Changes in numbers of staging and wintering geese in Sweden: 1977/78–2019/20

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Abstract

Regular goose counts made throughout Sweden since 1977/78 show that the total numbers staging and wintering in the country have increased markedly over the decades. October totals were of 51,000 geese in 1977, rising to *c.* 600,000 in 2018, during which time January totals also increased from 31,000 to 252,000 birds. The greatest change recorded was for the Greylag Goose *Anser anser*, numbers of which rose from 20,000 to > 250,000 individuals over a 35-year period. Changes in migration and wintering habits have also been recorded, with mid-winter (January) Greylag Goose numbers now amounting to 20–33% of the September totals in recent years, illustrating increases in the proportion of the population now wintering in the country. Moreover, large numbers of Barnacle Geese *Branta leucopsis* have started to stage and over-winter in Sweden, and are now becoming the commonest species, with 365,000 recorded in autumn 2019.

Key words: autumn, goose counts, migration patterns, population increase, winter.

During recent decades, most Northwest European goose populations have increased markedly (Madsen *et al.* 1999; Fox *et al.* 2010; Fox & Madsen 2017; Fox & Leafloor 2018), with some reaching levels where they have come into conflict with agriculture when feeding on crops causes economic losses for farmers (Fox *et al.* 2017). In contrast to the majority of goose species, however, a few of the European populations have decreased over the same period. This is most apparent for the Lesser White-fronted Goose *Anser erythropus*, which was formerly widespread across the Scandinavian mountain chain but is now reduced to very few breeding pairs, mainly in Norway, with a re-introduced population occurring in Sweden (Andersson & Holmqvist 2010; Fox & Leafloor 2018). The Taiga Bean Goose *Anser fabalis fabalis* also has declined in recent years. International Single Species Action Plans (ISSAPs) developed for the conservation both of the Lesser White-fronted Goose (Jones *et al.* 2008) and the Taiga Bean Goose (Marjakangas *et al.* 2015; *cf.* for

Swedish data Mathiasson 1963; Nilsson & Persson 1984; Nilsson 2013), have been adopted by the African-Eurasian Waterbird Agreement (AEWA) under the auspices of the Convention on Migratory Species.

In response to decreasing populations of Taiga Bean Geese and Lesser White-fronted Geese, the Nordic Council for Wildlife Research (NKV) established a Goose Working Group for the region. The main aim of the group was to study the two decreasing taxa in the Nordic countries but, following reports of mass mortality among Greylag Geese *Anser anser* wintering in southwest Spain (*e.g.* in drought conditions; Nilsson & Persson 1996), the Greylag Goose was also included in the study (Nilsson & Fog 1984). One important task for the working group was to start regular national censuses of staging and wintering geese; thus, regular goose counts commenced in 1977/78. During the first years of the goose counts, the primary objective was to cover all sites for focal species, *e.g.* the Bean Goose in Sweden (Nilsson & Persson 1984), but all species were counted at the sites visited. With the initiation of the Greylag Goose studies in 1984, a special September count was added to cover this species more effectively, because a proportion of the Greylag Geese summering in Sweden left the country before the October count. The Swedish goose counts are now a part of the European Goose Management Platform census programme, established under AEWA in 2016, and also contribute to the long-term International Waterbird Count (IWC) programme coordinated by Wetlands International.

Since the IWC programme was founded during the 1960s, there have been marked changes in the distribution patterns of different species, which largely seem to be related to climate change with milder winters enabling the birds to remain in more northerly parts of their wintering range. For several Anatidae species, this pattern has been established at the international scale (Lehikoinen *et al.* 2013; Pavon-Jordan *et al.* 2015; Ramo *et al.* 2015; Nilsson & Kampe-Persson 2018; Nuijten *et al.* 2020) but also within Sweden (Nilsson & Haas 2016). In other species, changes in migratory patterns have occurred where habitat management has affected food resources for the geese, *e.g.* the reduction in cattle grazing in the Baltic States which consequently reduced feeding areas available to Barnacle Geese *Branta leucopsis* in this part of the flyway (Eichhorn *et al.* 2009).

In the present paper, we use the Swedish goose counts to describe how the numbers of geese staging and wintering in Sweden have changed since the late 1970s. We also aim to evaluate the importance of Sweden as a staging and wintering area for its most abundant goose species – the Bean Goose, Greylag Goose, White-fronted Goose *Anser albifrons*, Pink-footed Goose *Anser brachyrhynchus*, Canada Goose *Branta canadensis* and Barnacle Goose – in a European context. Regional distributions of geese within Sweden have been published previously (Nilsson 1988, 2000, 2013) so, along with information on rare species occurring in the country (*i.e.* Lesser White-fronted Geese and Red-breasted Geese *Branta ruficollis*) these will not be discussed in detail here. Likewise the Brent Goose *Branta*

bernicla, which, although a common passage migrant, stages in the country in small numbers for only short periods.

Methods

The Swedish goose counts commenced as part of the joint Nordic Goose Programme in 1977/78 (Nilsson & Fog 1984), with the main aim of covering all important sites for Bean Goose at monthly intervals from September–April inclusive, but with all other goose species present counted as well. The surveys were made in the middle of each month, on dates coinciding with international waterbird counts determined by Wetlands International. September counts were added from 1984 onwards, following the development of the second Nordic Goose Programme focussing on Greylag Geese, which aimed to cover all sites potentially of importance for this species. Although during the first ten years of the study (in winters 1977/78–1986/87) the counts were undertaken each month, subsequently only four surveys were organised each year, in September, October, November (supplementing the October counts) and January (coinciding with the mid-winter count undertaken of all waterbirds for the IWCs). All goose species present were counted on each occasion. During the first year, however, it transpired that October was the most suitable month for counting staging geese in Sweden except for the Greylag Goose, which to a large extent had already left the country in October, but had not yet started their migration at the time of the September count.

