Changes in abundance and breeding output of Greylag Geese *Anser anser* breeding in southern Sweden

LEIF NILSSON

Department of Biology, Biodiversity, University of Lund, Ecology Building, S-223 62 Lund, Sweden.
E-mail: leif.nilsson@biol.lu.se

Abstract

Neck-banded Greylag Geese *Anser anser* from a population breeding in southwest Scania, southern Sweden, were studied to assess changes in the breeding population and breeding performance during 1984–2013. The population increased ten-fold during this period, only to decrease again in the later years of the study. Greylag Geese arrived on the breeding grounds about 3–4 weeks earlier by 2007–2009 compared to the 1980s, probably an effect of wintering further north closer to the breeding areas in more recent years. Mean hatch date did not advance significantly over the same period. The proportion of breeding Greylag Geese that produced a brood of small young decreased during the study. On the other hand, the mean brood size at hatching for those succeeding in producing a brood, and the survival of young to fledging amongst marked families, showed no significant trends.

Key words: breeding performance, Greylag Geese, migration pattern, south Sweden, survival.

The Greylag Goose *Anser anser* was a rare species in Sweden in the 1960s, with an estimated breeding population in the country of about 300 pairs following a long period of over-exploitation, similar to the situation reported for several other European goose populations (Ottosson *et al*. 2012). Also like many of the other European goose populations, Greylag Goose numbers started to recover in the 1970s, increasing markedly in Sweden and elsewhere (Fog *et al*. 1984; Fox & Madsen 2017; Nilsson *et al*. 1999). By 2008, the breeding population in Sweden had reached about 41,000 pairs (Ottosson *et al*. 2012). The recovery of the population led to an expansion of its breeding range and flocks of non-breeding Greylag Geese started to appear in many places, leading to increasing conflicts with agriculture and an increased damage of crops (Buij *et al*. 2017 and references therein).

As a response to this population increase, the Nordic Collegium for Wildlife Research

(NKV) initiated the Nordic Greylag Goose Project in 1984, which aimed to study the movement patterns, migrations and the establishment of new concentrations of Greylag Geese in four of the Nordic countries (Denmark, Finland, Norway and Sweden). Accordingly, a large-scale neck-banding programme commenced in 1984 (Andersson *et al.* 2001). In addition to the neck-banding, regular September counts, specifically targeting Greylag Geese to monitor population development, were included in the ongoing goose count programme (Nilsson 2013). The Nordic Greylag Goose Project originally aimed at a five-year study, but neck-banding continued in southern Sweden (until 2009, with checks for marked geese continuing to 2013) and in Norway (still underway). In southern Sweden, the neck-banded individuals also formed a basis for studies of various aspects of the birds' breeding ecology, population dynamics, moult and habitat selection (Nilsson 2016; Nilsson *et al.* 1997, 2002; Nilsson & Persson 1994, 1996, 2001a,b).

When the project started, the majority of the Greylag Geese from southern Sweden migrated to wintering areas in the Guadalquivir Marismas in the southernmost part of Spain, after staging in the Netherlands and at some other sites on the route (Andersson *et al.* 2001; Nilsson & Kampe-Persson 2018). Since then, marked changes have occurred in the birds' migration pattern and wintering habits, with a higher proportion of the population wintering further north and with the geese being away from the breeding areas for a shorter period of time (Nilsson 2006; Ramo *et al.* 2015; Nilsson & Kampe-Persson 2018).

In the present contribution, data from the neck-banded Greylag Geese from the study population in southwest Scania, southern Sweden are analysed to elucidate the development of the population over the years. Different aspects of the breeding performance of the study population are also investigated to assess whether changes in breeding performance and population size are related to changes in wintering habits and migration patterns of the population in recent decades (Andersson *et al.* 2001; Nilsson 2006, 2013; Nilsson & Kampe-Persson 2018). This therefore provides an update on earlier published results from the study (Nilsson & Persson 1994, 1996; Nilsson *et al.* 1997).

Study area

The study was undertaken on Greylag Geese breeding and moulting in a lakeland area in southwest Scania, southernmost Sweden (Fig. 1). The geese were mostly caught and neck-banded at Lake Yddingen (Fig. 2) and Lake Klosterviken, though the marking programmed extended to Lake Fjällfotasjön and Lake Börringe in some years (see Fig. 1). The study area also included Lake Björkesåkrasjön, but there was no marking of geese at this lake. The general area searched for marked Greylag Geese extended over a wider area covering some other inland lakes close to the study sites and the coastal staging area at Foteviken. Nilsson and Kampe-Persson (2017) provide further information on the wider area and its utilisation by Greylag Geese.

