The establishment of a new major moulting site for Greylag Geese *Anser anser* at Lake Hornborgasjön, southern Sweden

LEIF NILSSON[1,*] & CLAS HERMANSSON[2]

[1]Department of Biology, Biodiversity, University of Lund, Ecology Building, SE-223 62 Lund, Sweden.
[2]Lake Hornborgasjön Bird Observatory, SE-521 98 Broddetorp, Sweden.
*Correspondence author: E-mail: leif.nilsson@biol.lu.se

Abstract

At around 1900, Lake Hornborga in southern Sweden was considered to be one of the best breeding lakes for waterbirds in the country. In subsequent years, the area was drained and lake water levels reduced to avoid flooding and obtain land for farming. By 1950, the remaining lake and wetland area (34 km^2) had become a swamp, totally overgrown with reed beds and bushes. The Swedish Environmental Protection Agency initiated a lake restoration project during the 1960s and 1970s and by 1995 the site had been restored to a shallow lake. Greylag Geese *Anser anser* started using the lake for breeding and moulting shortly thereafter, and it has attracted increasing numbers of moult migrants over the last 15 years, with 28,000 moulting geese counted in 2015. Neck-banding and collar resightings during 2004–2007 showed that the lake attracted geese not only from south Sweden and Denmark but also from eastern continental Europe (*e.g.* Poland) to moult. Seventy-two Greylag Geese marked at a study area in Scania, southwest Sweden, have been seen moulting at Lake Hornborgasjön, whereas geese from this area formerly moulted mainly in Flevoland in the Netherlands and later in Denmark. Individual birds from other areas were also shown to have changed their moulting sites in recent years.

Key words: *Anser anser*, Greylag Goose, Lake Hornborgasjön, lake restoration, migration, moult, neck-banding.

Young individuals and failed breeders of several goose populations undertake a pre-moult migration to their moulting grounds each year, which are often remote from the main breeding areas of the species (Salomonsen 1968). Studies of different moulting flocks in Europe have shown that important factors behind the selection of a suitable moult site include the presence of extensive grazing areas close to safe roosting areas in undisturbed environments (Follestad *et al.* 1988; Fox *et al.* 1995; Lebret &

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Timmerman 1988; Nilsson *et al.* 2001; Zijlstra *et al.* 1991). For Greylag Geese *Anser anser*, the largest moulting site in Europe was established at Oostwaardersplassen, a vast reed bed area in the new Zuid-Flevoland polder in the Netherlands, which was created in the 1970s (Zijlstra *et al.* 1991; Van Eerden *et al.* 1997). Numbers of Greylag Geese in the Northwest European population have increased dramatically over the last 40 years (Fog *et al.* 1984; Fox *et al.* 2010; Nilsson *et al.* 1999; Nilsson 2013) and numbers moulting at Oostwaardersplassen also increased, eventually reaching a peak of 60,000 individuals in the early 1990s (Van Eerden *et al.* 1997). At the same time, several other important moulting sites were established elsewhere in Europe, *e.g.* in Vejlerne in Denmark (Salomonsen 1968), on Gotland (Essen & Beinert 1982), in central Norway (Follestad *et al.* 1988), and in Slonsk in Poland (Gromadzki & Majewski 1984). Additionally, several smaller moulting flocks have been recorded at a number of sites (Nilsson *et al.* 1999).

During the 1990s, the number of Greylag Geese moulting at Oostwaardersplassen declined, probably because of habitat degradation at the site (Van Eerden *et al.* 1997), whilst at the same time the geese started moulting in large numbers on the island of Saltholm, in the strait between Sweden and Denmark (Fox *et al.* 1995; Nilsson *et al.* 2001). Large-scale marking of Greylag Geese (started in the Nordic countries in 1984) showed that geese from southwest Scania originally migrated almost exclusively to Oostwaardersplassen to moult (Andersson *et al.* 2001; Nilsson *et al.* 2001). Following the habitat degradation at Ooswaardersplassen, however, the majority of the Scanian geese changed their habits and started moulting on Saltholm, much closer to the breeding areas where they had been marked (Nilsson *et al.* 2001), although some individuals moved to more distant moulting grounds.