In Scania, the southernmost province of Sweden, all important feeding areas were covered on the ground, with these field counts sometimes supplemented by observations of the birds' morning flights from the roost to their feeding areas. Intensive fieldwork during a study of the ecology of non-breeding ecology in southern Sweden provided the basis for determining the survey area in southwest Scania (Nilsson & Persson 1984), with new sites identified and included following observations of geese flying to their feeding areas. In southwest Scania (Fig. 1a), the counts were mostly undertaken by the second author covering all important feeding areas in the region, whilst in northeast Scania the feeding grounds for geese were covered by a team from the local bird club over the years (Kampe-Persson 2014; Kampe-Persson *et al.* 2017).

Further north, at three of the larger goose staging areas in south-central Sweden – Tåkern, Östen and Kvismaren (Fig. 1a) – counts were made by teams of voluntary observers counting the geese during the morning flights from the roost. In recent years, *c.* 300–350 sites have been covered annually in these areas during September and October. Elsewhere, in addition to these important goose sites, voluntary observers counted geese across the country during the selected months each year. Many of these sites were included in the annual sample of sites covered during the national waterbird surveys undertaken in September, and also during the mid-winter (January) counts in Sweden recorded for the IWCs. Additional goose counts were reported via the Swedish Bird Observation Portal (www.artportalen.se), which was checked regularly for information. When we found new goose sites in the bird

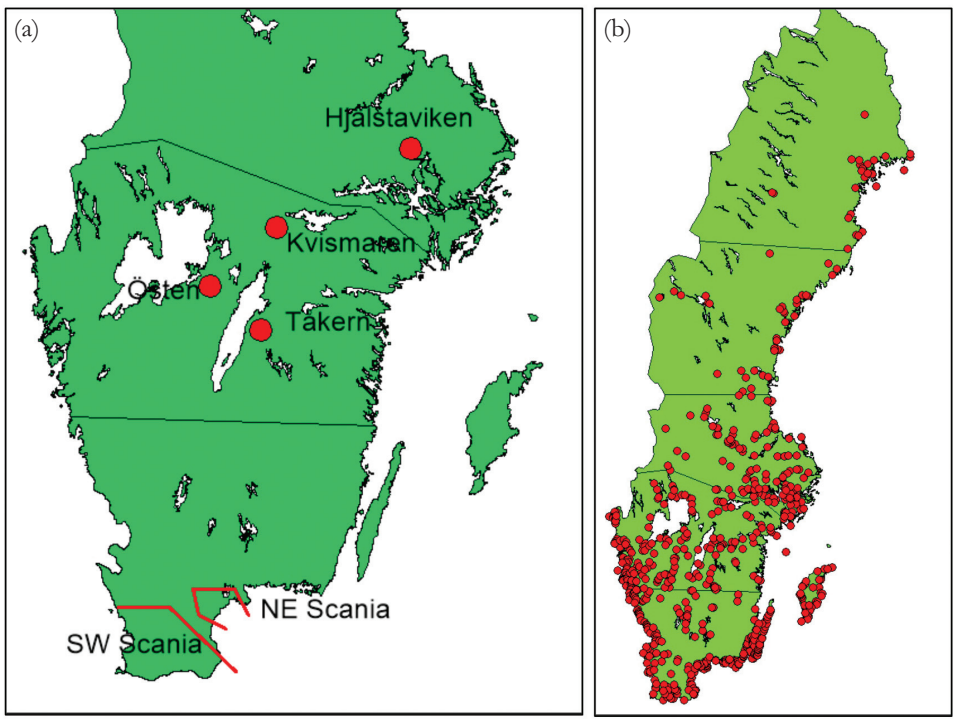

Figure 1. Map of the study area showing (a) the count areas and locations of important goose sites in southern Sweden mentioned in the text, and (b) sites where goose counts were reported in Sweden during winter 2019/20.

reports, we tried to contact the observers to recruit them to the network, asking them to make and report their counts on an annual basis.

Most counts of Bean Geese at larger sites in Sweden, north of Scania, were also made during the birds' morning flights from the roosting lakes to the feeding grounds, and it was not possible to separate the Tundra Bean Goose *Anser fabalis rossicus* from the Taiga Bean Geese on these occasions. During the last four autumns, however, special surveys by the second author of geese at feeding sites in the southern part of the country has made it possible to estimate the abundance of these two subspecies (Kampe-Persson 2017). In order to obtain some indication of the timing of passage migration for geese in southern Sweden, we compared the counts of geese at their autumn staging sites with the numbers of geese seen migrating past the Falsterbo Bird Observatory at the south-westernmost point of Sweden (Kjellén 2019, and the Bird Observatory homepage: www.falsterbofagelstation.se).

Although Lesser White-fronted Geese were seen regularly in small numbers during the autumn counts, the surveys did not cover the species effectively. These sightings

therefore are not included here, but the staging habits of the species can be found in the reports of the Swedish Lesser White-fronted Goose Project (Andersson & Holmquist 2010; Andersson 2019). Brent Geese pass through Sweden regularly in large numbers, with several thousand seen on migration, but as only a few rest for short periods in the country (with up to a few hundred counted on the staging sites in the autumn), they also are not described here in detail. Red-breasted Geese are occasional visitors to Sweden, with single individuals seen staging flocks of geese.

Results

Sites used by geese are concentrated to the southern third of Sweden but, as illustrated in the map of goose counts reported during 2018/19 (Fig. 1b), the birds are now found all along the Baltic coast of northern Sweden in early autumn. A total of 51,100 geese (all species combined) were found to be staging in Sweden when the regular counts started in October 1977. Since then, numbers in the country have since increased steadily, with > 600,000 birds recorded in October 2018 (Fig. 2). The number of geese present in mid-winter has likewise increased, from 31,000 birds during the first winter in January 1978, to 252,000 in January 2019 (Fig. 2).

Over the years, it was noted that January weather conditions in southern Sweden had a marked influence on the number of geese remaining in the country throughout the winter. The mean monthly January temperatures for ten weather stations across south Sweden (*i.e.* potential mid-winter goose areas) are presented in Fig. 3, to provide background for discussions of the counts recorded for the different species.

