

Newly established breeding sites of the Barnacle Goose *Branta leucopsis* in North-western Europe – an overview of breeding habitats and colony development

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Traditional breeding grounds of the Russian Barnacle Goose population are at the Barents Sea in the Russian Arctic. During the last decades, the population increased and expanded the breeding area by establishing new breeding colonies at lower latitudes. Breeding numbers outside arctic Russia amounted to about 12,000 pairs in 2005. By means of a questionnaire, information about breeding habitat characteristics and colony size, colony growth and goose density were collected from breeding areas outside Russia. This paper gives an overview about the new breeding sites and their development in Finland, Estonia, Sweden, Denmark, Germany, The Netherlands and Belgium. Statistical analyses showed significant differences in habitat characteristics and population parameters between North Sea and Baltic breeding sites. Colonies at the North Sea are growing rapidly, whereas in Sweden the growth has levelled off in recent years. In Estonia numbers are even decreasing. On the basis of their breeding site choice, the flyway population of Barnacle Geese traditionally breeding in the Russian Arctic can be divided into three sub-populations: the Barents Sea population, the Baltic population and the North Sea population. The populations differ not only in habitat use but also in breeding biology.

Key words: Barnacle Goose *Branta leucopsis*, breeding distribution, population development, breeding habitat.

1. Introduction

For a long time, Barnacle Geese have been considered to be breeding birds of the high Arctic (north of 69° N). During migration the Barents Sea population use stopover sites at the Baltic and North Sea. The majority of the geese winters in The Netherlands, and only during cold winters moves further south up to France (GANTER *et al.* 1999). In the beginning of the 1950s, the Russian population only numbered about 10,000 individuals (BOYD 1961). From the 1970s onwards, the number of wintering and spring staging geese along the coasts of the Baltic Sea and North Sea has increased. Simultaneously, non-breeding Barnacle Geese started to spend the summer period in these temperate regions. In 1971, the first breeding pair at the Baltic Sea was found on the island of Gotland in Sweden (LARSSON *et al.* 1988). Later on, further colonies were established on the island of Öland and along the coast of the Swedish mainland (LARSSON & VAN DER JEUGD 1998; STRID 2003), in southern Finland and in western Estonia (LEITO 1996) as well as on the Danish island of Saltholm (MORTENSEN & HANSEN 1999; OLSEN 1992). In the early 1980s, breeding colonies were established in the Delta area in the southwest of the Netherlands (MEINGER & VAN SWELM 1994; OUWENEEL 2001; VOSLAMBER *et al.* 2007) and at the end of the 1980s also in Germany (KOOP 1998; KRUCKENBERG & HASSE 2004). Almost all new colonies increased rapidly in size. Currently, the population outside Russia numbers up to 42,000–55,000 birds (VOSLAMBER *et al.* 2007). This paper describes the Northwest European

breeding areas and presents an overview of the population development of the Barnacle Goose outside of the traditional breeding grounds in Russia.

2. Material and Methods

We gathered characteristics of breeding habitats as well as data on breeding numbers and breeding biology of Barnacle Geese in Northwest Europe. Information was collected with the help of a questionnaire in 2005 (see FEIGE 2007). Areas with at least four breeding pairs in four consecutive years were included. Sporadic breeding attempts were ignored and breeding sites in artificial habitats like municipal parks (e.g. Nymphenburger Park in Munich, Germany) were not considered. In total, we compiled information on 51 breeding areas including about 85% of all breeding pairs outside the traditional breeding grounds in arctic Russia. A breeding area was defined as a region with one or more colonies. Within one breeding area geese used breeding sites and brood-rearing sites depending on their breeding state. The boundaries of an area were defined by its surroundings where no or only a few breeding or feeding geese are present. Breeding areas were named after the local regional names. A site was characterised by a specific combination of site characteristics and not distinguished by its spatial distribution in an area. A breeding site was defined as the area where nesting of geese takes place. A brood-rearing site was defined as the area where the parents moult and raise their young. We used the expression “colony” for all geese (BP and families, respectively) using the same site. Therefore, a colony was also not defined by its spatial distribution. According to this definition, the breeding areas were divided into 54 breeding sites and 53 brood-rearing sites (Table 1).

Table 1: Number of analysed Barnacle Goose nesting and brood-rearing sites. – Anzahl untersuchter Brut- und Aufzuchtgebiete der Weißwangengans.

Country – Land	total BP in 2005 – BP gesamt	analysed BP – untersuchte BP	breeding sites (n) – Brutplätze (n)	brood-rearing sites (n) – Aufzuchtgebiete (n)
Estonia – Estland	113	85	3	6
Sweden – Schweden	5,170	5,139	21	17
Denmark – Dänemark	504	504	1	1
Germany – Deutschland	184	178	7	10
The Netherlands – Niederlande	6,000	4,128	22	19
Total – gesamt	11,971	10,034	54	53

In the questionnaire we asked questions about the location of the breeding area (mainland or island, distance from island to mainland), the type and amount of vegetation cover, the presence of water, the management of sites (mowing, grazing, fertilisation), the presence of predators, human disturbance, hunting pressure and the conservation status of the sites. Further, colony size, colony growth rate and density at every individual site were determined. Goose numbers always refer to breeding pairs (BP) and represent the most recent counts (usually from 2005). Colony size was defined as the number of breeding pairs per breeding site and as the number of families at the brood-rearing sites, respectively. “Colony size” is not synonymous with “number of geese” as the number of geese refers to all geese distributed over all 30 breeding areas. Density was measured in geese/ha. Colony growth rate was determined for the last four consecutive years (2002–2005) according to the following formula: $\lambda = (N_t/N_0)^{1/t}$.