By the mid-1990s, the large lake restoration project at Lake Hornborgasjön had resulted in the establishment of a new shallow lake, in what is one of the largest single nature conservation projects ever carried out in Sweden (Hertzman & Larsson 1999). As early as the late 1990s, some marked Greylag Geese from the southwest Scania study area were recorded there during the moulting period. Intensive studies of the geese at Lake Hornborgasjön therefore were initiated, including neck-banding Greylag Geese caught at the site during 2004–2007. In this paper we aim to document the build-up of a novel moulting tradition for Greylag Geese at Lake Hornborgasjön and, from re-sightings of neck-banded individuals, try to elucidate their origin.

Study area

Lake Hornborgasjön is situated in a rich agricultural plain, south of Lake Vänern in southern Sweden, close to the slope of the calciferous Billingen Mountain (Fig 1). In the early 1800s, the shallow lake covered *c.* 30 km^2 and was used by the local people for fishing and waterfowl hunting. As early as 1802, initial attempts to lower the water level were undertaken to reduce the risk of flooding in the area, although it probably had little effect on the lake as a whole. Further attempts to lower the water table

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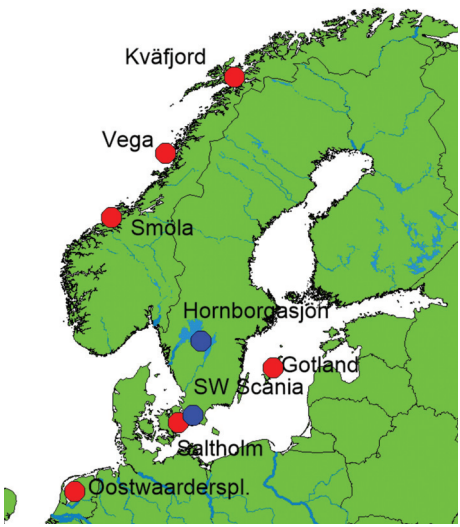

Figure 1. Map of northwest Europe showing the geographical position of Lake Hornborgasjön, the southwest Scania study area (shown as blue circles) and other moulting sites mentioned in the text (red circles).

were made again in 1848 and 1874, but both with limited effects on the lake.

By 1905, Lake Hornborgasjön had a maximum water depth in summer of about 2 m. Of a total area of *c.* 27 km^2, emergent vegetation, mainly Bulrush *Scirpus lacustris* and Common Reed *Phragmites australis*, covered about one third of the lake. Large parts of the open water lacked submerged vegetation and there were also large areas (*c.* 6.6 km^2) of shore meadows around the lake, much of which retained open shorelines and direct access to the lake. During these years, Lake Hornborgasjön was considered to be the best lake for breeding birds in the country (Söderberg 1947).

The water level of the lake was lowered twice more, in 1904–1911 and 1933–1935. These operations initiated a rapid spread of *Phragmites australis* over the now shallower areas, especially as the result of some dry summers which exposed large areas of the lake-bed, facilitating extension of the reed beds through seed propagation. Bushes, mainly of willow *Salix* sp., also spread throughout the former lake area. The net effect was a major expansion in the area of reed and willow bushes, which eventually came to cover more or less the entire area of formerly open water.

During the 1960s, discussions and studies were initiated with the aim of restoring Lake Hornborgasjön as a lake for breeding birds. In principle, the main aim was to clear large parts of the lake area from reeds (12 km^2) and bushes, remove ditches and canals and to raise the water table in order to create a lake with open water and a mosaic of wetland vegetation (Björk 1994). Before the main restoration work commenced in 1990, vegetation was removed from smaller areas to test the effectiveness of different techniques. Accordingly, smaller areas with open water were created before restoration operations actually started. The water level was then increased slowly between 1992 and 1995, after which the mean water level of the lake was maintained at 0.9 m. For further documentation of the restoration project, see Björk (1994) and Hertzman & Larsson (1999). Aerial photos in Fig. 2 show a section of the lake before and after the main restoration work at the site.