The lakes are situated in rolling landscape with agricultural land and smaller forest

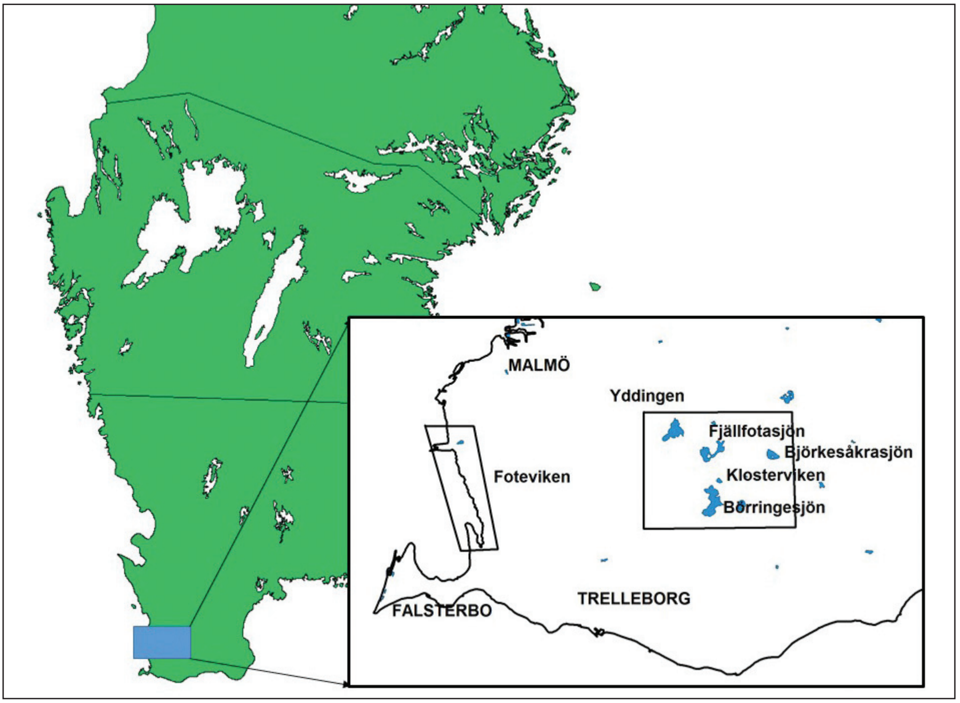

Figure 1. Map of south Sweden with a map of the lakeland study area inserted. The Foteviken area, on the coast, is an important staging area (and later a wintering area) for Greylag Geese from the study.

Figure 2. Aerial view of the study area, with Lake Yddingen (the main catching site) in the foreground. Lakes Börringesjön and Fjällfotasjön are seen in the background.

patches (Fig. 2). Lake Klosterviken has a border of reedbeds, with shore meadows offering good feeding opportunities during brood-rearing. Lake Börringe is more open but with reedbeds in some bays. Lake Fjällfotasjön has a number of small islands suitable for geese but has fewer feeding areas along the shores. Lake Yddingen, which is somewhat larger, has extensive reedbeds in the bays and some islands in the lake. There are meadows along the shore in some areas and part of the lake is adjacent to a golf course, which also provides good feeding conditions for parents and offspring during brood-rearing. Nilsson & Persson (1994) and Nilsson *et al.* (2002) provide more detailed descriptions of these lakes.

Material and methods

Families of Greylag Geese were caught and marked during early summer when the goslings were large enough to have neck-bands fitted but before the parents could fly. We drove the geese into nets mounted on the feeding grounds in the shoreline meadows and on the golf course at Lake Yddingen (Andersson *et al.* 2001; Persson 1994). All individuals were marked with a blue neck-band with a three-digit code and a metal leg-ring from the Swedish Ringing Centre. Marking commenced in 1984 and the last geese were marked in 2009. In all, 664 adults and 1,947 goslings were neck-banded in the study area. A total of 101,885 re-sightings were obtained locally from southwest Scania up to and including spring 2013, with a further 16,262 sightings reported from areas outside the study area, mainly from countries other than Sweden (Nilsson & Kampe-Persson 2018).

