 by studies in the eastern Taimyr Peninsula involving British, Russian, Dutch and South African biologists (Prŷs-Jones 1991). Prior to our expedition, it was unclear which subspecies of Brent Geese nested in the eastern Taimyr Peninsula (Uspenski 1960). Our first aim was to establish this. Our second aim was to make observations on breeding waterfowl in relation to the predators of lemmings.

Study area and methods

The study was conducted around the northern end of Pronchishcheva Lake (75°16'N, 112°28'E), 30 km from the sea. The habitat was arctic tundra (Chernov 1985) and the topography was hilly with streams and rivers, flowing either into Pronchishcheva Lake or into the Kuldima River (**Figure 1**). The study period was 15 June to 8 August 1991. Snow cover was estimated visually and air temperature recorded by a maximum/minimum thermometer placed one centimetre above the ground and shaded from the sun (Underhill *et al.* 1993).

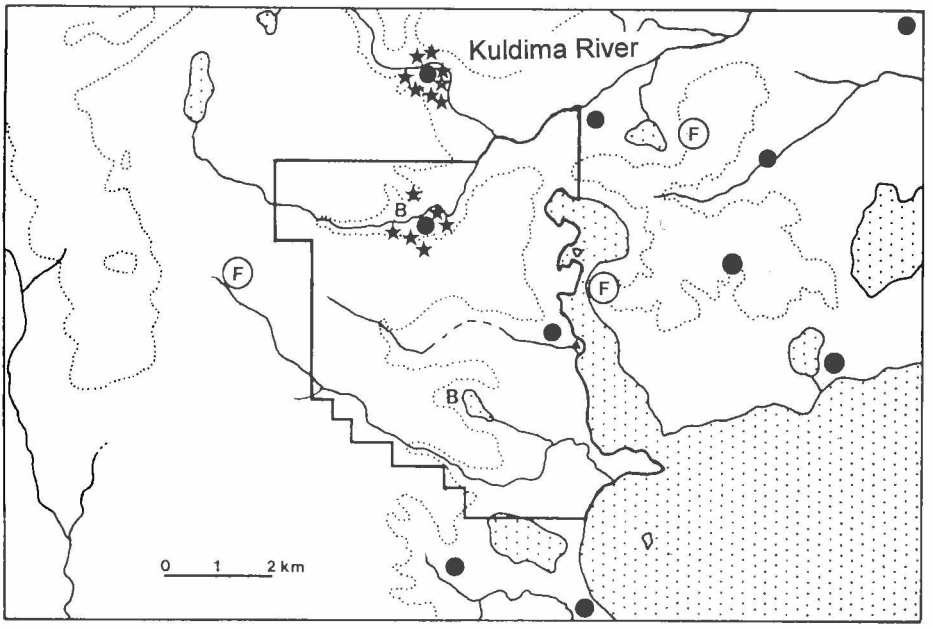

Figure 1. The study area at Pronchishcheva Lake, northeastern Taimyr Peninsula, Russia, showing the boundary of the intensive study (solid line) area. Locations of Brent Goose nests (stars) and broods (B), Snowy Owl nests (dots) and fox dens (F) are shown.

Pairs of Snowy Owls *Nyctea scandiaca* were conspicuous on the tundra and, once their nests had been located, nests of geese and ducks were searched for in the vicinity, and distance to the owl nest estimated. A major objective of the fieldwork was to find all nests of wildfowl, waders, gulls and Snowy Owls in an intensive study area of 14 km^2. Here, the nests were checked at intervals of about three days until the eggs hatched or disappeared. Extensive searches were also made for Snowy Owl nests in a larger area and, once found, nests of wildfowl were searched for in the vicinity of the owl nest, and distances to the owl nest estimated. Although the extensive study area had a lower search effort, it is likely that all owl nests, which were conspicuous, and colonies of geese in this area were found (Underhill *et al.* 1993). Eggs were measured and weighed. Fresh egg mass was estimated using the formula k_M x length x $breadth^2$, where the value of the conversion factor k_M was estimated from those eggs which were weighed before incubation had commenced, i.e. at nests which were found before the clutch was completed. When adult Brent Geese and King Eiders were captured for ringing, they were measured and weighed.