The number of sites with different habitat characteristics and the total number of geese using specific habitat characteristics were compared. We used Oneway-ANOVA to test for differences between population parameters of colonies in relation to the geographical location.

Similarity of habitat structure between breeding and brood-rearing sites of Barnacle Geese was analysed by hierarchical clustering and ordination of sites by multi-dimensional scaling (MDS). Information about habitat characteristics (island or mainland, distance to brood-rearing sites > 500 m, vegetation cover, management, predation and human disturbance) was transformed into a presence/absence matrix. Parameters that were rarely present (at less than five sites = 10% of the sampled sites) were excluded from the analysis since they do not contribute to the discrimination of sites (BACKHAUS *et al.* 2003). Rare parameters produce random noise and therefore it is recommended to delete them from the data set. Thus, the matrix for 49 breeding sites contained 15 parameters and for brood-rearing sites the matrix contained 43 parameters.

To visualise similarities between sites, ordination by non-metric MDS was carried out (BACKHAUS *et al.* 2003). The non-metric MDS describes similarities between sites (here: breeding and brood-rearing sites) in a multidimensional (non-metric) space. Only those two dimensions are shown, which explain the largest portion of the variance. The relative distance between two points mirrors the (dis)similarity between two sites. We used the stress value to give the grade of the analysis. A stress value between 0.1 and 0.2 gives a potentially useful two-dimensional picture (BORG & STAUFENBIEL 1997; CLARKE & WARWICK 2001).

MDS can be used to test for differences between certain groups of sites. We tested for differences between two geographi-

cal regions: Baltic Sea and North Sea. A valid test was established by CLARKE & GREEN (1988) built on a simple non-parametric permutation procedure, applied to the similarity matrix underlying the ordination of sites, and therefore termed an ANOSIM test (analysis of similarities). Average rank similarities within pairs of replicates (Baltic versus North Sea) are compared with the average rank similarities between sites of different replicates. The test statistic R lies within the range –1 and 1. R = 1 only if all replicates within sites are more similar to each other than any replicates from different sites. R is approximately zero if the similarities between and within sites will be the same on average (= representing the null hypothesis). R will usually fall between 0 and 1.

3. Results

3.1. Present distribution of Barnacle Goose breeding areas outside of Russia

Finland

The first pair of Barnacle Geese was breeding in the early 1980s on the Inkoo Archipelago. Ten years later already 18 breeding sites were confirmed that together held more than 30 breeding pairs in 1995 (LEITO 1996). The breeding sites are close to the Estonian breeding sites. Most birds breed in the vicinity of Helsinki and Turku. An unknown part of the Finnish geese originate from zoos in Stockholm and in Helsinki. Also the colony at Lake Vesijärvi near the city of Lahti is not of natural origin. Part of the parent birds have been raised in captivity. After these birds were released they started to breed. However, it seems quite clear that birds born in northern Russia joined the Finnish breeding population (VALKAMA, pers. comm.).

Estonia

In Estonia, the first pair of Barnacle Goose started to breed in 1981 on Papi laid Islet. None of the first breeders were ringed. LEITO (1996) concluded therefore, that the Estonian breeding birds originate from migrating geese of the Barents Sea population. The number of breeding pairs increased until 1999. Presently, the number of breeding pairs is declining (Fig. 2).

Up to 21 breeding sites were confirmed in 2002 (LEITO & TRUU 2004). In 2005, 3 breeding areas with at least 4 breeding pairs were known (Fig. 1) and the total number of breeding pairs was 113. All breeding sites are located on small offshore islands (between 2 and 5,5 ha in sizes) along the coast of Saaremaa Island, which traditionally is the most important Barnacle Goose breeding area in Estonia. LEITO (1996) describes in detail the development of breeding numbers and habitat characteristics of breeding areas in Estonia.

Sweden

In 1971 the first breeding pair of Barnacle Geese outside the traditional arctic breeding grounds in Russia was found on Laus holmar, i.e. three small offshore islands off the coast of the Swedish island of Gotland. In 1982, a