Around 2010, the total lake area extended to *c.* 27 km^2, most of which was open water with only small areas of reed beds and no *Scirpus* vegetation. There were still extensive shore meadows (*c.* 5.5 km^2). According to

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Figure 2. Aerial view of the southern half of Lake Hornborgasjön before restoration (on 7 September 1986, upper) and after restoration (on 5 May 2010, lower). Photographs by Jan Johansson.

the initial plan, the lake should retain a mosaic of open water and reed beds, but over the years most reed beds disappeared, as did the bushes that were left in shallow water after the restoration work. One objective for the restoration project was to re-establish some reed beds in the new open water areas to form a mosaic of open water and reed bed habitat but, partly as a result of grazing pressure from large numbers of Greylag Geese, this did not occur (Bjelke & Sundberg 2014).

Methods

Volunteers from the Lake Hornborgasjön Bird Observatory caught moulting non-breeders and also Greylag Goose families at Lake Hornborga during 2004–2007 by slowly herding flightless geese into a catching cage, via two arms of leading nets erected on the birds' feeding grounds (Fig. 3). All Greylag Geese caught at Lake Hornborgasjön were marked with blue neck-bands, of the same kind used in the Nordic Greylag Goose project (Andersson *et al.* 2001). Overall, 26 adult and 93 young birds were caught and neck-banded in families, in addition to 139 moulting non-breeders.

Once the goose catching programme had commenced, regular searches for marked Greylag Geese from Lake Hornborgasjön and elsewhere were undertaken at suitable feeding areas around the lake. Readings of Greylag Goose neck-bands were also downloaded from the www.geese.org website, with reports up until the end of 2016 included in this study. A total of 1,116 sightings were available for analysis from moulting non-breeders and 539 from geese caught in family groups, excluding local sightings made immediately after marking.

Regular counts of Greylag Geese moulting at Lake Hornborgasjön started in summer 2002 and were undertaken each year thereafter except in 2009–2011. Geese were counted from when they were unable to fly at the end of May and the beginning of June, with counts being made from a number of observation points, chosen to cover all areas potentially used by the geese. At this time, the birds were concentrated within specific shore

Figure 3. Shore-meadows at Lake Hornborgasjön used by grazing Greylag Geese during the moult, showing two of the trapping sites and the trap. Photographs by Clas Hermansson.

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meadows and moved little between different sites. One count was made each year, timed to coincide with the maximum number of geese occuring in the area. Numbers present were more difficult to determine during the early years of the study, when the vegetation was still dense, so count accuracy is thought to have improved over time as the area gradually became more open.

A number of sightings of neck-bands fitted to geese in other marking areas were recorded during observations made at Lake Hornborgasjön, including some from southwest Scania (Fig. 1) where intensive neck-banding of Greylag Geese started in 1984 and continued until 2009 (Andersson *et al*. 2001; Nilsson & Kampe-Persson 2018). During 1993–2000, when a detailed study of the species was undertaken on the island of Saltholm, an important moulting site between Sweden and Denmark close to the Scanian marking area (Fig. 1), 224 different individuals from Scania were reported as moulting on Saltholm (Nilsson *et al.* 2001). Unfortunately, there has been no checking for neck-banded geese on Saltholm since 2000, so it was not possible to establish whether Greylag Geese from Scania switched their moulting site from Saltholm to Lake Hornborgasjön during the period of increase in the number of moulters at Lake Hornborgajön. The number of moulters at Saltholm also increased during this period (M.F. Jörgensen, pers. comm.).