Results

On arrival at the study area on 15 June snow cover was estimated at 95%. This situation persisted for several days and thaw proceeded rapidly only after 21 June (Underhill *et al.* 1993). Lemming densities were high, with estimated densities between 100 and 400 per ha (Underhill *et al.* 1993).

Brent Geese were observed daily in the study area, mostly feeding in pairs on the snow-free patches from the time of our arrival. Small flocks, of nine or fewer Brent Geese, were occasionally seen flying past, with daily totals not exceeding 20 birds. In contrast, small groups of King Eiders (maximum 14 on 16 June) were observed overflying until 20 June, when two pairs occurred in the study area.

One female Brent Goose (which subsequently nested) had a unique combination of colour-rings (Ebbinge & St Joseph 1992) and had originally been ringed in Schleswig-Holstein, Germany, on 14 May 1982 (Bird W=BS in **Table 1**). It was resighted 20 times before being observed on the Taimyr Peninsula and five times afterwards. Five resightings in autumn (October and November) and 18 in spring (March, April, May) were within 2 km of the place of

Table 1. Observations of Dark-bellied Brent Geese ringed or resighted at Pronchishcheva Lake, northeastern Taimyr Peninsula. Where a range of dates is given, the total number of sightings is given in brackets. Countries and coordinates are given at the first mention of a locality.

Ring ID	Date (number of sightings)	Place
W=BS	14 May 1982	Norderheverkoog, Schleswig-Holstein, Germany 54 24 N, 8 47-48 E
	28 December 1985	Sandbeach, Dengie North, Essex, UK. 51 43 N, 0 56 E
	13,18 May 1987	Norderheverkoog, Schleswig-Holstein
	23 March,13 April,21 May 1989	Norderheverkoog, Schleswig-Holstein
	11 November 1989	Norderheverkoog, Schleswig-Holstein
	17 March,11,17 April 1990	Norderheverkoog, Schleswig-Holstein
	3,27 October 1990	Norderheverkoog, Schleswig-Holstein
	3 April-16 May 1991 (8)	Norderheverkoog, Schleswig-Holstein
	24 June-20 July 1991 (4)	Pronchishcheva Lake, Taimyr, Russia. 75 16 N, 112 28 E
	9 November 1991	Norderheverkoog, Schleswig-Holstein
	23,24 February 1992	Sandbeach, Dengie North, Essex
	23,30 April 1992	Norderheverkoog, Schleswig-Holstein
RIG-	1 July 1991	Pronchishcheva Lake
	10 November 1991	Cley Marshes, Norfolk, UK. 52 58 N, 1 03 E
RIG1	1 July 1991	Pronchishcheva Lake
	29 January 1992	Terschelling, The Netherlands. 53 22-23 N, 5 15-17 E
RIG=	1 July 1991	Pronchishcheva Lake
	5 March 1992	Zeeburg-noord, Texel, The Netherlands. 53 09 N, 4 53 E
RIGA	1 July 1991	Pronchishcheva Lake
	20 October 1991 - 27 April 1992 (38)	Terschelling
	21 November 1992 - 3 February 1993 (11)	Terschelling
RIGY	1 July 1991	Pronchishcheva Lake
	9 November 1991	Stanpit Marsh, Christchurch, Devon, UK. 50 44 N, 1 46 W
	8 February 1992	Exe Estuary, Devon, UK. 50 37 N, 3 25 W
GJR1	1 July 1991	Pronchishcheva Lake
	30 October 1991	Noordpolderkwelder, Groningen, The Netherlands. 53 26 N, 6 34 E

Ring identification refers to unique ring colours and symbols of the Brent Goose Colour-ringing Scheme, described by Ebbinge & St Joseph (1992).

Table 2. Nest details for Brent Geese (BG) and King Eiders (KE) breeding beside two Snowy Owl nests (BG1-7, KE1 at one owl, BG8-15, KE2 at other owl) and a Brent Goose (BG16) and King Eider (KE3) nesting in isolation at Pronchishcheva Lake, northeastern Taimyr Peninsula.

