From stopover to wintering: Bewick's Swans *Cygnus columbianus bewickii* in Schleswig-Holstein, northern Germany in winters 2016/2017 and 2017/2018

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Abstract

In recent years, Schleswig-Holstein in northwest Germany has held up to a third of the Northwest European population of Bewick's Swans *Cygnus columbianus bewickii* for several weeks, especially in March, as the birds staged in the region before continuing northeast to spring migratory sites in the Baltic Countries. Maximum numbers counted in Schleswig-Holstein during 2017 (5,591 birds) were recorded 10 days earlier (on 25 February) than the mean date of the peak count (7 March) recorded for nine previous winters for which the dates of the peak counts were known. Winter 2017/2018 started and ended with even higher numbers, including a new record count of 8,364 individuals on 24 February, perhaps reflecting warmer winter temperatures. Sightings of > 116 individual swans fitted with neck-collars or leg-rings gave detailed insight into their migration phenology. These ringed birds were recorded at sites south or southwest of the River Elbe especially in autumn before flying to Schleswig-Holstein, where they stayed for up to four months, albeit making short flights south or west during this period to cope with periods of snow. During these two winters, Bewick's Swans appeared at several new sites where they had not previously been recorded by observers, and the survey areas therefore were enlarged. Three trends in the swans' staging patterns are discussed: 1) an increase in numbers, 2) earlier arrival, and 3) longer staying by the swans in Schleswig-Holstein as a consequence of 1) and 2).

Key words: Bewick's Swan, climate change, distribution shift, maximum numbers, Schleswig-Holstein, wintering.

The Northwest European population of Bewick's Swans *Cygnus columbianus bewickii* has undergone a substantial decline in numbers, which has been most evident in the western part of the winter range (*e.g.* Ireland, the United Kingdom and the Netherlands; Nagy *et al.* 2012; Beekman *et al.* 2019). In contrast, peak counts in some

eastern parts of the wintering range (*e.g.* Germany) have increased. Data from long-term studies of marked birds found that the Bewick's Swans' apparent survival rates have declined in recent years (Wood *et al.* 2018), which could be explained by increased mortality or increased movements of marked birds away from areas traditionally monitored in mid-winter to new sites (*e.g.* further east). Recent evidence indicates that the decrease is not associated with changes in conditions for the swans at key traditional feeding sites (Wood *et al.* 2019a). In countries such as Germany and Denmark, however, an increase in Maize *Zea mays* fields has offered novel feeding opportunities and thus perhaps alternative wintering sites for Bewick's Swans for more than 20 years (Degen 1996; Wahl & Degen 2009; Clausen *et al.* 2018). Understanding patterns in swan use of key areas in the east of the winter range could help to elucidate the reasons for the recent and ongoing changes in Bewick's Swan numbers and distribution. In this study, repeated site-based counts therefore were combined with re-sightings of marked birds to assess recent changes in Bewick's Swans' use of winter and staging habitat in Schleswig-Holstein, northern Germany.

Methods

Schleswig-Holstein has three main landscapes, which align more or less along a north/south direction: the western sea marsh, the eastern uplands and the "Geest" in the middle (central shaded area in Fig. 1). The main staging areas for feeding and roosting used by Bewick's Swans in Schleswig-Holstein are well known and all are within the "Geest", which is a combination of arable sandy hills and river lowlands with grassland and wetland habitats. Reliable data on Bewick's Swans in the region have been recorded nearly every winter since 1953 (Schmidt 1965; Busche 1991) and more recently, from winter 2001/2002 onwards, synchronous counts have been made at the swans' main staging sites in the lowlands of the Rivers Eider, Treene and Sorge during their spring migration through Germany in March (Jeromin & Jeromin 2009). In combination, these counts and data from other parts of Schleswig-Holstein provide sound information on the swans' use of sites across the whole region (Jeromin & Koop 2007, 2014). Four and five synchronous counts covering the whole of Schleswig-Holstein from January to the end of March were made in 2015 and 2016 respectively (Wolff 2015, 2016). Counting frequency was intensified in the following winters, as described below.