Greylag Goose

During the first September surveys of Greylag Geese in 1984, a total of 19,000 were counted in Sweden, followed by a marked and steady increase in numbers up to autumn 2005, when > 200,000 Greylags were counted for the first time (Fig. 4a). After 2010, the counts were lower for several years, but it is thought that this did not represent a decline in the staging population, with the apparent drop in numbers potentially attributable to poorer

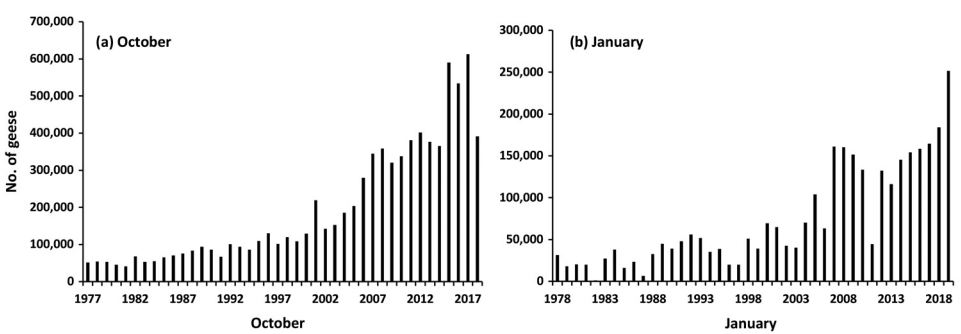

Figure 2. Total number of geese counted in Sweden (all species combined) during the mid-monthly counts in (a) October, and (b) January 1977/78–2019/20

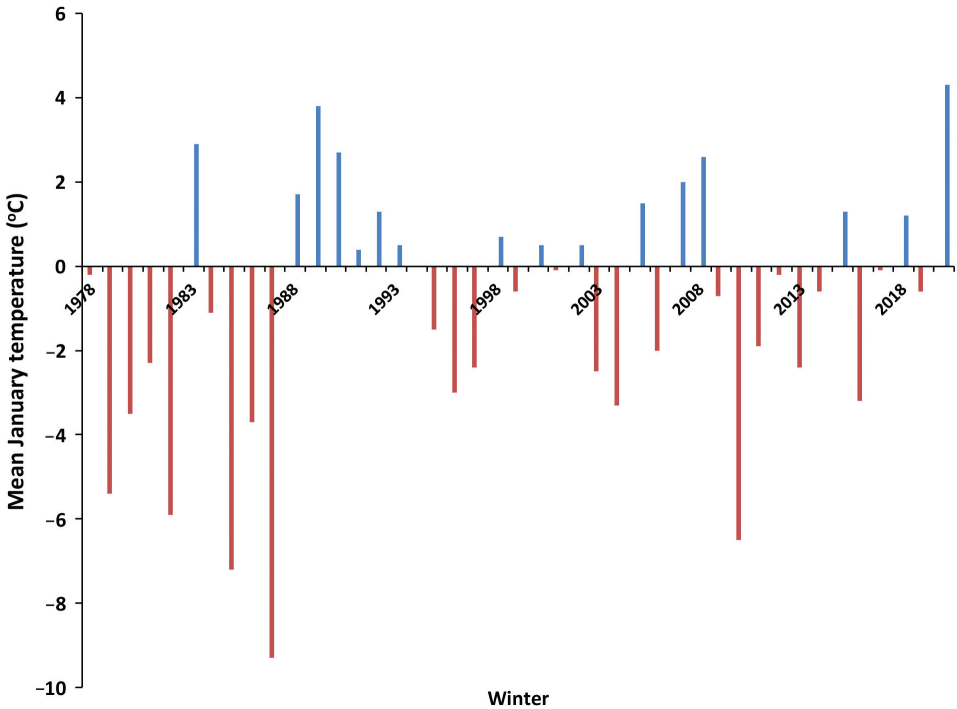

Figure 3. Mean monthly temperatures for January 1978–2020, recorded at ten meteorological stations in southern Sweden covering the part of the country shown in Fig. 1a.

coverage of the staging areas. The highest count to date is of 243,000 birds in September 2017, but some staging areas are still being missed, and the total is considered to be at least 10% higher. Large numbers of Greylag Geese were also recorded during the mid-October and mid-November counts (Haas & Nilsson 2019), peaking at 167,000 geese in October 2019, and November counts reached 90,000 birds in 2015. September data provide a better illustration of total numbers staging in Sweden, however, because the main migration is underway by October.

When the goose counts commenced in 1977/78, hardly any Greylag Geese occurred in Sweden through the mid-winter period. This continued until approximately the year 2000, when the number of Greylag Geese wintering in the southern part of the country began to increase markedly, rising to *c.* 50,000 in January 2008 (Fig. 4b). The highest January count to date is of *c.* 56,000 in 2019. Numbers remaining through the cold winter of 2010/11 were much lower than in the preceding and following years, but still 10,000 Greylag Geese stayed in Sweden for this cold and snow-rich winter (Fig. 3, Fig. 4b).

On comparing the counts recorded in January and September (Fig. 4a,b) it is clear that, in recent years, 20–33% of the total