Results

Numbers of moulting Greylag Geese

Following the restoration of Lake Hornborgasjön during the late 1990s, larger flocks of moult migrant Greylag Geese started to arrive in the area from mid-May and remained through the moulting period in June, then departed in July. Prior to the moult, newly arrived birds fed on grassland close to the lake, and also returned to these areas to feed in July before leaving on completing the moult. It is not known exactly when this new moult tradition commenced, but thousands of Greylag Geese were seen in the early years after the restoration, during the mid-1990s (C. Hermansson, pers. obs.). The first comprehensive count of Greylag Geese made at the site in early summer 2002 found 9,600 birds (Fig 4). In subsequent years, the estimated number of moulters decreased slightly to 8,000 in 2008. There were no counts in 2009–2011, but in 2012 a total of 18,500 Greylag Geese were counted and numbers increased to a peak of 28,000 in 2015, remaining at this high level in 2016, before dropping to < 25,000 in 2017 and 2018 (Fig. 4).

Greylag Geese marked elsewhere moulting at Lake Hornborgasjön

During 1993–2009, 72 different individuals marked in southwest Scania occurred at least once at Lake Hornborgasjön during the moulting period (Fig. 5). These included five of 224 Greylag Geese marked in Scania and reported moulting on Saltholm during 1993–2000 (one of these in two different years). Most were found moulting at Lake Hornborgasjön only once, but 12 individuals were recorded in two seasons, and 10 individuals were sighted in three or more years. One or two of these birds had probably moved to a breeding site close

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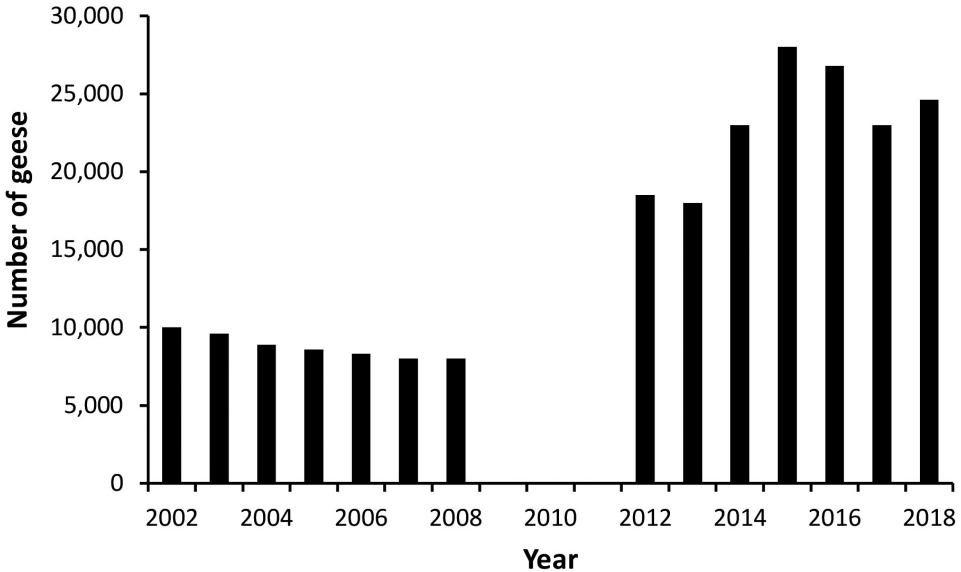

Figure 4. Number of moulting and breeding Greylag Geese counted (estimated) at Lake Hornborgasjön during 2002–2018. No counts were made in 2009–2011.