Count areas in Schleswig-Holstein

Observations made of all birds in Schleswig-Holstein have been entered in the German "*ornitho*" portal (www.ornitho.de) since 2011. For Bewick's Swans, all locations where the swans were recorded regularly between January 2012 and March 2016 were considered on a geographical basis, and 89 count areas with easily recognisable borders (mostly roads) were identified as being the main staging sites used by the species. These areas were grouped into nine Bewick's Swan count units: Northern (on the border with Denmark), Treene, Sorge, Eider, Haaler Au, Wildes Moor (near Rendsburg), Fuhlenau, Hörner Au and Probstei (Fig. 1), most of which were lowland areas in river valleys.

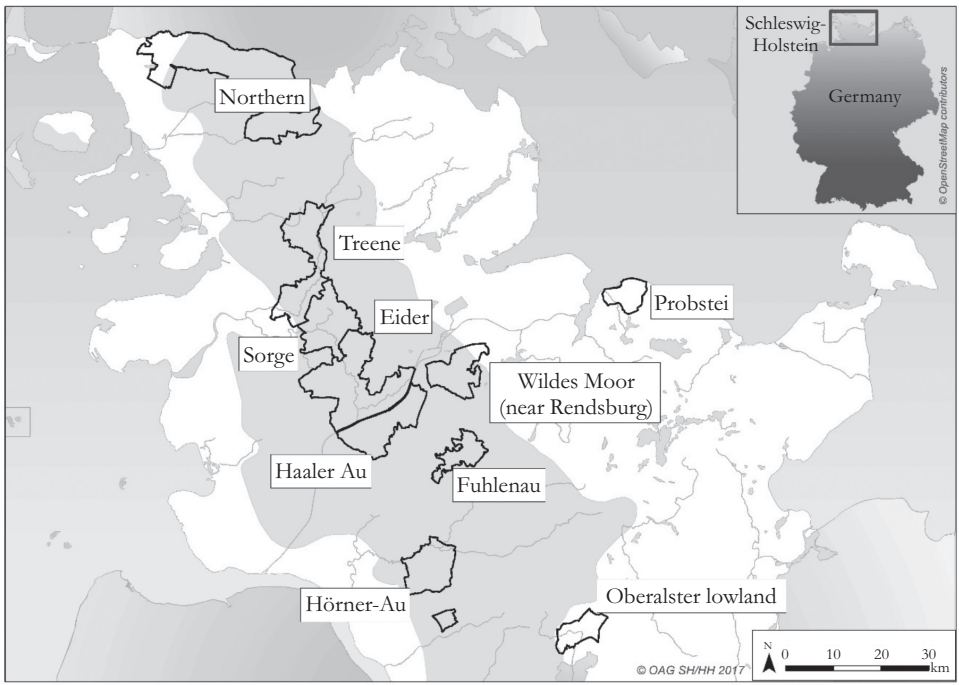

Figure 1. Location and names of count units described for monitoring Bewick's Swans in Schleswig-Holstein, Germany, in winters 2016/2017 and 2017/2018.

The count units consist of terrestrial areas for feeding and some areas of open water for roosting. Only a few of these roosts and none of the terrestrial habitats are included in other site networks used for monitoring other waterfowl, which focus on the most important lakes, rivers and marine areas of the North Sea and the Baltic Sea in Schleswig-Holstein.

From the start of winter 2016/2017, observers had to cover all 89 count areas (Appendix 1), but in mid-February (between count dates) many Bewick's Swans were also seen outside these areas. Eight new areas therefore were included in the surveys, and from 25 February to 25 March 2017 counts were made at 88–97 count areas, decreasing at Easter (31 March) to 44 areas (Appendix 1).

In the following autumn and winter of 2017/2018, Bewick's Swans again appeared at formerly unused sites, resulting in 15 additional count areas being included, as well as a new count unit: Oberalster Lowland, north of Hamburg (Fig. 1). Bewick's Swan presence was verified and counts undertaken at 99–112 count areas in seven of the censuses made in winter 2017/2018, but heavy snow cover and the Easter holidays coinciding with count dates meant that only 78 count areas were visited on two occasions (Appendix 1). On 11 March 2017 two observers also made a 2 h flight in a Cesna aircraft to cover the Eider, Sorge, Treene

and Northern units and the surrounding areas outside these units (between the Kiel Canal and the Danish border) to ensure that no swan flocks were missed. All flocks seen by plane had already been detected by observers on the ground, which supported the view that the ground counts were comprehensive.