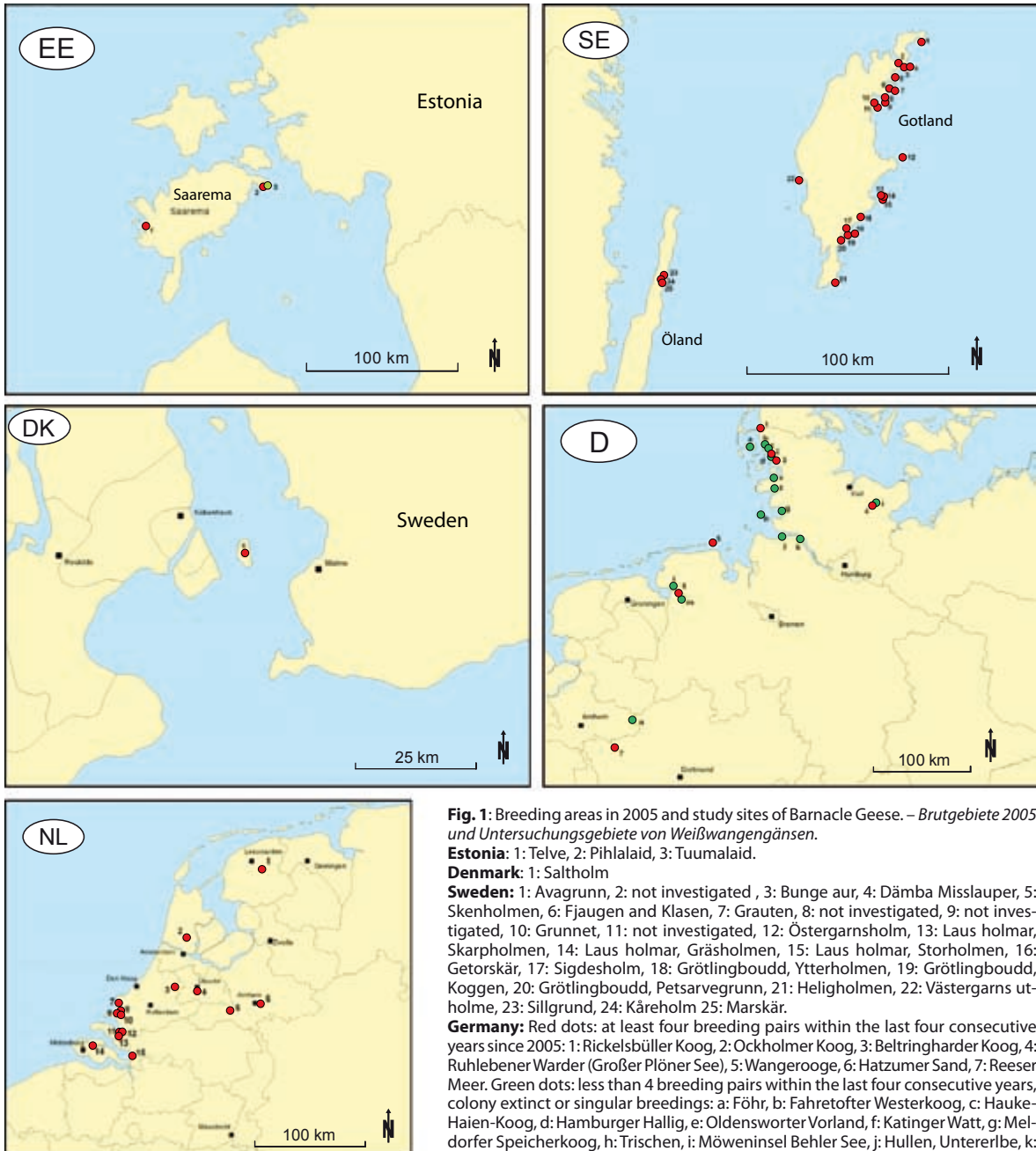


Fig. 1: Breeding areas in 2005 and study sites of Barnacle Geese. – *Brutgebiete 2005 und Untersuchungsgebiete von Weißwangengänsen.*

Estonia: 1: Telve, 2: Pihlalaid, 3: Tuumalaid.

Denmark: 1: Saltholm

Sweden: 1: Avagrund, 2: not investigated, 3: Bunge aur, 4: Dämba Misslauper, 5: Skenholmen, 6: Fjaugen and Klasen, 7: Grauten, 8: not investigated, 9: not investigated, 10: Grunnet, 11: not investigated, 12: Östergarnsholm, 13: Laus holmar, Skarpholmen, 14: Laus holmar, Gräsholmen, 15: Laus holmar, Storholmen, 16: Getorskär, 17: Sigdesholm, 18: Grötlingboudd, Ytterholmen, 19: Grötlingboudd, Koggen, 20: Grötlingboudd, Petsarvegrund, 21: Heligholmen, 22: Västergarns utholme, 23: Sillgrund, 24: Kåreholm 25: Marskär.

Germany: Red dots: at least four breeding pairs within the last four consecutive years since 2005: 1: Rickelsbüller Koog, 2: Ockholmer Koog, 3: Beltringharder Koog, 4: Ruhlebener Warder (Großer Plöner See), 5: Wangerooge, 6: Hatzumer Sand, 7: Reeser Meer. Green dots: less than 4 breeding pairs within the last four consecutive years, colony extinct or singular breedings: a: Föhr, b: Fahretofter Westerkoog, c: Hauke-Haien-Koog, d: Hamburger Hallig, e: Oldensworter Vorland, f: Katinger Watt, g: Meldorfer Speicherkoog, h: Trischen, i: Möweninsel Behler See, j: Hullen, Untererlbe, k: Allwördener Ad, l: Uphuser Meer, m: Bingumer Sand, Ems, n: Zwillbrocker Venn.

The Netherlands: 1: Alde Feanen, Jan Durks Polder, 2: Wormer- en Jisperveld, 3: Reeuwijkse Plassen, 4: Stuweiland Driel, 5: Drutensche en Leeuwensche Waarden, 6: Stuweiland Hagesteijn, 7: Beningerslikken, 8: Quarkgors, 9: Scheelhoek, 10: Slijkplaat, 11: Hellegatsplaten, 12: Krib Hellegat 13: Noordplaat, 14: Middelplaten, 15: Markizaat.

colony was established at Kåreholm off the island of Öland. It is assumed that the founders of the colony on Laus holmar originated from the Arctic Russian population, as the coastal areas around the Baltic Sea have been staging areas in spring and autumn for at least one century (LARSSON *et al.* 1988; FORSLUND & LARSSON 1991; LARSSON & VAN DER JEUGD 1998). Until 2002 the number of breeding pairs on Gotland and Öland increased (Fig. 2). In 2005,

the total number of breeding pairs amounted to 780 on Öland and 4390 on Gotland. About 25 breeding sites are known on Gotland and Öland (Fig. 1). Barnacle Geese are also found breeding in smaller numbers in other parts of Sweden (STRID 2003). These sites are not included in this study. Several birds born on Gotland have been found as breeding adults in northern Russia in recent years (VAN DER JEUGD & LITVIN 2006).