Nest	Number of eggs (E) or	Date of hatching young (Y)	Distance to Snowy Owl nest (m)
BG1	5Y	18 July	?
BG2	7E	18 July	40
BG3	5E	*c* 21 July	40
BG4	5E	23 July	120
BG5	6E	after 21 July	100
BG6	5E	22 July	250
BG7	6E	21 July	400
BG8	5E	?	50
BG9	4E	?	150
BG10	4E	?	150
BG11	4E	?	200
BG12	5E	?	150
BG13	4E	?	200
BG14	E[1]	?	150
BG15	E[1]	?	300
BG16	5Y	before 27 July	—
KE1	5E	*c* 21 July	150
KE2	5E	?	200
KE3	6E	after 20 July	—
KE4	3Y	before 3 August	—

[1]Birds were observed incubating, but the nests were inaccessible across a river.

Table 3. Summary statistics of egg dimensions and estimated initial mass for Dark-bellied Brent Geese and King Eiders at Pronchishcheva Lake, northeastern Taimyr Peninsula.

	Mean[1,3]	S.D.[1]	Range[1]	Sample size[1]	Range[2]	Sample size[2]
Dark-Bellied Brent Geese						
Length (mm)	70.7	2.5	63.6-76.2	60	66.4-73.6	11
Breadth (mm)	47.0	1.1	45.2-49.3	60	45.8-48.7	11
Estimated initial mass (g)	84.4	5.3	72.7-98.0	60	77.8-94.2	11
King Eider						
Length (mm)	64.7	2.4	60.0-70.0	16	62.3,64.7,66.6	3
Breadth (mm)	43.8	0.4	43.1-44.5	16	43.6,43.7,44.2	3
Estimated initial mass (g)	67.0	2.1	62.7-70.9	16	65.6,66.8,68.5	3

[1]Values based on all eggs.
[2]For Brent Geese, values based on means for clutches; for King Eiders, means for the three clutches are given.
[3]Means of means for clutches were nearly identical to means over all eggs (maximum relative discrepancy = 0.0014).

ringing and three in winter (December and January) were in Essex, UK. This bird was resighted in six of the ten winters between ringing and 1991/92 (1985/86, 1986/87, 1988/89, 1989/90, 1990/91 and 1991/92). Eight geese were captured at Pronchishcheva Lake and received colour-combinations. Subsequent resightings were made of six of these geese in England and The Netherlands (**Table 1**). These observations establish that the Brent Geese breeding as far east as 112°E belong to the population that migrates through the regions of the White and Baltic Seas to western Europe.

A total of 14 Brent Geese nests were found, clumped around two Snowy Owl nests, in groups of six and eight. The median distance of the goose nests from the owl nests was 150 m (range 40-400 m) (**Table 2**). In addition, a female Brent Goose with a brood of five goslings was observed on the river within 100 m of one of the Snowy Owl nests on 18 July before any of the known 5-egg clutches had hatched (**Table 2**). The dates of first hatching of these owl nests were 28-29 June and 30 June, so their laying would have started late in May given an incubation period of 32 days (incubation starts with the first egg) (Cramp 1985). In comparison, the known hatching dates for the Brent Geese were 18-23 July (**Table 2**), so that, given an incubation period of 25 days and a laying rate of one egg per day (Cramp & Simmons 1977), the first eggs would have been laid between 19-24 June.

A brood of five young was seen on a small lake on 27 July; a pair of Brent Geese had been suspected breeding in this area since early July, but the nest had not been found. At least one brood was seen near the northern end of Pronchishcheva Lake on 8 August; the number of chicks was not determined and it is unknown where the nest(s) were situated, but it is unlikely that they were associated with Snowy Owls.

Two pairs of King Eiders nested near Snowy Owl nests, one with each group of Brent Geese. A third King Eider nest with six eggs was found near the small lake, on which two females, with broods of sizes three and six, later appeared. Therefore, at least two pairs of King Eiders nested in isolation.