Given that Bewick's Swans sometimes appear outside count units, a request was made via the regional ornithological e-mail group (OAGSHNet@yahoogroups.de) before each census in each winter, for observers also to report data on all Bewick's Swans seen in other parts of Schleswig-Holstein.

Survey methodology

Prior to the surveys in both winters, a plan was developed to determine where, when and who would count Bewick's Swans and other species in the region. A total of 10 coordinated Bewick's Swan counts were then made in winter 2016/2017, and nine in 2017/2018 (Appendix 1), with the overall aim of determining the total numbers, length of stay and feeding areas used by Bewick's Swans in Schleswig-Holstein. Count dates were selected to correspond with other regional, national and international censuses; for instance, in December the date coincided with that of the regional population census and with the international assessment of Bewick's Swan breeding success. The date in mid-January is important for obtaining comparable information in years between the 5-yearly international censuses of migratory swans. From mid-February to the end of March there were censuses every weekend to determine the maximum numbers of Bewick's Swans in Schleswig-Holstein (which generally occur during spring migration) and to obtain information on their length of stay. During each of the counts, all three swan species native to Germany (*i.e.* the Bewick's Swan, Whooper Swan *Cygnus cygnus* and Mute Swan *Cygnus olor*) were recorded, and during counts made in the middle of the month all goose species (mostly Greater White-fronted Geese *Anser albifrons*, Greylag Geese *Anser anser* and Barnacle Geese *Branta leucopsis*) were also included.

Counts were usually made on a Saturday, because most volunteers were able to allocate time for monitoring birds on that day. Over both winters, the count date shifted to a Sunday only once (on 18 March 2018), because snowfall on the Saturday which would have hampered observing the birds. Swans were counted by experienced ornithologists: 62 volunteers, with an average of 22 counters participating in each census during winter 2016/2017; 73 volunteers with an average of 30 participating in each census in winter 2017/2018 (Appendix 1). Observers used telescopes to determine the swan species, age class (adult or young, determined by plumage characteristics) and the identity of individual birds (by reading the codes inscribed on neck-collars and leg-rings). Cars were used to enable observers to cover all count units within the census timescale.

Most of the data collected per census were recorded on a single day (see Appendix 1 for the main count dates), which is important to avoid double-counting the same birds on successive days. Some counts made around the main census dates were,

however, included in the survey totals in both winters, especially records from outside the count units: 10 counts made within two days of the weekend, and nine conducted within 3–4 days of the weekend (Appendix 1). The counts focussed on clear visible feeding areas (visited between 1.5 h after sunrise and 0.5 h before sunset) to get reliable date on numbers present in the region, because parts of the swans' wetland roost sites were sometimes hidden behind trees or reeds. Numbers of Bewick's Swans could be estimated for most roost sites but were considered less accurate than the field counts, and data on roost sites (swan numbers, habitat type) were gathered primarily from observations made outwith of the censuses, extracted from the "*ornitho*" portal. These roost site data were not collected systematically, but some observers aimed to find all sites in their counting units especially between census dates, and hence they visited potential roosts or followed flying swans. Flying birds leaving the count unit were not counted but reported by mobile phone to the observers in the next unit. All count data, including the numbers of adults and young, exact location, habitat and behaviour (*i.e.* whether feeding or roosting), recorded within or outside the count units, were entered to a database via the "*ornitho*" portal. The coordinator for the Bewick's Swans counts in Schleswig-Holstein (HJA) received extracted information from that database soon after the census and provided a feedback report to the observers.

During the censuses, and also between count dates, ornithologists tried to identify marked Bewick's Swans by reading the codes inscribed on their leg-rings or neck-collars. The data (date, type and colour of neck-collar or leg-ring, code, exact location, habitat, number of swans and other bird species) were entered by the observer onto the www.geese.org website (for neck-collars), sent to Didier Vangeluwe (for white neck-collars with X-code) or to the Wildfowl & Wetlands Trust (for birds marked with leg-rings). The ringing organisation provided observers with a list with all ringing and re-sightings details for the swan identified by its ring code. These lists were compiled into a table for Bewick's Swans identified in Schleswig-Holstein during winters 2016/2017–2017/2018, including information on the type and code of marking, and the date and location for re-sightings records. This table was then used to calculate the number of days between the first and last sighting for each individual swan seen in Schleswig-Holstein in these two winters, together with the number of re-sightings during this length of stay.