Denmark

In Denmark there is only one breeding site of Barnacle Geese on Saltholm Island (Fig. 1) situated at a distance of 3,500 m from the mainland. The breeding colony was established in 1992 and probably has its origin in a domestic population in Malmö, Sweden (FINK pers. comm.) GRELL *et al.* (2004) state that it possibly originates from the Baltic breeding colonies. The colony increased very rapidly and numbered 675 breeding pairs in 2006 (Fig. 2). Additionally, up to 3,000 non-breeding Barnacle Geese stay on the island during summer (FINK, pers. comm.).

Germany

The first German breeding site was colonised in 1988 on the island Ruhlebener Warder in the lake Großer Plöner See (Schleswig-Holstein). None of the first German breeding birds was ringed (KOOP 1998). 21 breeding areas are confirmed in 2005 of which seven areas harboured at least four breeding pairs. In 2006, the number of breeding pairs in Germany amounts to 246 (Fig. 2). The breeding site of the Ruhlebener Warder (Schleswig-Holstein) is the only one close to the Baltic. All other breeding sites are situated along the Wadden Sea coast of Schleswig-Holstein and in Lower Saxony, except for one breeding area inland in the Lower Rhine area (Fig. 1). Detailed descriptions of the breeding colony development and habitat use at Hatzumer Sand (Lower Saxony) and Ruhlebener Warder are available at KRUCKENBERG & HASSE (2004) and LUDWICHOWSKI & BRÄGER (2003), respectively.

The Netherlands

In 1982, the first Dutch breeding pair was observed. Some colonies, especially the early established ones, are said to originate from feral birds or water birds collections (MEINGER & VAN SWELM 1994), for other colonies, the origin is unknown. 270 Barnacle Goose breeding areas are known out of which 14 areas, harbouring about 70 % of all breeding Barnacle Geese in The Netherlands, were included

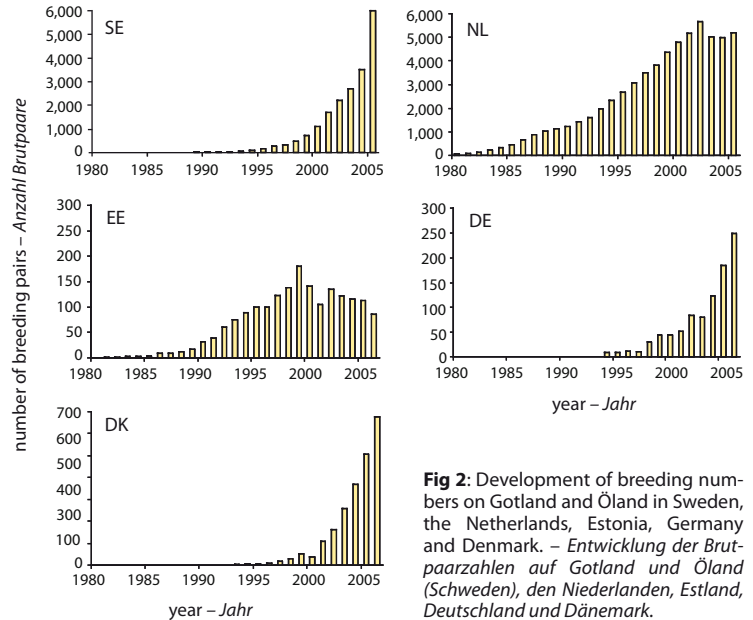


Fig 2: Development of breeding numbers on Gotland and Öland in Sweden, the Netherlands, Estonia, Germany and Denmark. – Entwicklung der Brutpaarzahlen auf Gotland und Öland (Schweden), den Niederlanden, Estland, Deutschland und Dänemark.

into this study (Fig. 1). The total number of breeding pairs amounted to approximately 6,000 in 2005 (Fig. 2). More than the half of the Dutch breeding population is found in the Dutch Delta area in Zuid-Holland and Zeeland where the combination of large estuaries, small islands and cattle-grazed shore meadows provide ideal habitats. Hellegatsplatten (Zeeland) is the best studied breeding area of Barnacle Geese in The Netherlands. Detailed information about the breeding biology and distribution of the geese can be found in POUW *et al.* (2005) and VAN DER JEUGD *et al.* (2006a). Two male birds born at Hellegatsplatten were found breeding in Northern Russia, on Kolguev Island and at Kolokolkova Bay in northern Russia in 2006 and 2007.

Belgium

In the 1980s Barnacle Geese started to breed in Belgium in the north of Flanders and along the North Sea coast in the surroundings of the Zwin nature reserve (Knokke). Today, the number of breeding pairs is assumed to be 150–200 or even more. The proximity to the breeding areas in The