Not all the Snowy Owls in the study area had attendant colonies of waterfowl. Ten nests of Snowy Owls were located (**Figure 1**), only two of which had geese and eiders nesting in association with them.

The mean clutch size for Brent Geese was 5.0 (S.D.=1.0, n=12). Mean dimensions of the eggs of Brent Geese were 70.7 x 47.0 mm and the mean estimated initial mass was 84.4 g (**Table 3**). The estimated value for k_M = 0.540 (S.D.=0.0009, n=22). An analysis of variance showed that within-clutch variation in all measurements was smaller than the overall variation (egg-length $F_{11,47}$=12.75, P<0.001; egg-breadth $F_{11,47}$=23.71, P<0.001; estimated egg-mass $F_{11,47}$=22.91, P<0.001). The overall coefficient of variation (CV) of egg-length was 3.56%, whereas the within-clutch CV (taken as the square root of the mean residual sums of squares from the analysis of variance divided by the mean) was 2.03%. For egg-breadth, the corresponding CVs were 2.25% and 0.97%. The within-clutch variability of egg-breadth was less than the

Table 4. Biometrics and mass of eight female Dark-bellied Brent Geese and two female King Eiders at Pronchishcheva Lake, northeastern Taimyr Peninsula.

	Mean	S.D.	Range[1]
Dark-bellied Brent Geese			
Bill (mm)	33.3	1.3	31.6-35.6
Bill + Head (mm)	88.8	2.7	83.2-91.2
Wing (mm)	328	13	308-343
Tarsus (mm)	58.0	2.8	53.3-61.8
Mass (g)	1089	108	904-1234
King Eider			
Bill (mm)	33.3		31.0-35.6
Bill + Head (mm)	105.0		102.1-107.8
Wing (mm)	281		280-282
Tarsus (mm)	43.8		41.0-46.0
Mass (g)	1317		1289-1345

[1]For King Eiders, each column gives the measurements for one bird.

within-clutch variability of egg-length. Likewise, the overall CV of estimated egg-mass was 6.3%, while the within-clutch CV was 2.8%.

The biometric measurements of the eight female Dark-bellied Brent Geese captured (**Table 4**) coincided closely with those given by Cramp & Simmons (1977) for this subspecies. The birds were caught during the second half of incubation and their mean mass (1089 g) was nearly identical to that of the subspecies *hrota* while breeding on Southampton Island, Canada (1090 g) (Barry 1962).

For King Eiders, the mean clutch size was 5.3 (clutch sizes of 5, 5 and 6). The mean egg dimensions were 64.7 x 43.8 mm and the mean estimated initial mass was 67.0 g (**Table 3**). The biometric measurements for the two female King Eiders captured was similar to those of Cramp & Simmons (1977), which were based on samples of size 10 or fewer.

All goose and duck nests hatched successfully.

Discussion

Uspenski (1960) placed the divide between the westward-migrating nominate subspecies *bernicla* and the race *orientalis* (which is no longer recognised and has been merged with the Black Brant, race *nigricans* (Ogilvie 1978)) at approximately 100°E. Uspenski considered that the latter race migrated eastwards from northeastern Taimyr and then southwards along the River Lena to China. Our finding that the Brent Geese at Pronchishcheva Lake belong to the westwards-migrating *bernicla* subspecies thus contradicts Uspenski (1960). It is not known what evidence Uspenski used to delineate the boundaries between the various subspecies. If his boundaries reflected the true situation in the 1950s, when the total population of nominate *bernicla* was at its lowest (*c* 15,000 compared with *c* 200,000 in the early 1990s (Ogilvie & St Joseph 1976, Kirby 1992)), it possibly indicates that *bernicla* has expanded its breeding range eastwards at the expense of *nigricans*. It is known that the population size of the race *nigricans* has undergone a major decrease between the Taimyr and Kolyma Rivers since Uspenski did his surveys (EES unpublished data).