Results

Phenology of Bewick's Swans' use of sites in Schleswig Holstein in winters 2016/2017 and 2017/2018

The first Bewick's Swan of the 2016/17 winter was observed near the mouth of the River Eider on 3 October. From this arrival date until mid-November, up to 30 swans were reported in Schleswig-Holstein, mostly on lakes and lagoons along the Baltic Sea and the North Sea coastlines. During the second half of November, numbers at well-known staging areas in the inland lowland areas of Schleswig-Holstein ranged from

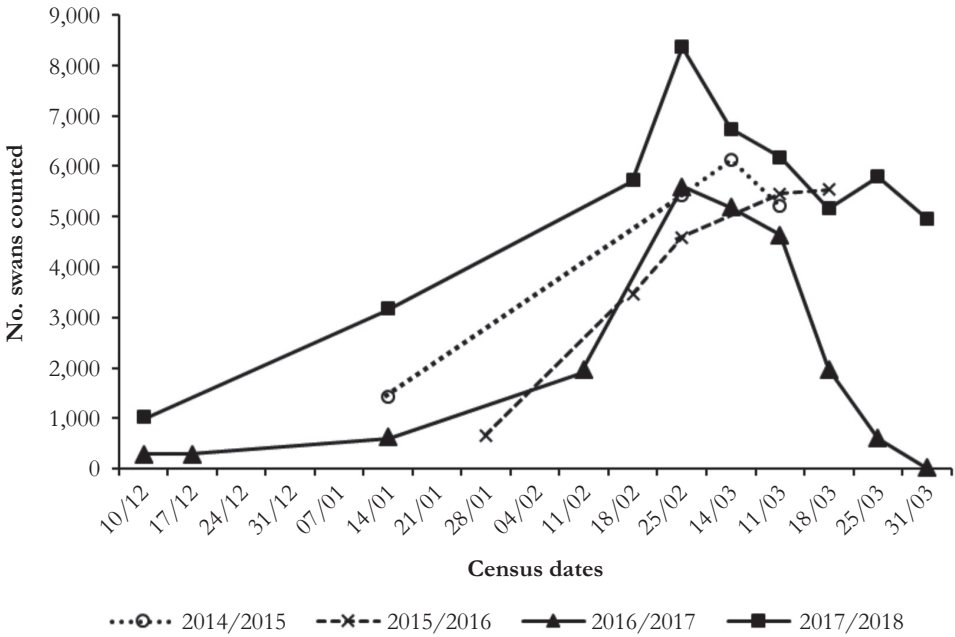

Figure 2. Total numbers of Bewick's Swans recorded in Schleswig-Holstein on census dates in winters 2014/2015 to 2017/2018 inclusive.

6–80 individuals, and by mid-January 2017 a total of 641 Bewick's Swans were present in the region (Fig. 2). Thereafter, counts rose steeply and the maximum number of 5,591 birds was recorded on 25 February before declining in March, especially during the second half of the month. By the end of March nearly all Bewick's Swans had left Schleswig-Holstein with the last individual seen on 24 April 2017.

The following winter the first Bewick's Swans again arrived in early October, with eight birds observed on the Baltic and North Sea coastlines on 8 October 2017. During October–November, the majority of Bewick's Swans (13–54 individuals) rested in two brackish polders on the coast of the North Sea, but by the end of November up to 200 individuals were present on the inland lowlands. In early December 2017 more than 1,000 swans were counted (Fig. 2), with numbers rising steadily to the peak count of 8,364 on 24 February. The majority of Bewick's Swans were observed in the Treene, Haaler Au and Sorge units at this time (Fig. 3a). Freezing conditions and 20 cm snow cover in northern Schleswig-Holstein on 3 March 2018 resulted in a drop in numbers to 6,744 (Fig. 2), and swans from northern parts of Schleswig-Holstein moved 30–40 km west and south, so that highest numbers were in the Beltringharder Koog on the North Sea coast and south of the Kiel Canal in the Haaler-Au lowlands (Fig. 3b). Subsequently, numbers declined to 5,161 birds in mid-March before recovering