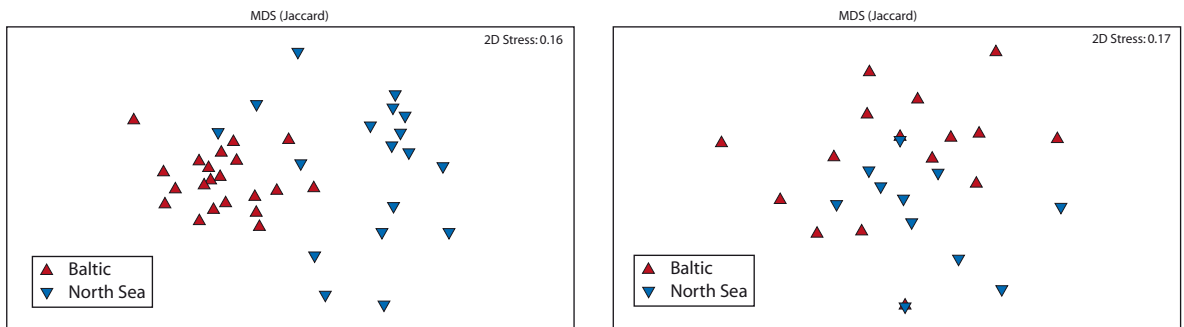


Fig. 3: Two-dimensional non-metric MDS configuration of North-west European Barnacle Geese breeding sites (left) and brood-rearing sites (right). – Zweidimensionale nicht-metrische MDS-Konfiguration der nordwesteuropäischen Nistplätze (links) und Brutaufzuchtgebiete (rechts) der Weißwangengans.

Table 2: Number of sites, total number of geese, colony growth, colony size and density in the Baltic and North Sea countries. Oneway-ANOVA test; * $p > 0.5$; ** $p > 0.01$; *** $p > 0.001$; n.i.: not investigated, n.s.: not significant. – Anzahl der Gebiete, Gesamtbestand und Wachstumsraten der Kolonien sowie Brutdichte in den Ostsee- und Nordseestaaten. Oneway-ANOVA * $p > 0.5$; ** $p > 0.01$; *** $p > 0.001$; n.i.: nicht untersucht, n.s.: nicht signifikant.

	EST	SE	DK	D	NL	Significance
	breeding sites – Brutgebiete					Signifikanz
number of sites – Anzahl Brutgebiete	3	14	1	7	22	
total number of breedings pairs (BP) – Anzahl Brutpaare	85 <i>n</i> = 3	5138 <i>n</i> = 21	504 <i>n</i> = 1	179 <i>n</i> = 7	4226 <i>n</i> = 22	
colony size (BP) – Koloniegroße (BP)	28 ± 15 <i>n</i> = 3	245 ± 397 <i>n</i> = 21	504 <i>n</i> = 1	26 ± 29 <i>n</i> = 7	192 ± 236 <i>n</i> = 22	*
colony growth (λ) – Wachstumsrate (λ)	n.i.	1.17 ± 0.27 <i>n</i> = 20	1.68 <i>n</i> = 1	1.3 ± 0.34 <i>n</i> = 6	1.5 ± 0.31 <i>n</i> = 22	**
density (BP/ha) – Nestdichte (BP/ha)	10.5 ± 7.0 <i>n</i> = 3	19.4 ± 19.7 <i>n</i> = 21	1.7 <i>n</i> = 1	170 ± 178 <i>n</i> = 5	77.8 ± 137.4 <i>n</i> = 20	n.i.
	Brood-rearing sites – Aufzuchtgebiete					
number of sites – Anzahl Gebiete	6	17	1	10	19	
total number of families – Gesamtzahl Familien	85 <i>n</i> = 6	n.i.	504 <i>n</i> = 1	179 <i>n</i> = 10	3431 <i>n</i> = 12	
number of families (BP) – Anzahl Familien (BP)	28 ± 13 <i>n</i> = 6	n.i.	504 <i>n</i> = 1	18 ± 23 <i>n</i> = 10	286 ± 328 <i>n</i> = 12	***
growth of brood-rearing flocks (λ) – Wachstumsrate der Familientrupps (λ)	n.i.	n.i.	1.68 <i>n</i> = 1	1.37 ± 0.27 <i>n</i> = 9	1.55 ± 0.41 <i>n</i> = 14	n.s.
density (geese/ha) – Familiendichte (Gänse/ha)	0.8 ± 0.3 <i>n</i> = 6	n.i.	1.7 <i>n</i> = 1	6.8 ± 10.6 <i>n</i> = 9	3.0 ± 4.5 <i>n</i> = 11	n.s.

Netherlands very likely influenced the establishment of the colonies, but also escaped feral birds of water bird collections started to breed in Flanders (KUIJKEN pers. comm.; ANSELIN & VERMEERSCH 2005).

3.2. Habitat characteristics of North Sea and Baltic breeding areas

Multivariate analysis of habitat characteristics of Barnacle Goose breeding sites revealed significant differences between Baltic and North Sea sites (ANOSIM test, global $R = 0.569$, $p < 0.001$). The result of the analysis is visualised in the two-dimensional plot of the non-metric MDS (Fig. 3). Significant differences between brood-rearing sites were not found (global $R = 0.111$, $p > 0.05$).

The Oneway-Anova revealed significant differences in average colony growth rate between countries (Table 2), with higher growth rates in The Netherlands and Denmark compared to Germany and Sweden. Also Salholm, the only colony in Denmark, has a high growth rate. This is a large island (8 km²) and suitable free nesting sites are still available (MORTENSEN, pers. comm.). Largest colonies are found in Sweden.

3.3. Habitat use

3.3.1. Breeding sites

In the Baltic, all geese breed on off-shore islands. Contrastingly, in the North Sea region about 30% of the breeding sites are located on the mainland, all of which are in the Netherlands. Almost all remaining breeding sites are on islands either in lakes, rivers or in the recently embanked areas in Schleswig-Holstein (“Köge”) and in The Netherlands. Most of the islands are artificially created. Islands

in Germany mainly have a size of less than 0.02 ha such as in the Köge, and only a short distance to the mainland (10–400 m). In The Netherlands, islands have a distance of 70–1500 m to the mainland.