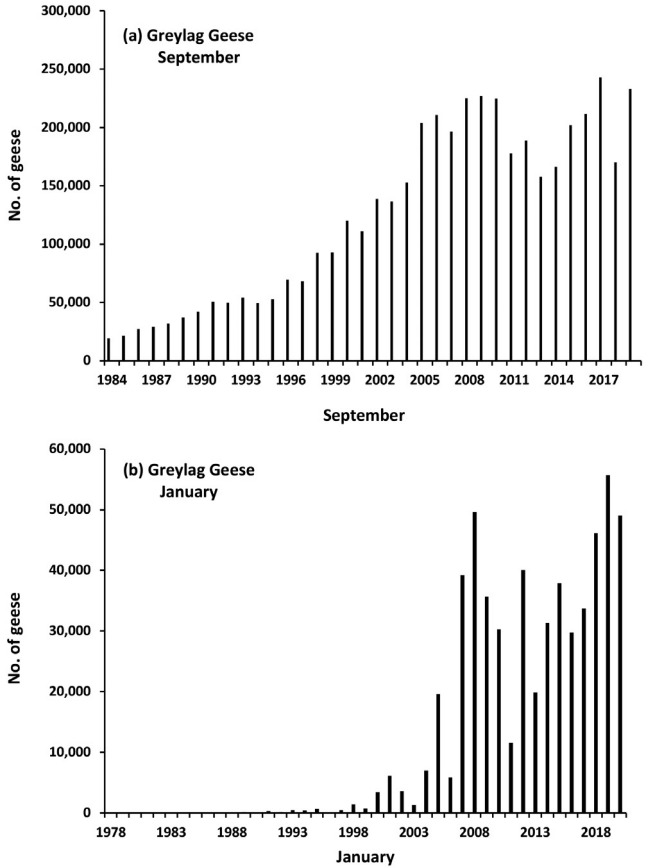

Figure 4. Total number of Greylag Geese counted in Sweden during the mid-monthly counts in (a) September, and (b) January 1977/78–2019/20. Note: September surveys focussing on Greylag Geese commenced in winter 1984/85.

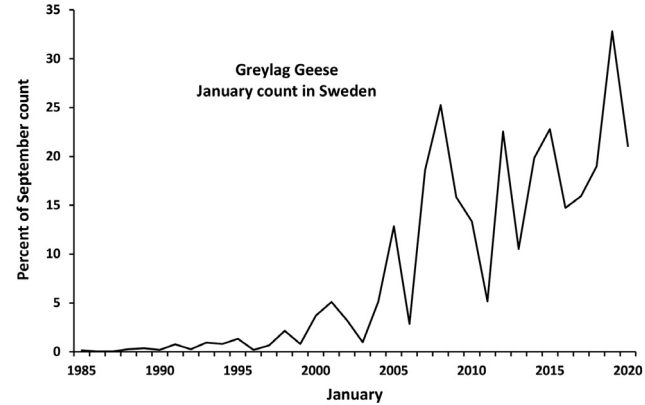

Figure 5. Number of Greylag Geese counted in Sweden in January, as percent of the numbers counted in September.

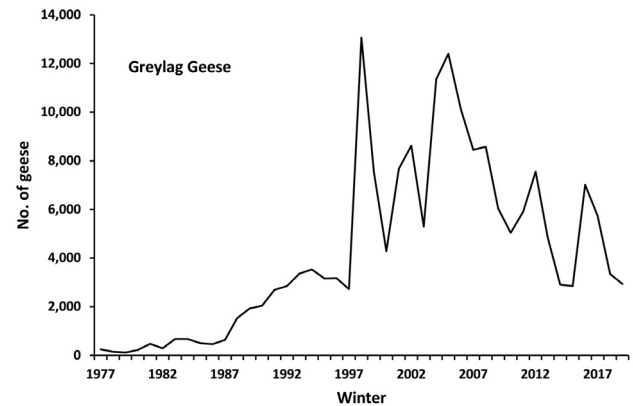

Figure 6. Number of migrating Greylag Geese observed leaving Sweden from the Falsterbo Bird Observatory during 11 August–20 November 1977–2019.

counted in September have overwintered in Sweden (Fig. 5). Most of these Greylag Geese stay in southwest Scania, the southernmost province of the country.

The increase in numbers of Greylag Geese present later in autumn and into winter reflects a delay in the departure of the geese from southern Sweden, evident in counts made of migrating geese seen from the Falsterbo Bird Observatory (Fig. 6). Numbers counted here during 11 August–20 November increased up to the late 1990s but decreased again from 2005, indicating a change in the timing of Greylag Goose migration from Sweden, with more Greylags leaving the country after the counts of bird migration at the Bird Observatory had concluded each year.

White-fronted Goose

The White-fronted Goose is a regular passage migrant in southern Sweden, staging in the goose areas mainly of southwest Scania in markedly varying numbers. As for most other goose species, numbers have increased over the years with the highest total hitherto of > 18,000 recorded in October 2010 (Fig. 7a). There was also an increase in the number of wintering White-fronted Geese in Sweden, reaching 21,600 in January 2007, but again there was much variation between years (Fig. 7b). In some of the hardest winters (Fig. 3), almost all White-fronted Geese left Sweden (Fig. 7b).

Bean Goose

When the regular goose counts started in Sweden in 1977/78, October Bean Goose totals were close to 50,000 individuals (Fig. 8a). Numbers increased over the next ten years and reached a peak of 76,000 geese in October 1989, which was followed by a decline to a low of little more than 40,000 in the early 2000s. Then, from 2007, there was again an increase in the total number of Bean Geese recorded in Sweden during October. This coincided with a change in the migration habits of the Tundra Bean Goose, which in earlier years was a rare subspecies in Sweden (Persson 1990), whilst the majority of Bean Geese are of the taiga subspecies *Anser fabalis fabalis*. In the autumn of 2009, more than 9,000 Tundra Bean Geese were counted in southern Sweden. Total numbers of Bean Geese then decreased again for a few years, but during the last five years the total number of Bean Geese (both Taiga and Tundra Bean Geese) has been between 65,000–80,000 individuals (Fig. 8a). Based on the special surveys undertaken in October 2016–2019, numbers of Taiga Bean Geese in southern Sweden were estimated at between 65,000–75,000 birds, with 3,000–9,600 Tundra Bean Geese also found in the same area during the October counts. In the first years of the goose count programme, most of the Bean Geese were found in the province of Scania, but over the years there was a marked shift in their distribution (Nilsson 2013). In more recent years, autumn-staging Bean Geese have been found primarily in south-central Sweden, with the sites at Tåkern, Östen and Kvismaren (Fig. 1a) especially important.