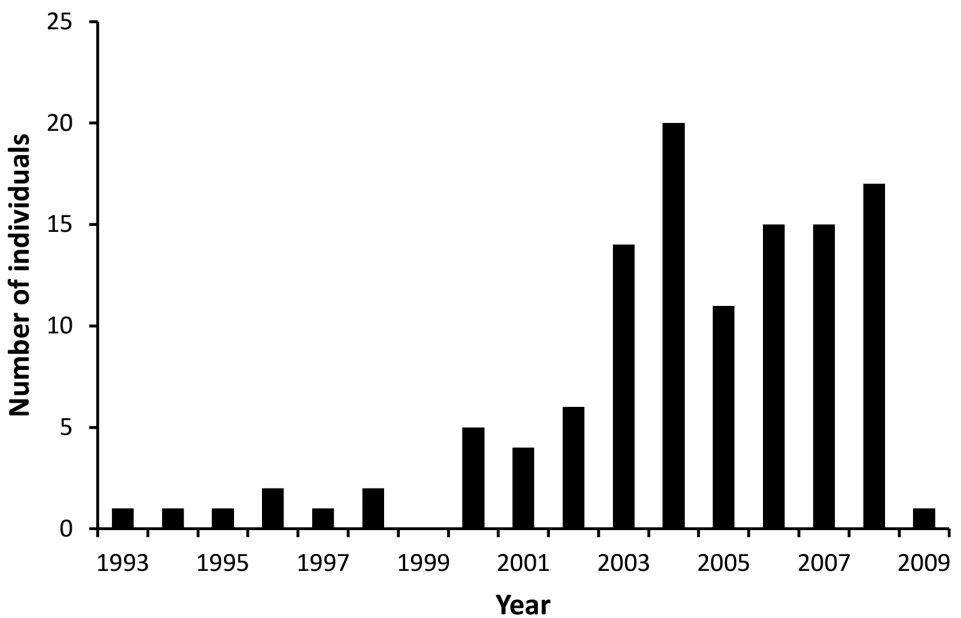

Figure 5. Number of Greylag Geese marked in southwest Scania found moulting at Lake Hornborgasjön during 1993–2009.

to Lake Hornborgasjön. Prior to the more intensive work on Greylag Geese at Lake Hornborgasjön from 2002 onwards, relatively few sightings were made there of moulting geese which had been marked in southwest Scania (Fig. 5). The last year in which large numbers were caught and marked in Scania was 2007 (with only a handful being marked in 2008–2009), so it is not possible to determine in detail the extent to which Scanian Greylag Geese chose to moult at Lake Hornborgasjön, but the account below describes the numbers of moulting geese marked at Lake Hornborgasjön later seen in southwest Scania.

As part of the Nordic Greylag Goose project, large-scale marking of the species was also initiated in Norway in 1986 and the Norwegian goose marking programme continues into the 21st century (Andersson *et al.* 2001; A. Follestad, unpubl. data). In all, eight different individuals marked at three sites in Norway have been seen moulting at Lake Hornborgasjön. Six of these birds were marked on Vega Island and one each at Kväfjord in Troms and at Smöla in Möre and Romsdal (Fig. 1). Two of the Norwegian birds were marked as young, whereas five birds from Vega and the bird from Smöla were marked during moult in Norway, thus being examples of birds changing their moulting site. The Smöla bird was marked as a moulter in 2000. In 2007 and 2008, it stayed at the Lake Yddingen breeding area in southwest Scania, south Sweden, and in 2008 (like several other birds from Scania) it migrated to Lake Hornborgasjön for moulting. This is probably an example of a bird from Scania first moulting in Norway, then changing to moult at Lake Hornborgasjön.

Migrations of Greylag Geese marked at Lake Hornborgasjön

Geese marked as breeding adults and goslings (n = 119 individuals) at Lake Hornborgasjön migrated southwest following the coast to wintering areas mainly in Germany and the Netherlands, although seven birds were seen in France and six birds at the former traditional winter areas in Spain (*cf.* Andersson *et al.* 2001; Nilsson & Kampe-Persson 2018; Fig. 6).