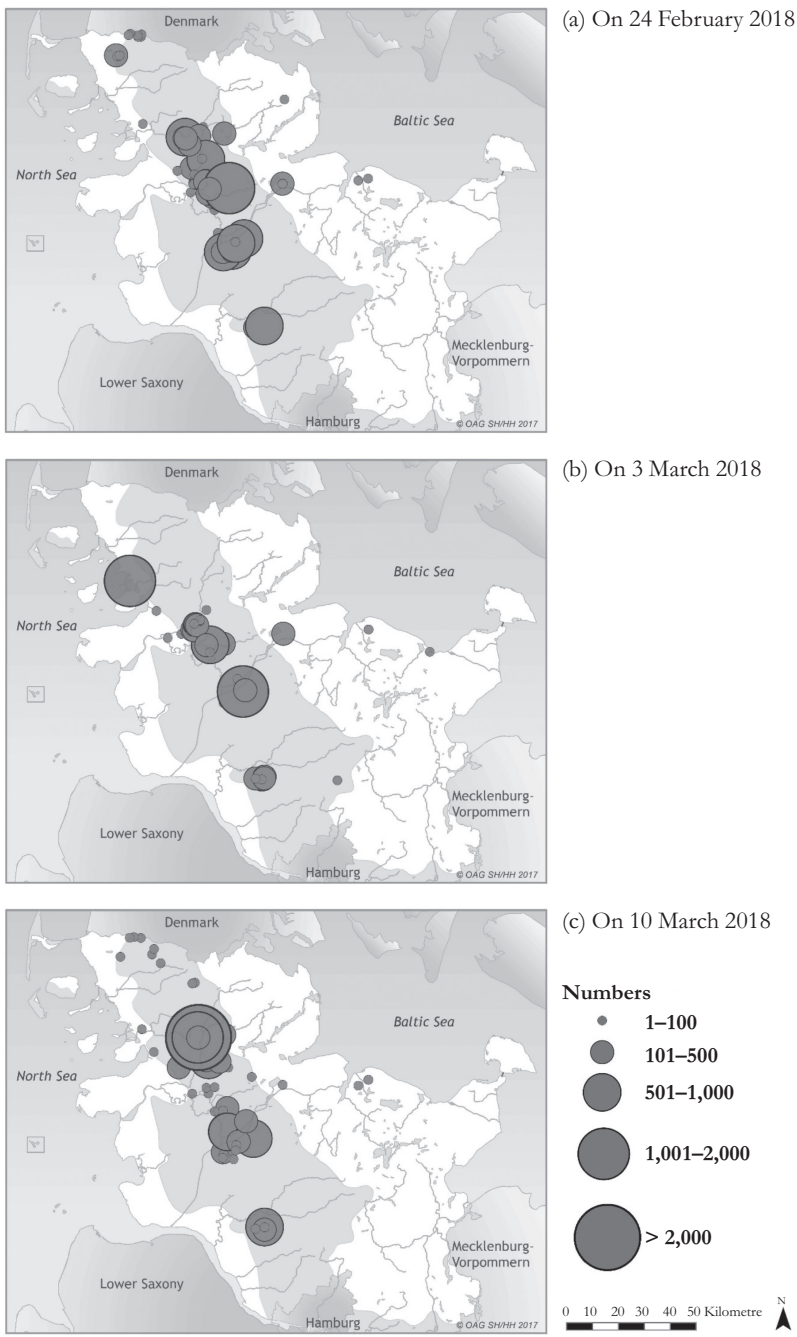

Figure 3. Map of Schleswig-Holstein with numbers of Bewick's Swans recorded during censuses

to 5,799 then dropping to 4,964 individuals at the end of March. Over this period numbers were always (much) higher than the previous year. Final departure was rapid; most Bewick's Swans had left Schleswig-Holstein by 2 April 2018 (with perhaps only 332 individuals remaining by that date, although no comprehensive census was possible), with the last individual seen on 14 April.