The mean egg-length (70.6 mm) was 4.4 mm shorter than the value of 75 mm reported by Schönwetter (1967) for *B. b. bernicla*, although the mean egg-breadths (47.0 mm) coincide exactly. However, Schönwetter only had a sample of nine eggs for nominate *bernicla*. Schönwetter's length-breadth ratios for the remaining eight species/subspecies in the genus *Branta* range from 1.45-1.53 (mean 1.50, S.D. 0.02), so his length-breadth ratio of 75.0/47.0=1.60 for nominate *bernicla* appears incompatible with the values for the remainder of the genus. Our value for this ratio (70.6/47.0=1.50) is equal to the mean of the genus. Working on Black Brant, Flint & Sedinger (1992) also found that the within-clutch size variability of egg size was smaller than the overall variability, but our sample sizes are too small to perform their comparisons of the variation in egg size in relation to clutch size. Our egg dimensions for King Eiders were close to those of Schönwetter (1967).

Ellenberg & Dreifke (1992) invented the term 'abrition' to describe the ecological relationship between at least three species, whereby an aggressive species offers indirect protection from a predatory species to other species which are unable to defend themselves against the predator. Abrition has been recorded on Wrangel Island; Portenko (1972), Syroechkovskiy & Krechmar (1981), Litvin *et al.* (1985) and Dorogoi (1990) found that Snow Geese *Anser caerulescens*, Black Brant *Branta b. nigricans* and Common Eider *Somateria mollissima* all nested beside Snowy Owl nests. Indeed, they indicated that, on Wrangel Island, Black Brants breed only in association with owls, such is the predation pressure from foxes, the main cause of clutch loss amongst geese. For example, after a peak lemming year in 1981, the enhanced fox population accounted for the loss of 4500 nests of Snow Geese in 1982 (Litvin *et al.* 1985). The Common Eiders on the other hand are less dependent on the owls and rely on camouflage to protect the nests. Abrition is also well known for Red-breasted Geese *Branta ruficollis* in the southern regions of the Taimyr Peninsula, where small colonies of Red-breasted Geese are located 50-100 m from nests of Peregrine Falcons *Falco peregrinus*, Rough-legged Buzzards *Buteo lapgopus* and inside colonies of gulls *Larus argentatus* and *L. hyperboreus* (Kretchmar 1965, Rogacheva 1992). Also, King Eiders have been found nesting in association with Long-tailed Skuas *Stercorarius longicaudus* (Blomqvist & Elander 1988).

The minimum distances that Snow Geese, Black Brants and Common Eiders nest from Snowy Owl nests on Wrangel Island were 0.8, 12 and 0.6 m respectively, and the maximum numbers recorded around a nest were 1000, 5 and 40 respectively (Litvin *et al.* 1985, Dorogoi 1990). Nests closer than 4 m tended to be deserted, as the Snowy Owls do not tolerate such close presence. Snowy Owls typically exclude foxes within a 200-300 m radius of their nests, and up to 500 m during years of high lemming abundance (Litvin *et al.* 1985, Dorogoi 1990). However, when there are few lemmings the owls either do not breed at all or have small clutches. They are then less effective in defending their nesting area and foxes are able to approach much closer (Litvin *et al.* 1985). Also, in these years, Common Eiders and geese are susceptible to attacks by Snowy Owls which will take both the sitting females and their eggs (Dorogoi 1990). For Red-breasted Geese, Kretchmar (1965) reported colonies of 2 to 6 pairs of geese; Rogacheva (1992) reported that 4-8 pairs are typical, with an upper limit recorded at 24 pairs. The minimum distance between a Red-Breasted Goose nest and the nest of a bird of prey was 1.5 m (Kretchmar 1965).

The ducks and geese on Wrangel Island nested beside Snowy Owls which were close to water, especially near rivers and streams, so that ducklings and goslings can be taken to the sea. This distance to the sea can be up to 40 km on Wrangel Island (Dorogoi 1990). Our study area was 30 km from the sea but the journey along the Kuldima River, next to which all Brent Geese nested (**Figure 1**), was 80 km.