The breeding areas were checked for neck-banded geese and counts of breeding pairs and non-breeding individuals were made several times a week from February until the goslings fledged in early summer. During the main hatching period the main brood-rearing areas were checked for new broods almost daily. The number of breeding pairs was established from intensive observations made of the geese on feeding areas close to the different breeding lakes; the number of nests could not be counted because the geese mostly bred out of view in dense reedbeds. The geese gather on a few easily overlooked sites (mostly meadows) in the area around the lake area, which facilitated determining the first sightings each year for individually-marked birds. These observations were treated as the arrival dates for the different individuals. Later in the season, families with young used a small number of meadows along the shore of each lake for rearing their goslings. The hatching date could not be established precisely because the birds bred on islands and in reedbeds, but parents take their newly-hatched young to the main rearing areas soon after hatching, so first observations made of families with small goslings therefore was considered a good proxy of hatching date. As both parents were marked for the majority of families, it was also a good indication of hatching when the male did not show up alone anymore but was accompanied by a brood. Pairs referred to as having small young in the text therefore are those with a brood of newly-hatched young.

From July to late autumn regular controls for marked geese were undertaken both in the main feeding areas of the inland study area and at the coastal areas of Foteviken (Fig. 1), the major autumn staging area in southern Sweden for the geese on leaving the breeding areas. Other goose areas in southwest Scania (*cf.* Nilsson & Kampe-Persson 2017) were visited at least once a month with more frequent checks made during spring. The intensity of checks for neck-banded birds in southeast Scania was consistent throughout the study. Reports of observations of neck-banded Greylags from abroad were obtained from a large network of observers in different countries (*cf. e.g.* Andersson *et al.* 2001); in later years observations were also downloaded from the website www.geese.org, an on-line portal used to submit records of marked geese and swans.

Mean arrival dates and the mean hatching dates were calculated for each year of the study, from the dates on which breeding geese (*i.e.* those that bred at least once during the study) were first seen in spring, and parent birds were first seen with goslings, measured as the number of days after 1 January in each year. Linear regression analyses tested whether there was evidence for winter weather conditions (measured as the mean temperature in southwest Sweden in January each year) and also trends over time (*i.e.* a Year effect) influencing the timing of the birds' return to the breeding areas. Whether mean temperature in February and Year affected the birds' hatching dates was similarly investigated. Linear regressions were also used to test for trends in the proportion of small broods (arcsine transformed data), and the proportion of broods that fledged (arcsine transformed) recorded for the breeding pairs. Weather data for Scania were obtained from the Swedish Meteorological and Hydrological Institute (SMHI).

Results

The first breeding pair of Greylag Geese with a brood of small young was found in the study area during the late 1960s and a breeding population became established at different lakes during the 1970s. The first survey of numbers breeding in 1985 found 120 pairs present in the area. Numbers then increased tenfold to a peak of 1,340 pairs in 2004 (Fig. 3), decreasing to about 800 pairs in 2013.

At the same time as the Greylag Geese started to winter further north (Nilsson 2006, 2013; Nilsson & Kampe-Persson 2018), they also arrived earlier to the breeding areas in southwest Scania in spring. In the early years of the study, the mean arrival of breeding Greylag Geese in the breeding area was in March but over the years the birds arrived progressively early and during the last few years the mean arrival was about one month earlier that 30 years previously (linear regression: $F_{1,20} = 21.07$, $P = 0.0001$; Fig. 4). An increasing proportion of the breeding birds moved no further from the breeding lakes during the winter than to the neighbouring coast at Foteviken (Fig. 1) or to other areas in southwest Scania (*cf.* Nilsson & Kampe-Persson 2018). No Greylag Geese remained in the breeding area over the winter, but some returned in late January and early February. There was a positive association between January temperatures in southwest Sweden and the dates on which breeding birds returned to the breeding grounds, with the birds arriving