Percentage of cygnets in winters 2016/2017 and 2017/2018

Age counts recorded on each of the count dates showed that the percentage of cygnets in Bewick's Swan flocks in Schleswig-Holstein increased markedly in spring 2016/2017, but were more consistent across the subsequent 2017/2018 winter season (Fig. 4, Table 1). The mean of the percentage of young recorded on each count day in winter 2016/2017 (12.64%) was nearly three times higher than in the next winter, in 2017/2018 (4.71%), but age counts made across the wintering range in 2017/2018 indicated that 2017 was a poor breeding season for the Northwest European population as a whole (Table 1).

Comparison of feeding habitat between 2016/2017 and 2017/2018

Grassland was the main feeding habitat used by Bewick's Swans in 2016/2017 (Fig. 5a), although 25% were feeding on winter cereals and 11% on maize stubbles during December.

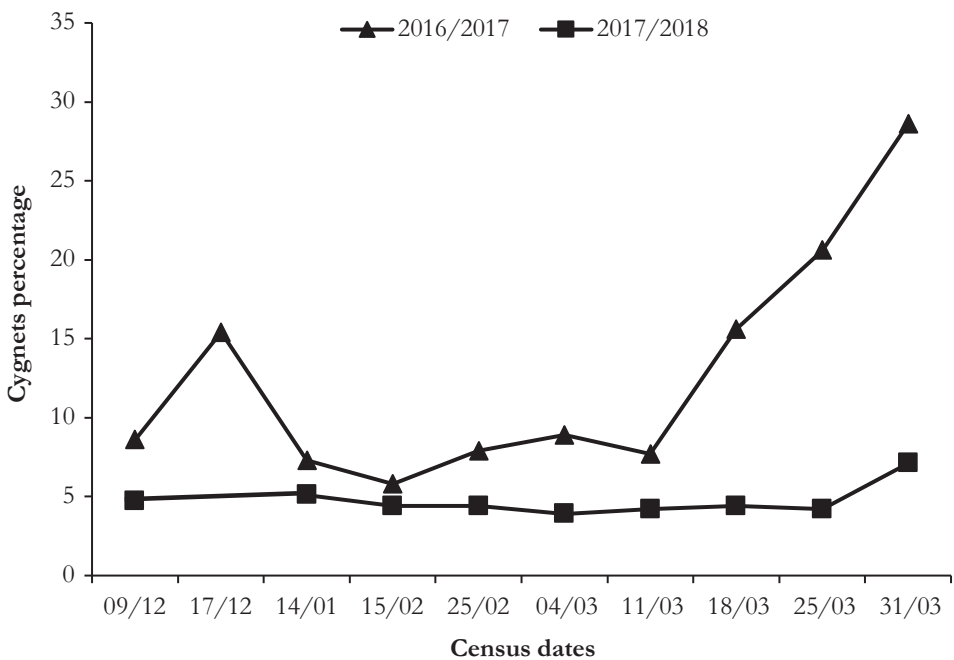

Figure 4. Percentage Bewick's Swan cygnets recorded in flocks wintering in Schleswig-Holstein from early December to end March during winters 2016/2017 and 2017/2018.

Table 1. Percentage of Bewick's Swan cygnets during winter 2016/2017 and 2017/2018 in Schleswig-Holstein (this study), all-Germany (A. Degen, pers. comm.), Britain (https://monitoring.wwt.org.uk) and northwest Europe (Tijsen & Koffijberg 2018).

Winter	Mean % cygnets recorded in Schleswig-Holstein	Trend in % cygnets recorded during the winter	Percentage cygnets recorded on the date of internationally coordinated age assessments (% in December)			
			Schleswig-Holstein	All-Germany	Britain	Northwest Europe
2016/2017	12.64	rising	8.6	10.5	16.5	8.2
2017/2018	4.71	constant	4.7	4.2	5.7	3.9

In 2017/2018, maize stubble was the main feeding habitat on three of the nine count dates on which habitat was recorded, during two counts in early–mid winter but also on one day in mid-March (Fig. 5b). During the other counts made in 2017/2018, the majority of Bewick's Swans were found on grasslands. Feeding in aquatic habitats played a minor role in both winters.