Summers & Underhill (1987) found a correlation between the breeding success of Dark-bellied Brent Geese and lemming abundance, and proposed that this was caused by foxes switching from lemmings as prey in years when they are abundant to the eggs and young of geese when the lemming population was low or decreasing. The nesting association which Brent Geese have with Snowy Owls adds another possible dimension to the causal links between lemmings, foxes and goose production. Snowy Owls breeding in arctic tundra feed almost exclusively on lemmings in summer and their breeding success is dependent on this food supply (Pitelka *et al.* 1955, Litvin & Ovsyanikov 1990). Thus, in years when the lemming population is low, the Snowy Owls move elsewhere to breed, or fail to breed. If they do breed, the territories are poorly defended against Arctic Foxes which even predate some owl nests successfully. Therefore, in years of low lemming abundance, Brent Geese will not have the protecting influence of nesting Snowy Owls and will be vulnerable to fox predation. Litvin *et al.* (1985) and Dorogoi (1990) found that, in such years, the Brent Geese on Wrangel Island do not even attempt to nest. This may be largely true for our Pronchishcheva study area. In 1992, no Snowy Owls nested and only two pairs of Brent Geese attempted, both unsuccessfully (Underhill et al. 1993). However, on islands off the Taimyr coast, where fox predation may be less, breeding clearly does occur in years of low lemming abundance (B.S. Ebbinge & B. Spaans pers. comm.).

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References

Anthony, R.M., Flint, P.L. & Sedinger, J.S. 1991. Arctic Fox removal improves nest success of Black Brant. *Wildl. Soc. Bull.* 19:176-184.

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

Blomqvist, S. & Elander, M. 1988. King Eider (*Somateria spectabilis*) nesting in association with Long-tailed Skuas (*Stercorarius longicaudus.*) *Arctic* 41:138-142.

Boyd, H. 1987. Do June temperatures affect the breeding success of Dark-bellied Brent Geese? *Bird Study* 34:155-159.

Chernov, Yu.I. 1985. *The living tundra.* Cambridge University Press, Cambridge.

Cramp, S. (Ed.) 1985. *The birds of the Western Palearctic*, Vol IV. Oxford University Press, Oxford.

Cramp, S. & Simmons, K.E.L. (Eds.) 1977. *The birds of the Western Palearctic*, Vol I. Oxford University Press, Oxford.

Dorogoi, I.V. 1990. Factors influencing communal nesting of Snowy Owls and Anseriformes on Wrangel Island. *Ornitologia* 24:26-33. (Russian, with English summary).

Ebbinge, B.S. 1989. A multifactorial explanation for variation in breeding performance of Brent Geese *Branta bernicla. Ibis* 131:196-204.

Ebbinge, B.S. 1991. Brent Goose research in Taimyr 1990. *IWRB Goose Research Group Bulletin* 1:8-10.

Ebbinge, B.S. & St Joseph, A.K.M. 1992. The Brent Goose Colour-ringing Scheme: unravelling annual migratory movements from high arctic Siberia to the coasts of western Europe. In: *Population Limitation in Arctic-breeding Geese*, PhD thesis, University of Groningen. pp 93-104.

Ellenberg, H. & Dreifke, R. 1992. "Abrition" -Der Kolkrabe als "Schutzchild" vor dem Habict. *Corax* 15:2-10.

Flint, P.L. & Sedinger, J.S. 1992. Reproductive implications of egg-size variation in the Black Brant. *Auk* 109:896-903.

Kirby, J.S. 1992. *An assessment of breeding success in the Dark-bellied Brent Goose in 1991.* Report to the Joint Nature Conservation Committee, The Wildfowl & Wetlands Trust, Slimbridge.

Kretchmar, A.V. 1965. Zur Brutbiolgie der Rothalsgans, *Branta ruficollis* (Pallas), in West-Taimyr. *J. Ornithol.* 106:440-445.

Litvin, K.YE. & Ovsyanikov, N.G. 1990. Relationship between the reproduction and numbers of Snowy Owls and Arctic Foxes and the number of true lemmings on the Vrangel Island. *Zoologischeskii Zhurnal* 69:52-64. (Russian, with English summary).