Breeding sites are predominately grassy. In contrast to the Baltic, where the vegetation consists mainly of grasses and bushes, the vegetation at the North Sea is very diverse: grasses, eutrophic herbs, reed and bushes grow at many places (Fig. 4).

In terms of management, differences between sites in the Baltic and North Sea as well as within the individual countries are found. In Estonia, Denmark and Germany none of the breeding sites is managed. By contrast, in Sweden half of the sites are grazed and in the Netherlands half of the sites are grazed and mown (Fig. 5). Whereas in Sweden islands are predominantly grazed by sheep, in the Netherlands all sites are cattle-grazed, and half of them in combination with sheep and/or horses.

Breeding sites in the Baltic are influenced by avian predators (Estonia: predominantly White-tailed Eagle *Haliaeetus albicilla*, Sweden: predominantly large gulls like Herring Gull *Larus argentatus* and Greater Black-backed Gull *Larus marinus* as well as White-tailed Eagle, but in recent years also by Red Fox *Vulpes vulpes*; Denmark: large gulls and Marsh Harrier *Circus aeruginosus*). In the North Sea population the Red Fox is important as a ground predator. Especially in the Köge in Schleswig-Holstein, and at several inland sites in The Netherlands, predation by foxes can be rather high in years with a low water table, which makes breeding islands easily accessible. Two larger colonies in The Netherlands, both included in this study, have been almost completely eradicated due to predation by Red Foxes in recent years.

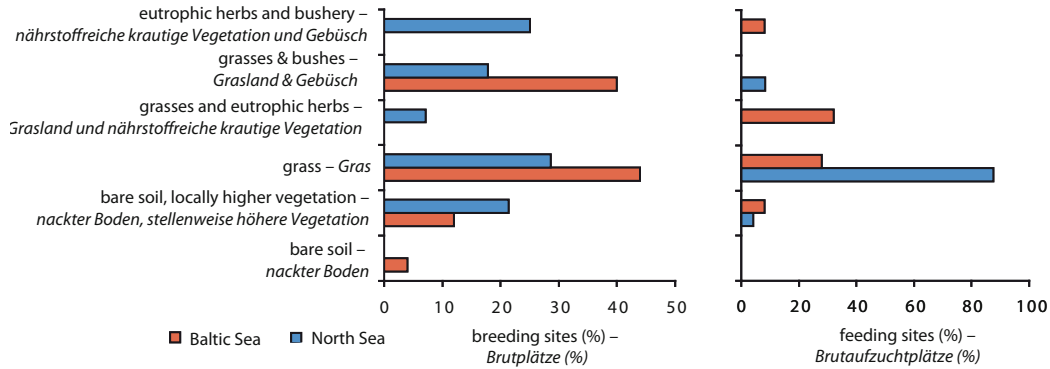


Fig. 4: Vegetation at breeding and brood-rearing sites (Baltic Sea: breeding sites n = 25, brood-rearing sites n = 24; North Sea: breeding sites n = 28, brood-rearing sites n = 19). – Vegetation an den Brut- und Brutaufzuchtplätzen (Ostsee: Brutplätze n = 25, Brutaufzuchtplätze n = 24; Nordsee: Brutplätze n = 28, Brutaufzuchtplätze n = 19).

3.3.2. Brood-rearing sites

Because many of the breeding islands do not provide sufficient feeding habitat to raise goslings the brood-rearing geese often move to the mainland. Nevertheless, the geese of more than half of the colonies in the Baltic and North Sea use breeding sites also as brood-rearing sites at least for a while. Birds from 12 out of 24 colonies in the Baltic use brood-rearing sites that are located more than 3000 m from the breeding site. In the North Sea, the farthest distances are between 1000 m and 3000 m. Whereas in the Baltic only half of the brood-rearing sites are on the mainland, in the North Sea 80 % (n = 29) of the sites are on the mainland.

At almost all sites management takes place. Generally, brood-rearing sites are pastures or meadows. Brood-rearing sites in the Baltic are less intensively managed than in the North Sea and only mowing or grazing occurs. In the North Sea, additional fertilisation occurs at some places and many sites are managed by a combination of grazing and mowing. In the Baltic, brood-rearing sites are mainly grazed by cattle, but on some Swedish islands sheep grazing is common. Contrastingly, in the North Sea one half of the sites is cattle-grazed and the other half is grazed by a combination of cattle, horse, and sheep. The management of brood rearing sites in the North Sea countries is similar (Fig. 5).

Due to the fact that brood-rearing sites in the North Sea are more intensively managed than in the Baltic, the vegetation is generally shorter (Fig. 4, for a description of a Baltic brood rearing site see also VAN DER GRAAF *et al.* 2007). The predation situation is only known for the North Sea. There, avian and ground predators occur at half of the sites. All sites at the Baltic Sea and at the North Sea have a clear escape to water as a refuge.

3.3.3. Nature protection and human disturbance

Most of the breeding areas are located in protected areas. In Sweden, about half of the breeding sites are outside of nature reserves. Most of these sites were formerly used for military purposes and were not open to the public. Disturbance by humans is low. Farmers play the major role for human disturbance, but also here disturbance is generally low, though in some areas sites are visited daily. Generally, disturbance levels are lower in the Baltic.

4. Discussion

4.1. Shifts of the breeding range

The colonisation of Northwest Europe by the Barnacle Goose appeared during a period of constant population growth (average 7 % annually) on the traditional arctic breeding grounds in North-West Russia (GANTER *et al.* 1999). Shortly after the first breeding pair was observed in the Baltic, Barnacle Geese also expanded their breeding range in Russia. New breeding sites were established westwards and southwest of Novaya Zemlya and Vaigach along the coast of the Barents Sea and the eastern border of the White Sea (FILCHAGOV & LEONOVICH 1992; VAN DER JEUGD *et al.* 2003). A spectacular increase occurred especially on Kolguyev Island. Breeding numbers amounted to only several hundreds in the late 1980s and are estimated up to 65,000 pairs in 2006 (KRUCKENBERG *et al.* 2007).