The geographical patterns of neck-band sightings of geese marked as non-breeding moulting birds (n = 139 individuals) were similar to those marked as breeding adults and goslings, but there were some differences (Fig. 6). Specifically, there were a number of reports of non-breeding moulters from areas further east in Europe, where no sightings of birds caught as breeders/goslings were reported. This is a strong indication that a number of Greylag Geese from areas other than Scania (*e.g.* Poland) migrate to Lake Hornborgasjön to moult. One Greylag Goose marked during the moult at Lake Hornborgasjön spent four winters in the Camargue, southern France, where most geese are considered to be of an easterly origin (Nilsson *et al.* 2013). As mentioned above, 72 individuals marked in southwest Scania are known from sightings reports to have moulted at Lake Hornborgasjön. Conversely, 30 (21%) of the 139 geese neck-banded as non-breeders at Lake Hornborgasjön were seen in southwest Scania later in the season. Thus there is a marked exchange of birds

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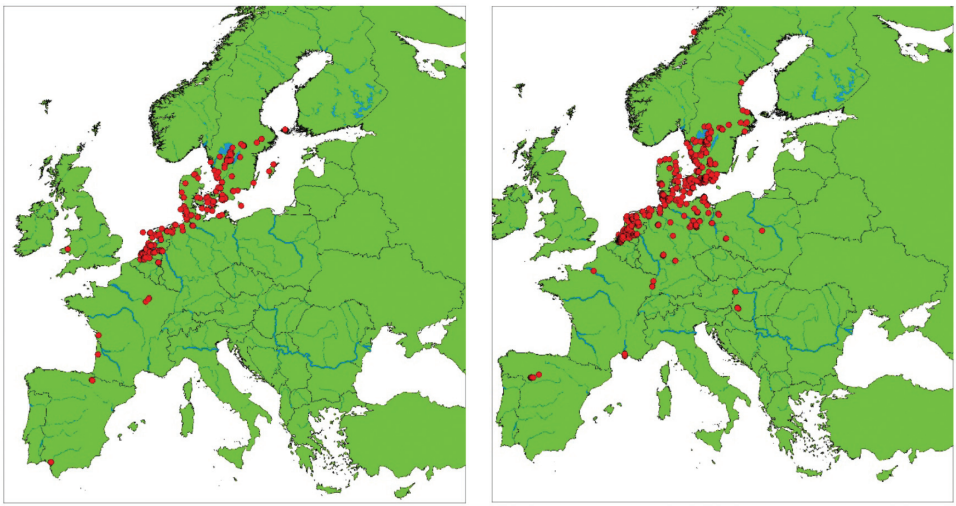

Figure 6. Summary of all observations of neck-banded Greylag Geese from Lake Hornborgasjön reported until the end of 2016. Birds marked in families in the left map and as moulters in the right map.

between the breeding areas (also used by non-breeders) in southwest Scania and the moulting site at Lake Hornborgasjön. Moreover, one of the Greylag Geese marked during the moult at Lake Hornborgasjön was later found in Vega in Norway, an area from which six marked individuals were found moulting at Lake Hornborgasjön. Several of the family geese from Lake Hornborgasjön also passed through southwest Scania during their migration in autumn and spring.

Of 139 Greylag Geese marked as non-breeders during moult, 35 were seen at Lake Hornborgasjön during the moulting season the following year, 15 individuals were seen at the lake in two consecutive years after marking and three returned in three subsequent years. In addition to these, five more were seen at the lake up to ten years after being caught and marked there during moult.

Discussion

The main restoration efforts at Lake Hornborgasjön were completed in the mid-1990s, creating a new wetland area with ideal feeding and roosting conditions for a large number of waterbirds including Greylag Geese (Björk 1994; Hertzman & Larsson 1999). The increase in goose numbers and the relocation of individuals from other moulting areas described above indicate that they responded to the new conditions promptly, with an important moulting pattern becoming established over a short period of time. Before the start of the restoration process, there was very little open water at the site and consequently no good moulting habitats for the geese, so it is highly unlikely that Greylag Geese previously gathered here in any numbers to moult. A similar situation was recorded following the creation of the new Züd-

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Flevoland polder in the Netherlands during the 1970s, with the Oostwaardersplassen eventually developing into the most important moulting site for Greylag Geese in Europe, where numbers peaked at 60,000 individuals (Zijlstra *et al.* 1991).