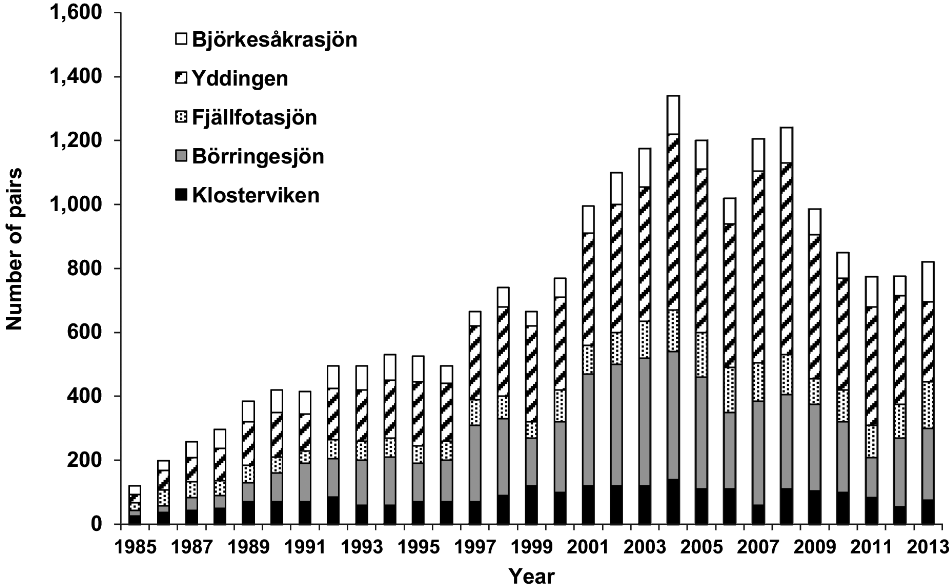

Figure 3. Number of breeding pairs of Greylag Geese at the five different lakes in the study area in southwest Scania in 1985–2013.

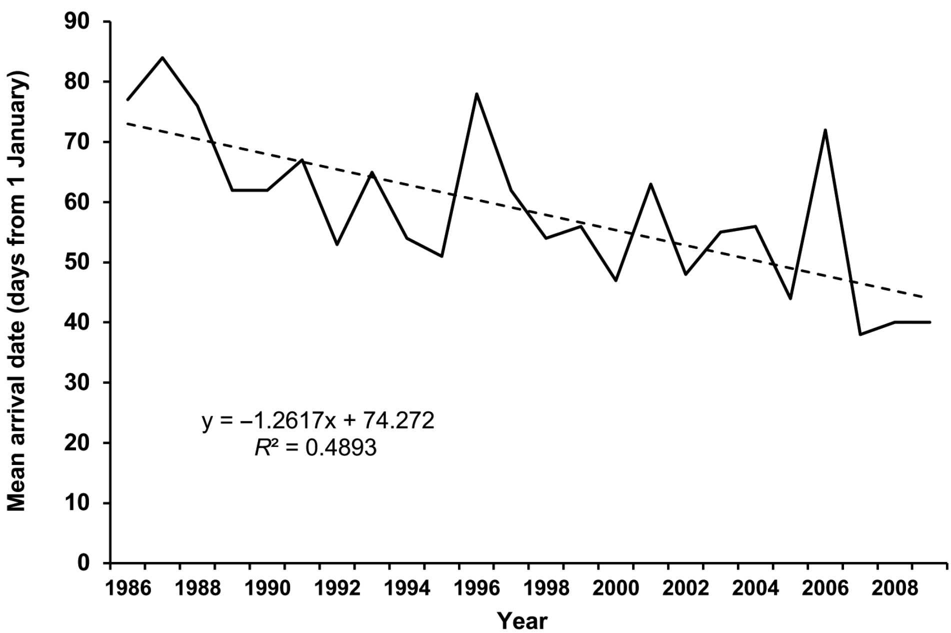

Figure 4. Mean annual arrival date (days from 1 January) for marked Greylag Geese returning to the breeding areas (linear regression: $F_{1,20} = 21.07$, $P = 0.0001$).