Virtually all of the new breeding areas outside the Russian Arctic are situated with-

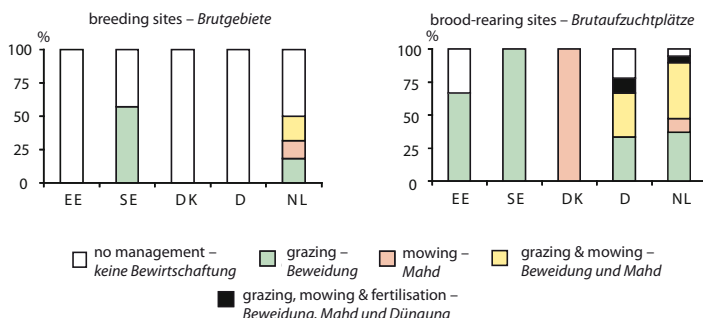


Fig. 5: Management at breeding and brood-rearing sites in percentages of total number of sites. – Management an Brut- und Brutaufzuchtplätzen in Prozent der Gesamtzahl der Gebiete (breeding sites – Brutgebiete: EE: n = 3, SE: n = 21, DK: n = 1, D: n = 7, NL: n = 22; brood-rearing sites – Brutaufzuchtgebiete: n = 24; EE: n = 6, SE: n = 17, DK: n = 1, D: n = 10, NL: n = 11).

in the traditional Barnacle Goose flyway and were used during migration for a long time before the first breeding occurred (GANTER *et al.* 1999). Prior to the establishment of new colonies, often small goose numbers were seen in future breeding areas throughout the entire summer (KRUCKENBERG & HASSE 2004). These geese stayed in the wintering area or at stop-over sites and finally started to breed. This is proven for the first breeding colonies in Schleswig-Holstein (BERNDT & BUSCHE 1991) and can generally be assumed for newly established breeding areas outside of Russia.

Apart from that, at some places ring recoveries clearly demonstrated that colony establishment was initiated by birds escaped from breeders or neglected waterfowl collections:

- Finland: surroundings of the cities of Helsinki, Lathi and Turku (VALKAMA pers. comm.),
- Denmark: Saltholmen (FINK pers. comm.),
- Germany: Wangerooge (HECKROTH pers. comm.),
- The Netherlands: some regions in the Dutch Delta and some inland sites (MEINGER & VAN SWELM 1994; LENSINK 1996),
- Belgium: Flanders (ANSELIN & VERMEERSCH 2005).

The North Sea region offers new breeding opportunities due to hydro-engineering measures, especially in the Dutch Northern Delta and at the German coast of Schleswig-Holstein where many newly created water bodies and artificial islands became popular breeding sites for birds in a short time (OUWENEEL 2001; POUW *et al.* 2005). Large water reservoir constructions, new water bodies and wetlands were also created inland. These artificial water bodies are important water bird habitats in Northwest Europe, and they even have supra-regional importance (VULINK 1991).

Our study shows that most of the brood-rearing sites are managed grasslands. Farmland provides food of much higher quality than the geese can find in their traditional habitats on salt and fresh-water marshes or pastures along estuaries and natural lakes (MADSEN *et al.* 1999). In North-west Europe, modern mowing schemes, fertilisation and livestock grazing produce forage for geese which remains available in high quality and quantity throughout for a longer period and provides suitable habitats for brood-rearing.

The modern cultural landscape also improved conditions for predators. Foxes e.g. learned to populate croplands where they can reach high reproductive rates (LANGGEMACH & BELLEBAUM 2005) and in addition benefit from anti-rabies inoculation. By-catch and fishery waste are a new food source for a great number of gulls (GARTHE 1993) and raptors profit from changes in hunting legislations and the prohibition of DDT in European countries since the 1970s (BAUER *et al.* 2005). However, in contrast to most other waterfowl species, predation does not seem to limit site use in geese inevitably. Many colonies are obviously growing due to high reproductive success despite predation on goslings by gulls. At some sites, predation by e.g. Red Foxes does limit site use. For example, Barnacle Geese do not breed on the Gotland mainland and colonies are severely affected when foxes reach breeding islands.

Likewise, in The Netherlands breeding Barnacle Geese are largely confounded to the almost fox-free Delta area, and several inland colonies have recently disappeared due to fox predation (VAN DER JEUGD *et al.* 2006a). Though predation has negative impacts on hatching success and goslings survival (VAN DER JEUGD *et al.* 2006a), almost all colonies are obviously growing due to dispersal.

4.2. Breeding sub-groups of the Russian Barnacle Goose population

Multivariate analyses of habitat factors of Northwest European Barnacle Goose breeding sites revealed significant differences between sites from the Baltic and the North Sea area. Additionally, Western European colonies, Baltic colonies and colonies in the Russian Arctic distinguish themselves by a different breeding biology and different migration strategies (BLACK *et al.* 2007):

Breeding biology differs in terms of timing: At the time Russian birds leave the stopover sites at the North and Baltic Seas, local geese already start with breeding. On Gotland, the first young hatch well before the time the Russian birds start egg-laying. Goslings on Gotland hatch one week later than in the Netherlands. Clutch size decreases with latitude. Due to nutrient poor vegetation, gosling growth is slowest in the Baltic whereas the young geese in Russia reach fledging time most rapidly (VAN DER JEUGD *et al.* submitted). Whereas the North Sea population does not migrate anymore, the Baltic population reaches its first breeding sites after 1,000 km (Öland, Denmark excluded). By contrast, the Russian birds have to migrate another 2,000 km to reach their breeding grounds. Non-migratory birds in The Netherlands still show Zugunruhe in spring which is reflected in short visits of other parts of the country (POUW *et al.* 2005; VAN DER JEUGD *et al.* 2006a). Recently, the geese tend to fly directly from their wintering grounds to the breeding areas without using former stopover sites (KOFFIJBERG & GÜNTHER 2004).