In winter, the majority of Bean Geese occurred in Scania, especially in the south-western part of the province (Nilsson 2013). There was marked annual variation in the numbers recorded (Fig. 8b), and during

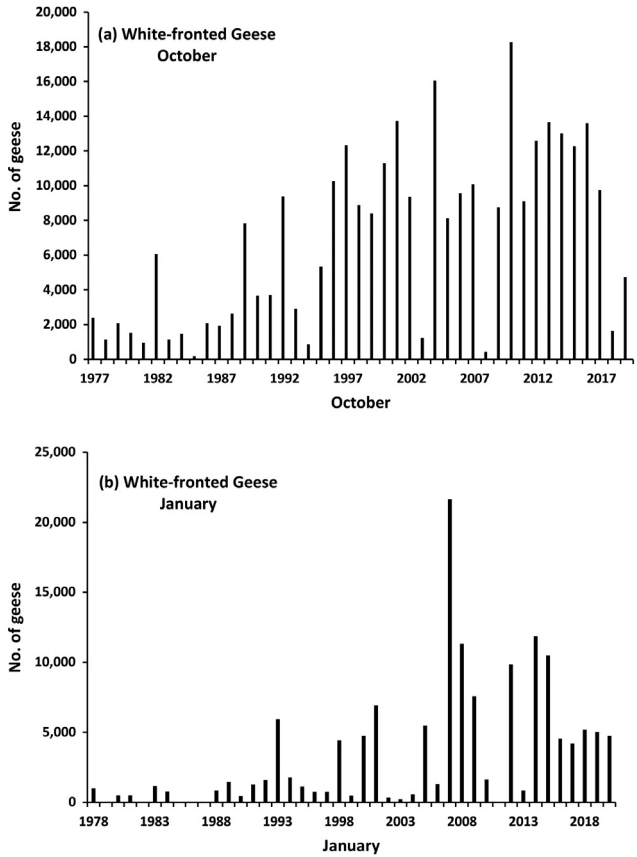

Figure 7. Total number of White-fronted Geese counted in Sweden during the mid-monthly counts in (a) October, and (b) January 1977/78–2019/20.

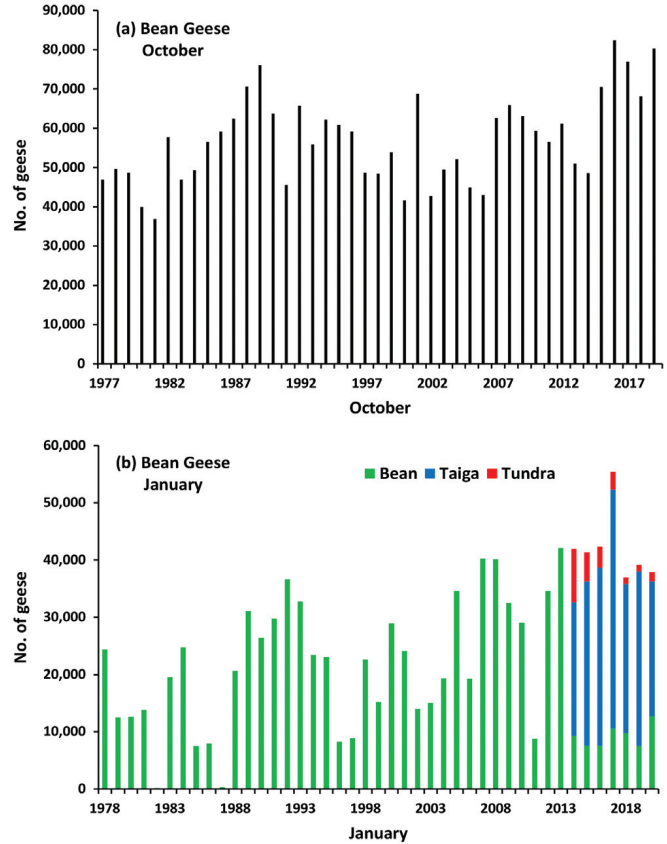

Figure 8. Total number of Bean Geese counted in Sweden during the mid-monthly counts in (a) October, and (b) January 1977/78–2019/20. For the last seven years of January counts, totals recorded for the Taiga and Tundra Goose subspecies (as well as those unassigned to subspecies) are given separately.

the very hard winters of 1981/82 and 1986/87 (Fig. 3) only a few birds stayed in Sweden into January. Likewise, Bean Goose totals were much lower in the cold 2010/11 season following a series of milder winters (Fig. 8b). This concurs with an earlier study (Nilsson 2013), which found a significant correlation between winter temperatures in southern Sweden and the mid-winter Bean Goose counts. Overall, however, there has been a long-term increase in the number of Bean Geese remaining in Sweden in mid-winter (Fig. 8b).

Pink-footed Goose

Only small groups or single individuals of Pink-footed Geese were seen in the early years of the goose count programme, mainly in the larger Bean Goose flocks. During the 21st century, however, there has been a substantial rise in the numbers of Pink-footed Geese counted, reaching > 3,500 recorded in October 2017 (Fig. 9a). Most of these were counted in south-central Sweden, with Kvismaren (Fig. 1a) and nearby Tysslingen being two of the important sites.

January counts showed a similar pattern but involving fewer birds, with > 100 individuals counted in most of the last fifteen winters. The maximum count to date was of 468 geese in 2020 (Fig. 9b).

Canada Goose

The introduced Canada Goose, like most of the other goose species, has increased markedly in numbers since the start of the regular goose counts. As stated by Nilsson (2013), autumn counts are less suitable for monitoring the population of this species because, at this time of year, it is spread over a large area in the northern part of the country with few counters, and is thus relatively difficult to cover reasonably well. In contrast, in January when the species is more concentrated at fewer sites and it is easier to obtain good coverage, some Canada Geese may have left the country for wintering areas further south.

Both the October and January counts show increases from the start of the monitoring programme to a peak of *c.* 37,700 in 2011 for the October counts and *c.* 70,000 individuals in 2009 for the January counts (Fig. 10a,b), followed by lower counts recorded thereafter. As for the Bean Goose, there were hardly any Canada Geese left in the country during the hard winter of 1981/82 and, as for most of the other goose species, there were markedly fewer Canada Geese recorded in January during the ice-winter of 2010/11 (temperature data in Fig. 3).