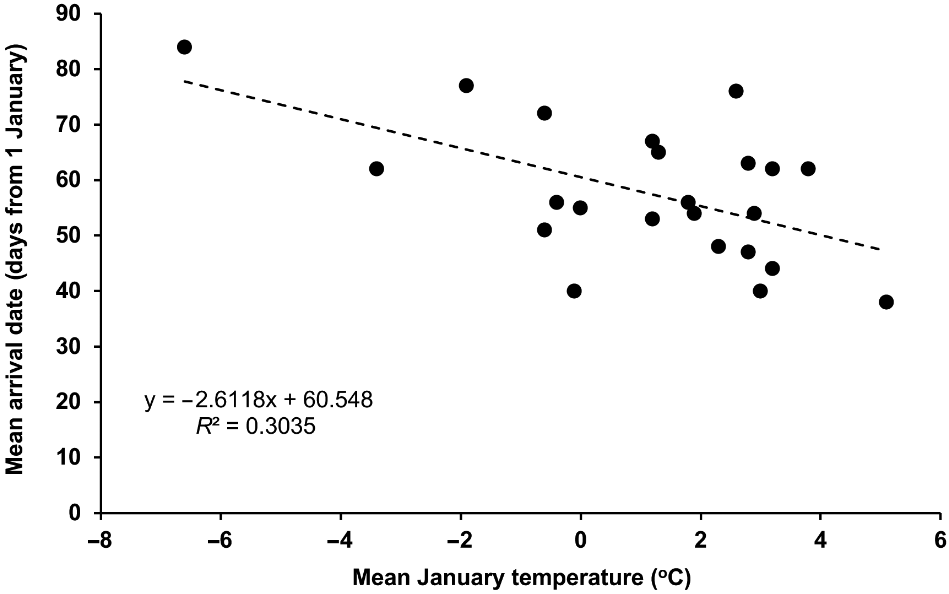

Figure 5. Mean annual arrival date at the breeding areas for Greylag Geese in southwest Scania, in relation to local mean temperature for January (linear regression: $F_{1,20} = 9.15$, $P = 0.006$).

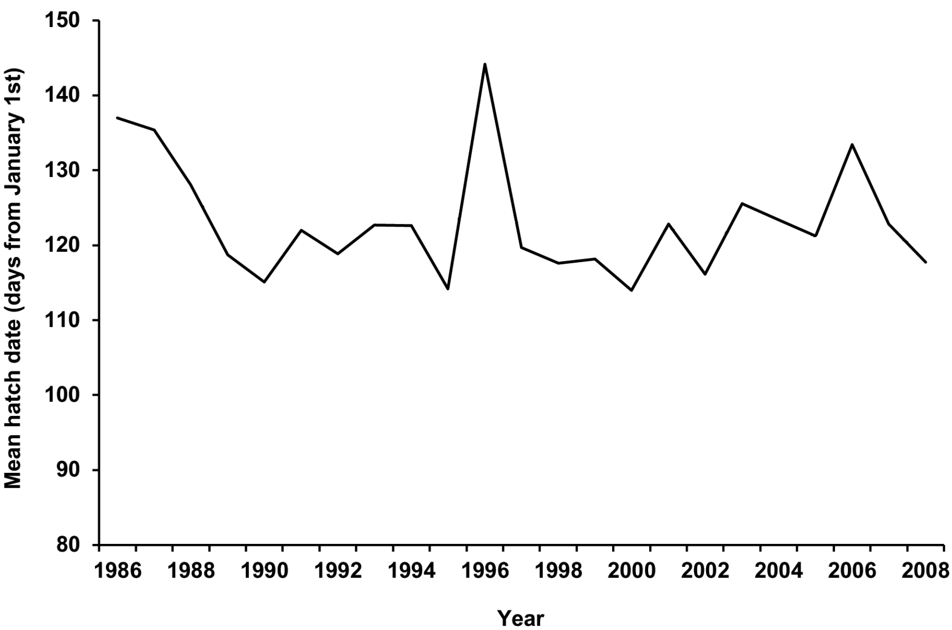

Figure 6. Annual mean hatch date (first observation of a brood of small young) for marked Greylag Geese in the study area of southwest Scania (linear regression: $F_{1,21} = 1.02$, $P = 0.32$, n.s.).

earlier following milder winters (linear regression: $F_{1,20} = 9.15$, $P = 0.006$; Fig. 5), but no significant trend in mean January temperatures recorded each year from 1986 to 2009 inclusive (linear regression: $F_{1,21} = 1.64$, $P = 0.215$, n.s.).

With a markedly earlier arrival of the breeding Greylag Geese in the study area over the study period, it might be expected that the mean hatching date should also have advanced. On testing the trend in hatching date in relation to Year and also to February Temperature, however, there was no clear effect of Year (linear regression: $F_{1,21} = 1.02$, $P = 0.32$, n.s.; Fig. 6), but hatching date was significantly associated with the mean February Temperature ($F_{1,21} = 4.14$, $P = 0.05$; Fig. 7). The mean temperatures for March showed a similarly high correlation with hatching date as February temperature, whereas the January and April mean temperatures showed weaker correlations with mean hatching date.

At the start of the study a high proportion of the Greylag Geese breeding in the area produced a brood of small young, but the percentage decreased significantly over time (linear regression: $F_{1,22} = 7.86$, $P = 0.01$; Fig. 8). On the other hand, there was no evidence of a decrease in mean brood size over the study period (linear regression: $F_{1,23} = 0.47$, $P = 0.50$, n.s.; Fig. 9). The mean brood sizes in different years were mostly between four and five small goslings. The annual survival to