Comparison of roost sites between 2016/2017 and 2017/2018

A total of 51 roost sites were recorded in winter 2017/2018 (Fig. 6), two of which are speculative because only feathers were found and no swans (of any species) were seen there. Eighteen held > 200 Bewick's Swans on at least one count date (Appendix 2), and swans were present for at least half a month at 23 sites. Correspondingly, in 2016/2017 there were data for 11 roost sites and hints (feathers or data from preceding years) for another 11 sites. Habitat types at most roost sites (n = 51) in winter 2017/2018 were grassland (flooded or riparian, 25%) or standing water in peat bogs (22%), but with freshwater lakes (16%) and ponds (14%), dammed rivers (8%) and gravel pits (6%) also used as roosts. Some brackish polders along the North Sea coast (8%) held considerable numbers of roosting swans, especially in autumn or during freezing conditions. In periods with sub-zero temperatures, such as in February and March 2018, many swans remained at the roost (on water or ice) until after sunrise, and flew out late to the fields to feed, sometimes at noon. This resulted in flying flocks frequently being seen over the course of the day.

Duration of stay by individual birds

During detailed observations made in winter 2017/2018, a total of 116 colour-marked swans (62 fitted with neck-collars, 54 with leg-rings) were identified by their leg-ring or neck-collar codes. The overall maximum length of stay was 110 days, *i.e.* nearly 4 months, recorded for a swan with a neck-