Barnacle Goose

The Barnacle Goose has, for many years, been a passage migrant through southern Sweden. The population breeding in the Russian arctic migrates along the Baltic Sea coast to wintering sites in northwest Europe, and in the early 1900s a habit of spring staging was established on the islands of Öland and Gotland in the Swedish part of the Baltic Sea (Beinert 1982). When the regular goose counts started in 1977/78, small numbers were found on the staging areas of other geese, but the national totals for October (and November) rarely exceeded 100 individuals at that time. Numbers counted in October (and November) started to increase markedly from around the

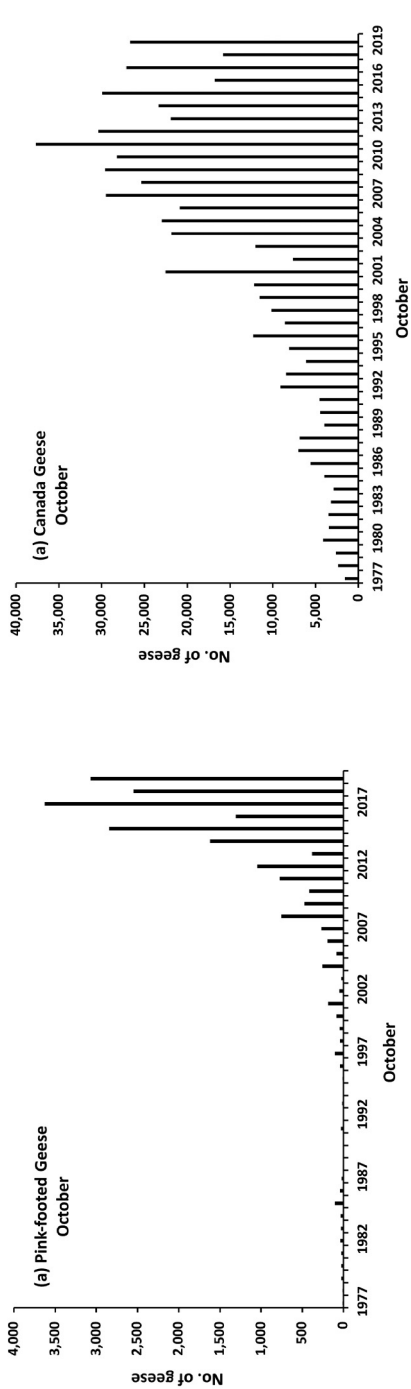

Figure 9. Total number of Pink-footed Geese counted in Sweden during the mid-monthly counts in (a) October, and (b) January 1977/78–2019/20.

Figure 10. Total number of Canada Geese counted in Sweden during the mid-monthly counts in (a) October, and (b) January 1977/78–2019/20.

year 2000 and in October 2019, > 365,000 Barnacle Geese were counted (Fig. 11a). There was some variation between years, probably related to the timing of the main passage in relation to the dates of the goose counts. In some years, November totals therefore were higher than the October totals.

The counts of migratory birds seen from the Falsterbo Bird Observatory show the same marked increase in numbers of Barnacle Geese on migration each year as counts made of the species at their autumn staging sites in southern Sweden. Before 2000, relatively few Barnacle Geese were counted at Falsterbo but, over the last two decades, numbers have increased exponentially and reached a peak of *c.* 450,000 in 2019 (Fig. 12).

Before 2000, few Barnacle Geese were counted in January, with totals of > 100 birds recorded in only one winter during the 1990s. As for autumn-staging geese, the increase in mid-winter totals did not commence until the early 2000s, but the January counts then increased markedly, reaching a peak of *c.* 97,000 in 2019 (Fig. 11b).

Discussion

With the exception of the Lesser White-fronted Goose (not covered by the present study) and the Taiga Bean Goose, each species of goose staging and wintering in Sweden has increased noticeably in numbers since the Nordic Goose Programme was initiated in 1977/78. These increases reflect the general escalation reported for most goose populations in Northwest Europe, as summarised by Fox *et al.* (2010) and Fox & Leafloor (2018). Much of the growth in the Swedish goose counts therefore may be attributable to changes in the size of the flyway populations. However, some of the national trends may also be due to changes in staging and wintering habits, with migratory birds able to remain at higher latitudes for longer periods in milder winters (Ramó *et al.* 2015; Nilsson & Kampe-Persson 2018; Nilsson & Persson 1984).

For the Greylag Goose, which breeds in Sweden, the pre-migration September counts have shown a marked increase from *c.* 20,000 individuals in the mid-1980s to *c.* 250,000 individuals in 2017. Back in the 1960s, the breeding population was of the order of 300 pairs or fewer, rising to *c.* 1,700–2,200 pairs in 1979–1980 (Nilsson 1982) and *c.* 41,000 pairs estimated in 2008 (Ottosson *et al.* 2012). The same marked increase in Greylag Goose numbers has also been found internationally. In the early 1980s, the total flyway population was estimated to be in the order of 120,000, then after the mid-1990s it escalated to an estimated winter population of *c.* 960,000 in 2014 (Fox & Leafloor 2018). In addition to the increase in the size of the Northwest European population, there have also been major shifts in the migratory patterns of the Greylag Geese in Europe. During the 1980s, the majority of the Greylag Geese spent the winter in Spain, with 82% of the total population of 120,000 birds occurring there in the early part of the decade, compared to *c.* 20% (out of 610,000 birds) in 2009 (Ramó *et al.* 2015). This change in the choice of winter quarters was also seen for tagged geese from the Nordic neck-banding programme (Andersson *et al.* 2001; Nilsson & Kampe-Persson 2018).

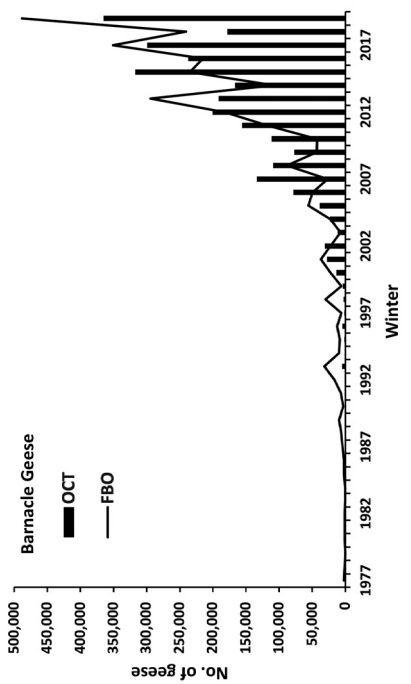

Figure 12. Numbers of Barnacle Geese passing the Falsterbo Bird Observatory, southern Sweden, on migration during 11 August–20 November 1977–2019, in relation to the number of Barnacle Geese counted during the mid-October counts in southern Sweden.