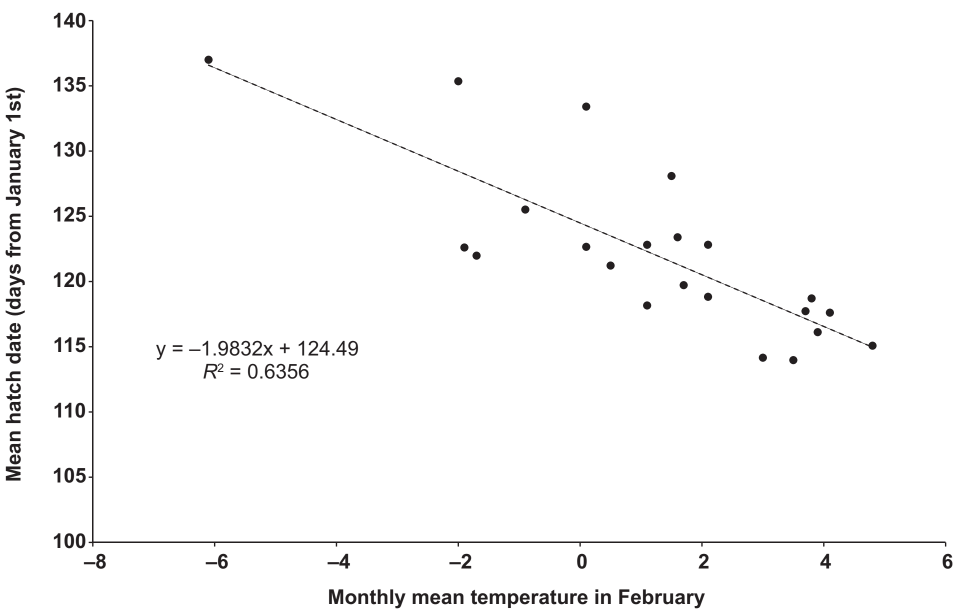

Figure 7. Annual mean hatch date of Greylag Geese *Anser anser* from southwest Scania in relation to local mean temperature for February (linear regression: $F_{1,21} = 4.14$, $P = 0.05$).

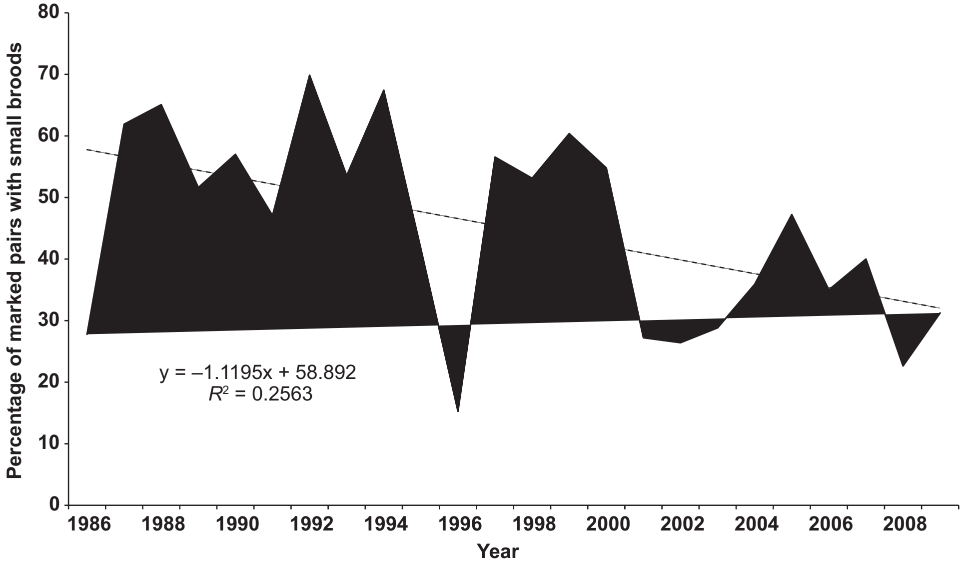

Figure 8. Percentage of marked breeding Greylag Geese seen with a brood of small young in the study area in southwest Scania in different years (linear regression for arcsine transformed data: $F_{1,22} = 7.86$, $P = 0.01$).