On this basis, the formerly Russian Barnacle Goose population can be divided into three breeding sub-groups: the Russian meta-population with breeding sites in Russia, the Baltic meta-population with breeding sites in the Baltic region and the North Sea meta-population with breeding sites at the North Sea. The Baltic population amounts to approximately 21,000 birds and the North Sea group to approximately 25,000 birds (The Netherlands only; VAN DER JEUGD *et al.* 2006a). Though all three populations are increasing, colony growth differs significantly. Mean annual growth rates of new colonies, especially at lower latitudes, can be very high (POUW *et al.* 2005). The Russian population as a whole increased at 7%, but individual colonies can increase at much faster rates (VAN DER JEUGD *et al.* 2003). The Baltic population initially increased at 41% but colony growth rapidly decreased in recent years, and total numbers have even gone down. The North Sea population (The Netherlands only) increased at 48% annually between 1982 and 2005, making it the fastest growing goose population of the world (VAN DER JEUGD *et al.* 2006). However, it is expected that also here, growth rates will decrease when carrying capacity has been reached.

As colour ringing schemes demonstrate, there is an exchange between birds within the breeding range of the

Russian Barnacle Goose population (VAN DER JEUGD 2005; VAN DER JEUGD & LITVIN 2006; BLACK *et al.* 2007) E.g. out of 4,500 colour-ringed birds born on Gotland, 11 were seen as a breeding bird in Russia, 4 in the Netherlands, 3 in Finland, 1 on Svalbard and one in Belgium. Almost all of these dispersers were males (VAN DER JEUGD & LITVIN 2006). This demonstrates that Barnacle Geese can breed in habitats totally different from their place of birth.

5. Outlook

VAN DER JEUGD *et al.* (2006b) tentatively estimated suitable breeding habitat in The Netherlands for 15,000–20,000 pairs of Barnacle Geese. As a result of specialised behaviours and body designs the current habitat conditions in wetland areas in North-western Europe are perfectly suitable for herbivorous waterfowl (BLACK *et al.* 2007). Predation might be a factor that is potentially of very great importance for the population development, as can be predicted from recent developments in the Baltic and the Netherlands. The magnitude of this effect will depend on the general policy towards these predators (amount of persecution) as well as on possible behavioural reactions to predator abundance by the geese (e.g. a change from colonial to solitary breeding). Also, population growth may become limited by changing habitat conditions along the migration route or at the wintering grounds. Increasing conflicts with agriculture will influence the decision to manage goose populations, especially in the North Sea population. Today, farming practices and nature protection depend on international developments

and European agreements. In the international context our countries have a great responsibility for the Barnacle Goose population, both as provider of safe wintering grounds for visiting arctic geese as well as host to an increasing local breeding population. Balancing management decisions between these two roles will prove difficult and requires careful planning and monitoring.

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6. Zusammenfassung

Feige, N., H. P. van der Jeugd, A. J. van der Graaf, K. Larsson, A. Leito, A. & J. Stahl 2008: Neu begründete Brutgebiete der Weißwangengans *Branta leucopsis* im Nordwesten Europas – eine Übersicht über die Bruthabitate und die Entwicklung der Kolonien. *Vogelwelt* 129: 244–252.

Die traditionellen Brutgebiete der russischen Brutpopulation der Weißwangengans liegen an der Barentssee in der russischen Arktis. In den vergangenen 30 Jahren ist die Population stark gewachsen und hat ihr Brutgebiet durch die Begründung von neuen Brutkolonien nach Südwesten erweitert. Die Zahl der außerhalb des traditionellen russischen Brutgebietes brütenden Paare war 2005 auf ca. 12.000 Brutpaare angestiegen. Mittels einer Literaturrecherche und anschließender Befragung von Feldornithologen über die typischen Eigenschaften der Bruthabitate, die Koloniegroße, das Koloniewachstum und die Gänsedichte wurden Daten über die Brutgebiete außerhalb der russischen Arktis gesammelt. In dieser Arbeit wird ein Überblick über die neuen Brutgebiete in Finnland, Estland, Schweden, Dänemark,

Deutschland, den Niederlanden und Belgien und ihre Entwicklung gegeben. Eine statistische Analyse zeigte signifikante Unterschiede zwischen den Habitateigenschaften und den Populationsparametern verschiedener Brutgebiete im Nordseeraum und im Baltikum. Die Kolonien an der Nordsee wachsen gegenwärtig noch schnell, während sich das Wachstum in Schweden in den letzten Jahren deutlich verringert hat. In Estland nehmen die Brutpaarzahlen sogar ab. Die ursprüngliche Weißwangenganspopulation der russischen Arktis kann in drei Subpopulationen verteilt werden: die Barentssee-Population, die Baltische Population und die Nordsee-Population. Diese (Sub-)Populationen unterscheiden sich nicht nur in ihrer geographischen Verteilung und Brutbiologie sondern auch in der Habitatnutzung.

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