Litvin, K.E., Pulyaev, A.I. & Syroechkovskiy, E.V. 1985. Colonies of the Snow Goose *Anser caerulescens*, Brent Goose *Branta bernicla* and Eider *Somateria mollissima* near the Snowy Owl *Nyctea scandiaca* nests on the Wrangel Island. *Zoologischeskii Zhurnal* 64:1012-1023. (Russian, with English summary).

Martynov, A.S. 1986. *Summer distribution of the Brent Goose. Study of birds in the USSR, their protection and efficient exploitation.* Academy of Sciences of the USSR, Moscow.

Ogilvie, M.A. 1978. *Wild geese.* Poyser, Berkhamsted.

Ogilvie, M.A. & St Joseph, A.K.M. 1976. Dark-bellied Brent Geese in Britain and Europe, 1955-76. *British Birds* 69:422-439.

Pitelka, F.A., Tomich, P.Q. & Treichel, G.W. 1955. Ecological relations of jaegers and owls as lemming predators near Barrow, Alaska. *Ecol. Monogr. 25:85-117.*

Portenko, L.A. 1972. *Birds of the Chukchi Peninsula and Wrangel Island,* Vol I, Nauka, Leningrad. (English translation, 1981, Amerind, New Delhi).

Prŷs-Jones, R.P. 1991. Ornithological cooperation in Siberia. *Nature* 354:102

Rogacheva, E.V. 1992. *The birds of central Siberia.* Husum Druck und Verlagsgesellschaft, Husum.

Roselaar, C.S. 1979. Fluctuaties in aantallen Krombekstrandlopers *Calidris ferruginea. Watervogels* 4:202-210. (Dutch, with English summary).

Schönwetter, M. 1967. *Handbuch der Oologie.* Akademie-Verlag, Berlin.

Summers, R.W. 1986. Breeding production of Dark-bellied Brent Geese *Branta bernicla bernicla* in relation to lemming cycles. *Bird Study* 33:105-108.

Summers, R.W. & Underhill, L.G. 1987. Factors related to breeding production of Brent Geese *Branta b. bernicla* and waders (Charadrii) on the Taimyr Peninsula. *Bird Study* 34:161-171.

Summers, R.W. & Underhill, L.G. 1991. The growth of the population of Dark-bellied Brent Geese *Branta b. bernicla* between 1955 and 1988. *J. Appl. Ecol.* 28:574-585.

Syroechkovski, E.E.jr. In press. The Brent Goose in Taimyr: distribution, population dynamics and progress of conservation. *Wildlife of Arctic Taimyr and its Conservation.* Institute for Evolutionary Morphology and Animal Ecology, Russian Academy of Sciences, Moscow. (Russian, with English summary).

Syroechkovskiy, Ye.V. & Krechmar, A.V. 1981. The fundamental factors determining the abundance of Snow Geese. In: *The Ecology of Mammals and Birds of Wrangel Island.* Krivosheyev, V.G. (Ed.) DVNTs Akad., Nauk, SSSR, Vladivostok. pp 3-27.

Syroechkovskiy, Ye.V., Litvin, K.Ye. & Ebbinge, B.S. 1991. Breeding success of geese and swans on Vaygach Island (USSR) during 1986-1988; interplay of weather and Arctic Fox predation. *Ardea* 79:373-382.

Underhill, L.G., Prŷs-Jones, R.P., Syroechkovski, E.E.jr., Groen, N.M., Karpov, V., Lappo, H.G., van Roomen, M.W.J., Rybkin, A., Schekkerman, H., Spiekman, H. & Summers, R.W. 1993. Breeding of waders (Charadrii) and Brent Geese *Branta bernicla bernicla* at Pronchishcheva lake, northeastern Taimyr, Russia, in a peak and a decreasing lemming year. *Ibis* 135:277-292.

Uspenski, S.M. 1960. The Brent Goose in the Soviet Union. *Wildfowl Trust Annual Report* 11:80-98.

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