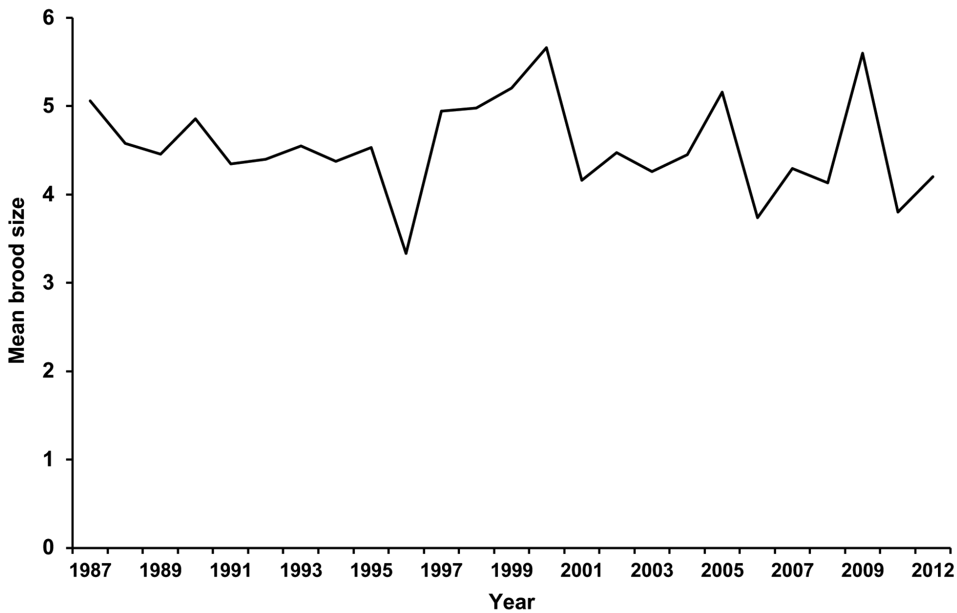

Figure 9. Annual mean brood sizes for marked Greylag Geese seen with at least one small young in the study area in southwest Scania (linear regression: $F_{1,23} = 0.47$, $P = 0.50$, n.s.).

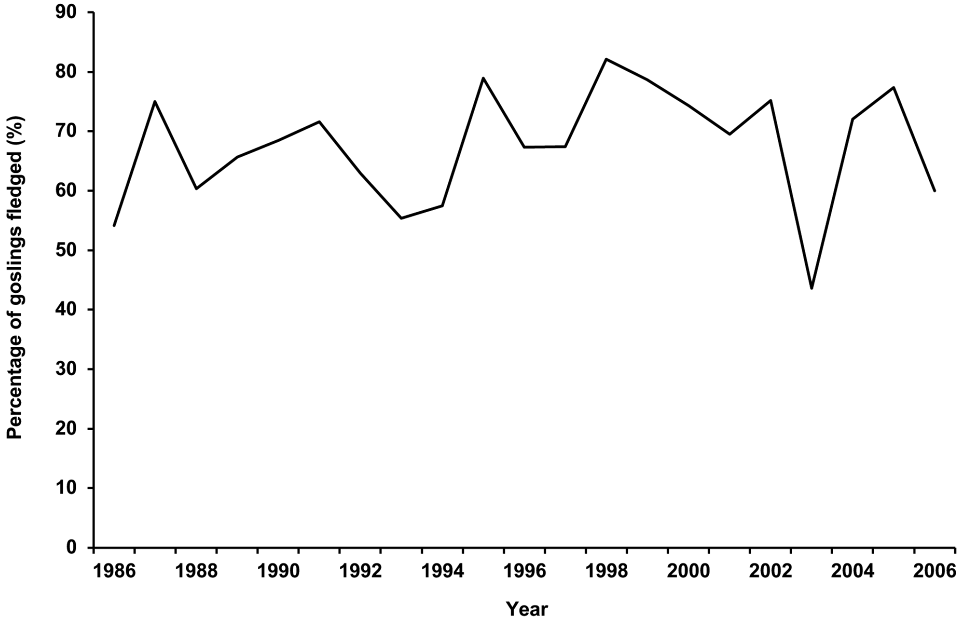

Figure 10. Annual survival rate of goslings in marked families of Greylag Geese *Anser anser* to fledging in southwest Scania (linear regression for arcsine transformed data: $F_{1,19} = 0.67$, $P = 0.42$, n.s.).

fledging of goslings with marked parents varied between 50–80% without showing any significant trend (linear regression: $F_{1,19} = 0.67$, $P = 0.42$, n.s.; Fig. 10).

Discussion

Over the years, the breeding population of Greylag Geese in the study area increased markedly (about tenfold), as was also the case across Sweden (Ottosson *et al.* 2012). In the same period the seasonal movements of the Greylag Geese changed, with the geese leaving Sweden later and arriving back to the breeding areas earlier in spring (Nilsson 2013). Moreover, an increasing proportion of the national population never left the country during the winter. In Scania, several marked birds from the study area merely relocated a short distance to the coast for the winter months (Nilsson & Kampe-Persson 2017, 2018).