It is difficult to obtain a true picture of the origin of the moulting Greylag Geese at a site such as Lake Hornborgajön from sightings reported by birdwatchers, because the chances of receiving a sighting of a neck-banded goose varies considerably between different regions. In some countries, including Denmark, the Netherlands and northwest Germany, birdwatchers actively search for neck-banded geese and the reporting frequency for marked birds is very high. This is also the case for southwest Sweden, whereas the number of people checking for and reporting marked geese is much lower in other parts of Europe.

Given that geese are generally traditional and use the same moulting sites for long periods of time (Owen 1980), it is interesting to follow changes in their choice of main moulting areas over the years. During the 1980s and early 1990s, Greylag Geese from southwest Scania, along with geese from other parts of Europe, migrated mainly to Oostwaardersplassen in the Netherlands to moult (Nilsson *et al.* 2001). Then in the 1990s, intensive studies in the Öresund region between Denmark and Sweden, especially on the island of Saltholm (as part of the impact assessment for the fixed bridge/tunnel link between Sweden and Denmark), led to large numbers of marked Greylag Geese from neighbouring Scania being identified as moulters on Saltholm (Fox *et al.* 1995; Nilsson *et al.* 2001). Unfortunately, we do not have any information about the situation on Saltholm before and after these intensive studies, but during the same period the habitat at Oostwaardersplassen deteriorated and progressively fewer Greylag Geese from Scania moulted at the site. Some individuals even migrated to the moulting place at Oostwaardersplassen and were sighted there, but then returned to Scania before starting to lose their flight feathers (Nilsson *et al.* 2001). We also recorded five individuals that had moulted in the Netherlands in one year that later moulted on Saltholm. Saltholm continues to be an important moulting site for Greylag Geese; numbers counted have been even higher in recent years than during the detailed study at the site during the 1990s, with 46,500 reported in 2011 (M. Fink, pers. comm.). As there have been no regular checks made for marked Greylag Geese on Saltholm since the year 2000, it was not possible to evaluate the extent to which moulters have relocated from Saltholm to Lake Hornborgasjön, but a few individuals are known to have made this transition.

Prior to the establishment of Lake Hornborgasjön, there were no major moulting concentrations of Greylag Geese in Sweden except on the island of Gotland (Essen & Beinert 1982; Andersson *et al.* 2001), although small flocks were known to moult at some other sites. It is interesting to note that, despite being further west, Lake Hornborgasjön attracts Greylag Geese from eastern Europe for the moulting period (non-breeders in Fig. 6), as previously reported for the traditional moulting sites

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on Gotland (Essen & Beinert 1982; Andersson *et al.* 2001).

Most of the neck-banded Greylag Geese recorded during moult were seen at a given moulting site (at either Lake Hornborgasjön or elsewhere) in only one year. A few individuals were recorded moulting at the same site for two or more seasons, but individuals also changed moulting sites between years. Based on earlier studies of marked Greylag Geese in southwest Scania (Nilsson *et al.* 2001), individuals are known to have switched moulting sites between Oostwaardersplassen and Scania, Oostwaardersplassen and Saltholm, Saltholm and Lake Hornborgasjön and between Norway and Lake Hornborgasjön.

Following completion of the restoration programme, Lake Hornborgasjön has proved to be an ideal site for moulting geese, with extensive shoreline meadows for grazing close to water for an easy escape, and an open landscape where predators can be spotted at a distance. Moreover, the mosaic of reed beds and bushes left after the restoration formed a good protective screen for the geese. The increasing number of Greylag Geese using the lake did however graze on the sprouting reed, and over the years most of the reed beds disappeared from the lake. Even in the present situation with few remaining reed beds, large numbers of geese continue to moult at the site. Presumably, the open undisturbed landscape, with shore meadows for grazing and a large shallow lake close by, provide good moulting habitat for the species. In any case, it will be of great interest to follow the development of this moulting tradition in future years.

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