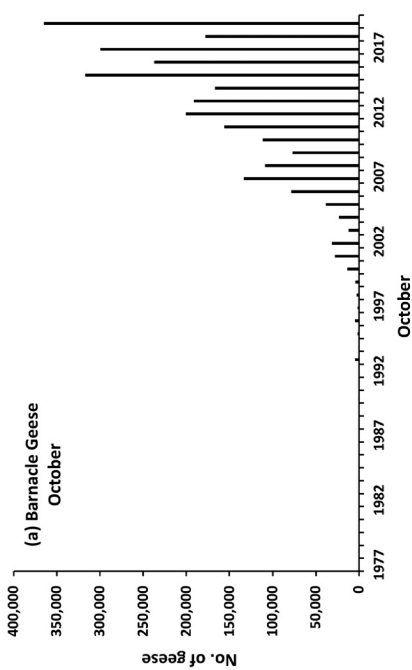

Figure 11. Total number of Barnacle Geese counted in Sweden during the mid-monthly counts in (a) October, and (b) January 1977/78–2019/20.

The Greylag Geese breeding in southern Sweden have not only shortened their migration distances over the years, but a larger proportion of birds from this population have been overwintering in the country (Nilsson & Kampe-Persson 2018), with *c.* 33% of the September 2018 total reported in January 2019 (Fig. 5). Studies of neck-banded Greylag Geese from southwest Sweden have shown that a large proportion of the birds remained in Scania for the winter, merely moving short distances to other local areas within the province (Nilsson & Kampe-Persson 2017).

The Taiga Bean Goose also breeds in northern Sweden but the breeding population is only *c.* 850 pairs (Ottosson *et al.* 2012), compared to a much larger staging and wintering population. During the first years of regular goose counts in Sweden, like most of the other goose species, numbers of staging and wintering Bean Geese increased and peaked at *c.* 76,000 in 1989. For the Bean Goose, this population increase started during the 1950s (Jensen *et al.* 1962; Mathiasson 1963), but following the peak in 1989, the number of Bean Geese (Taiga Bean Geese, mostly) has declined and recovery to its earlier levels is included within the aims of the ISSAP (Marjakangas *et al.* 2015). Of four management units (MUs) identified for Taiga Bean Geese within the Action Plan (the Western, Central, Eastern1 and Eastern2 MUs), most of the species in Sweden are from the western and central units, and almost the entire population of the Central MU Taiga Bean Geese stages in Sweden in October (Marjakangas *et al.* 2015).

The global population of the Western Taiga Bean Goose *Anser f. fabalis* was estimated at 100,000 birds in the mid-1990s but by 2009 it had declined to *c.* 63,000 individuals (Fox *et al.* 2010; Marjakangas *et al.* 2015). This coincided with the drop in numbers to 40,000–50,000 Bean Geese recorded during October counts in Sweden in 2000–2006, but more recently the number of staging Taiga Bean Geese in Sweden has increased, with counts of *c.* 70,000–82,000 geese recorded in October 2015–2019 (Fig. 8a). These likely covered most or all of the bird in the Western and Central MUs at this time (Marjakangas *et al.* 2015). Geese from the Western MU occur mainly in the western parts of south Sweden, including at Kvismaren and Östen (Fig. 1a), where they mix with the much larger numbers from the Central MU. Spring counts made in southern Sweden before the Taiga Bean Geese leave for breeding grounds in northern Sweden, Finland and Northwest Russia indicate only slightly lower numbers than the October Taiga Bean Goose counts (Skyllberg 2015; Skyllberg & Nousiainen 2017), indicating that the majority of the population stages in southern Sweden in spring as well as autumn.

Counts conducted in Europe in winter 2014/15, reported in the ISSAP, yielded a total of *c.* 52,600 Taiga Bean Geese (Marjakangas *et al.* 2015), suggesting that the winter population size continued to decline. The Swedish counts presented here, and also the spring counts by Skyllberg & Nousiainen (2017), however suggest that this estimate may now be too low, perhaps because they are based on mid-winter counts, which do not achieve as good

coverage as the October and spring counts from Sweden. The ISSAP gives an estimate of *c.* 35,000 for the Central MU and 1,500 for the Western MU, based on the 2014/15 mid-winter counts, with a further 15,000 Taiga Bean Geese in the Eastern1 MU, where coverage is much less complete than in the Western and Central MUs. Numbers of Taiga Bean Geese in the Eastern2 MU are unknown. More recently, the AEWA process has recognised the discrepancy between staging and total winter counts and the variation in the count data. As a result it has been recommended that the spring and autumn counts are used to assess the size of this population (which is also affected by annual breeding success and harvest levels). Using these counts, with an integrated population model, the Central MU Taiga Bean Goose population size was estimated at 80,700 in October 2019 and 75,200 in March 2020 (Heldbjerg *et al.* 2020).

Like the Greylag Geese, the Taiga Bean Geese have changed their staging and wintering habits over the years (Nilsson & Persson 1984; Nilsson 2011, 2013). In the early years of the study, a proportion headed southwest in cold periods to winter in Germany and the Netherlands, but have stayed further north in more recent years. Moreover, there has been a marked change in the autumn staging pattern within Sweden (Nilsson & Persson 1984; Nilsson 2013). The majority of staging geese originally alighting in Scania, but very few Taiga Bean Geese now occur there, with most found further north in south-central Sweden (at sites such as Östen, Tåkern, Kvismaren and Hjälstaviken; Fig. 1a) during the October counts.