The mean arrival date of marked Greylag Geese advanced by about one month by the end of the study period compared to the early years. On the other hand, there was no clear trend in the mean hatching date for the goslings, which was more or less the same as when the study started. Both arrival in the breeding areas and the mean hatch date were related to local temperature during the winter and early spring.

At the start of the study, early-arriving neck-banded Greylag Geese breeding in southwest Scania had larger broods of small goslings than late-arriving individuals, and a higher proportion of the early geese managed to produce a brood (Nilsson & Persson 1994). Moreover, the goslings of early parents had better survival to fledging. With the geese arriving much earlier to the breeding areas in the latter part of the study period, it could have been expected that this early arrival had a positive effect on the productivity of the geese. However, the proportion of pairs producing a brood was lower in more recent years, the decreasing trend being significant. As the breeding population of Greylag Geese increased markedly during the study, the negative trends were most likely attributable to density dependent factors such as availability of nesting territories and food supply (*cf.* Nilsson 2016). Larsson & Forslund (1994) found similar density dependent effects on reproduction for the recently established of Barnacle Goose *Branta leucopsis* in the Baltic area. In contrast to the decreasing trend in the proportion of breeding pairs managing to produce a brood of small young, there were no clear changes in the size of broods of small goslings during the study period. In the same way, the proportion of goslings that survived from hatching to fledging did not show any clear trend; only fluctuations between years.

Over the years, a marked tendency has been established for the Greylag Geese of western Europe to winter further north (Nilsson 2006, 2013; Ramo *et al.* 2015; Nilsson & Kampe-Persson 2018). This change in distribution has been attributed to the possible effect of climate warming (Ramo *et al.* 2015). Climate change can also be a possible factor behind the earlier arrival of the Greylag Geese to the study area. The geese may either start their spring migration earlier as an effect of milder winters and springs, or the earlier arrival can be an effect of shorter migrations related to wintering further north and closer to the breeding grounds. It is however also possible that the very marked increase in the population had led to a northward shift in the wintering range. The availability of suitable food resources over the entire winter can be an important factor in this respect (Nilsson & Kampe-Persson 2013).

Climate warming probably has a greater influence on arctic-breeding geese than on the temperate-breeding Greylag Goose. Lameris *et al.* (2017) presented a model that predicted that the arctic-breeding populations of Barnacle Geese could suffer reduced reproductive success through mistimed arrival into the breeding areas. Even if Barnacle Geese of the temperate-breeding populations in the Baltic and North Sea area bred much earlier than the arctic populations, they were not able to acquire the body stores needed to breed sufficiently early for the young to hatch at peak availability of high quality food (van der Jeugd *et al.* 2009). Climate change has also affected the demographic traits of the Greater Snow Geese *Chen caerulescens atlantica* (Doiron *et al.* 2015) and Light-bellied Brent Geese *Branta bernicla hrota* (Cleasby *et al.* 2017) nesting in the Canadian arctic.

In contrast to the decreasing trends in productivity of the study population over the years, other researchers have found increased survival of Greylag Geese neck-banded in Scania between the early 1980s and early 2000s, both for young and for adult birds (Pistorius *et al.* 2007). This suggests that the longer migration evident in the early years of the study coincided with lower survival, especially for the young geese, compared to the shorter migrations made possible by the milder climate in later years. More detailed analysis of annual variation in survival rates, in relation to weather and latitude of the wintering sites, is however required to test and confirm this hypothesis. In addition to the direct energetic costs of a long migration affecting survival (Owen & Black 1989), severity of conditions experienced in the different winter areas and the differential risk of hunting mortality in different countries may also be influencing survival rates.

At the start of the study, when a large proportion of the Greylag Geese from southwest Scania wintered in southern Spain, the survival and breeding performance was better for those wintering further north in the Netherlands compared to those that migrated to Spanish wintering grounds, where the species was also hunted (Nilsson & Persson 1996). With an increasing trend for the Greylag Geese from southwest Scania to winter further north (*i.e.* not travelling to Spain anymore, Nilsson 2006; Nilsson & Kampe-Persson 2018), the breeding performance of birds experiencing reduced energetic costs of shorter migration could be expected to improve. However, in the latter part of this study, there was evidence of a general decline, which suggests some other means of local population regulation is operating, and Nilsson (2016) found that density dependence was influencing Greylag Goose breeding success in the study area at this time.

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Photograph: Greylag Goose parent and goslings, by Leif Nilsson.