Large numbers of Tundra Bean Geese (> 9,000) were identified in the Swedish goose counts for the first time in 2009. Although the years in which this subspecies changed its migratory patterns are not known precisely, it is thought that increasing numbers started to stage in Sweden during autumns 2004–2009 (Kampe-Persson 2014; H. Kampe-Persson, unpubl. data).

The White-fronted Goose is another species where the flyway population has shown a marked increase during recent years, and the population size is now in the order of 1 million birds (Fox & Leafloor 2018). The species stays in Sweden during migration and also in mid-winter if the winter is not too hard. Numbers counted in Sweden have increased over the years, peaking at 21,600 in January 2007, but the annual totals are quite variable and also relatively low in comparison with the flyway population.

The Svalbard Pink-footed Goose population was estimated at 15,000–18,000 geese during the 1960s to mid-1970s, but increased four-fold to *c.* 81,600 by 2013 (Fox & Leafloor 2018). In the first 25 years of goose counting in Sweden, only single individuals or small groups of Pink-footed Geese were seen, mainly in the flocks of staging and wintering Bean Geese. Over the last 15 years, however, numbers staging in the country have increased (reaching 3,600 individuals in October 2017) in line with the population trend. Numbers present in mid-winter have also increased, but to a lesser extent (< 500 counted in January 2020), with Denmark, the Netherlands and Belgium being the main wintering areas (Madsen *et al.* 1999; Madsen & Williams 2012).

The Russia/Germany and the Netherlands Barnacle Goose population is another of the goose populations which has surged in numbers during the late 20th–early 21st centuries, from only *c.* 20,000 individuals in the 1950s to 770,000 in winter 2007/08 (Fox *et al.* 2010) and an estimated 1.2 million by 2014/15 (Jensen *et al.* 2018; Fox & Leafloor 2018). Numbers staging in Sweden started to increase during the mid-1990s, with large numbers (> 350,000 in October 2019) now counted at staging sites in southern Sweden during both autumn and spring. Nearly 500,000 Barnacle Geese were seen on passage during the regular observations made of bird migration at the Falsterbo Bird Observatory in October 2019. In contrast, in earlier years (from the late 1970s to the mid-1990s), only small numbers were counted in Sweden.

Historically, during the early 1800s, Barnacle Geese also staged in large flocks in southernmost Sweden, where they fed on spilled grain in oat stubbles, but they disappeared from these areas in the 1850s (Kampe-Persson 2013). When the species returned to southern Sweden in large flocks 150 years later, it was to a fully modernised agricultural landscape, offering a much wider variety of harvest remains. Sweden's sugar production had recently been centralised to one factory, at Örtofta in southwest Scania, and in order to process the entire national sugar beet harvest at this factory, the annual season was prolonged. As a result, the staging and wintering geese had access to large amounts of sugar beet remnants from about 10 September to well after the New Year, sometimes (as in 2020) until the end of February. This suited the Barnacle Geese well, because they had already learned to utilise this food source in the 1990s (Nilsson & Kampe-Persson 2013). In southwest Scania, sugar beet waste has now become the most important food source for staging Barnacle Geese, as well as for other goose species in autumn and in winter in milder years. Growth of the naturalised Barnacle Goose population in the Baltic Sea region (Kampe-Persson 2010) may, however, attract passing birds into making stop-overs in their areas, which may in turn explain why Barnacle Geese have started to stage in other areas of Sweden where sugar beet is not currently grown.

Internationally, Sweden is an important country for several of Europe's goose species, with a high proportion of the flyway populations covered during the autumn counts (Table 1). This is particularly true for the Taiga Bean Goose, as birds belonging to both the Western and Central MUs use autumn staging areas in Sweden, and numbers counted have exceeded the official population estimate in recent years (Marjakangas *et al.* 2015). Moreover, > 25% of the flyway populations of the Greylag Goose and the Russian/German and Netherlands Barnacle Goose now regularly stage in Sweden. The marked increase in almost all goose species seen in Sweden during autumn or mid-winter likely reflects the general increase in the size of their flyway populations, associated with changes in the agriculture that have created superabundant food resources for geese in the non-breeding season over recent decades (Fox & Abraham 2017). These changes and their influence on the geese have also been seen on a smaller scale within

Table 1. Maximum numbers of geese counted in Sweden during the autumn migration period, for the most abundant goose taxa in the country (this study), compared to the recent Northwest European population estimates for these species (from Fox & Leafloor 2018). * = Russian-Baltic-German-Netherlands population; ** = Western and Central Management Units (Marjankangas *et al.* 2015).

	NW Europe		Sweden		
	Population	**Year**	**Highest count**	**Year**	**% in Sweden**
Taiga Bean Goose**	52,000	2015	65,000–75,000	2019	100.0
Tundra Bean Goose	600,000	2013	9,600	2017	1.6
Pink-footed Goose	76,000	2014	3,620	2017	4.8
White-fronted Goose	1,000,000	2012	29,800	2010	3.0
Greylag Goose	960,000	2014	242,800	2017	25.3
Barnacle Goose*	1,200,000	2015	365,000	2019	30.4

Sweden (*cf.* Nilsson & Persson 1984; Nilsson 2013; Nilsson & Kampe-Persson 2013). Climate change can also be an important factor in influencing population trends, distribution and migratory patterns, especially for populations breeding in the arctic (Jensen *et al.* 2014), and this may be a reason why some species (*e.g.* the Pink-footed Goose, Barnacle Goose and Tundra Bean Goose) showed a much faster, and later, increase in numbers staging and wintering in Sweden. Slower changes in migratory habits, found for the Greylag Goose and the Taiga Bean Goose, have apparently involved "short-stopping", in which the geese shortened their migration distances and stage as long as possible at more northerly sites than in former times (Elmberg *et al.* 2014).

In conclusion, the 43 years of goose counts in Sweden presented here describe massive changes in numbers and distributions recorded for the focal populations, which coincided with similar trends and shifts in migration patterns for these species across Europe. It is of utmost importance that goose monitoring programmes in different European countries continue into the future, for assessing variation in site use and population growth, and for determining how newly-emerging environmental conditions affect migratory populations, in order to inform the ongoing management and conservation of Europe's goose species.

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