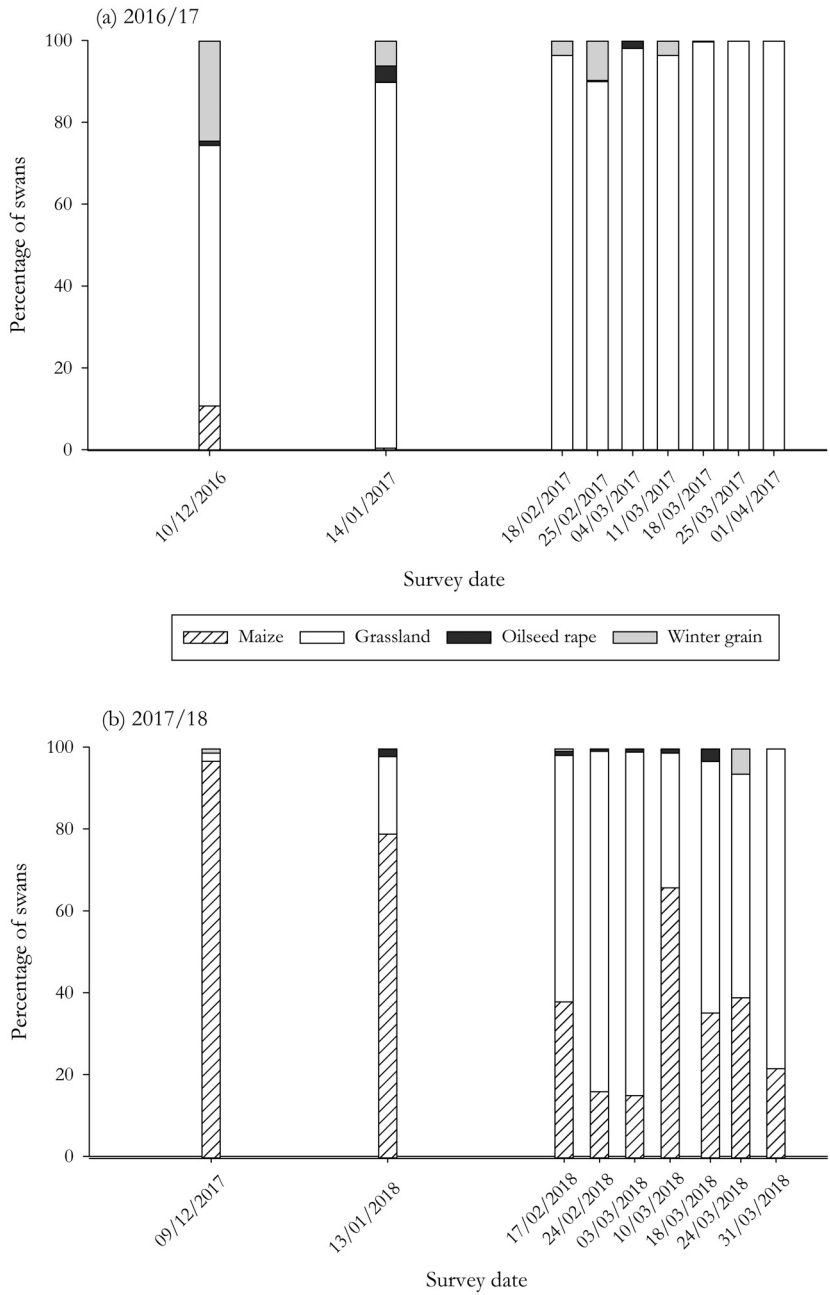

Figure 5. Terrestrial feeding habitats of Bewick's Swans in Schleswig-Holstein in winters a) 2016/2017 (n = 20,924) and b) 2017/2018 (n = 47,138).

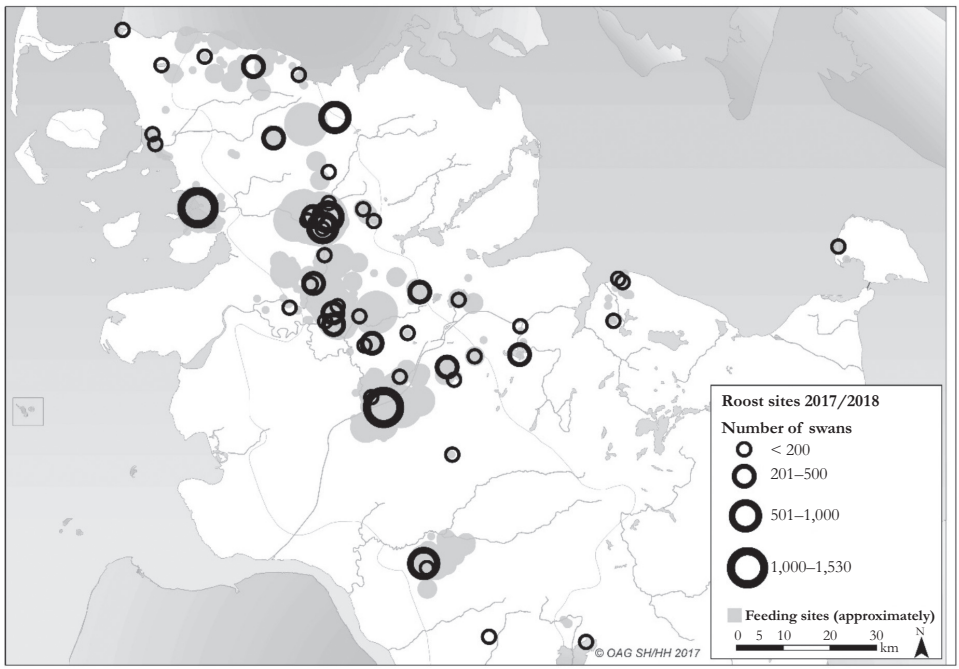

Figure 6. Bewick's Swan roost sites in Schleswig-Holstein during winter 2017/2018. Maximum numbers of observed swans and surrounding feeding sites are indicated.

collar code 056E (Fig. 7a). Six birds with the longest duration of stay in 2017/2018 were seen, on average, on 16.5 count days (range = 9–22) during the winter and their mean length of stay was 99 days (range = 87–110 days) between late November and early April (Fig. 7a). Most of the 116 birds stayed in Schleswig-Holstein for a shorter period, however, with 13 swans recorded in the region for 30–40 days, and 57 were seen between 1–20 days (Fig. 8).

In the preceding winter of 2016/2017, the six Bewick's Swans with the longest duration of stay were seen on fewer (6–11) occasions in Schleswig-Holstein and were in the region for a shorter period (mean = 35 days, range = 27–65 days; Fig. 7b). A seventh swan (neck-collar yellow 024E) was observed here in early December 2016 and again in March 2017, but the time between sightings was too long to exclude the possibility of his moving on to winter outside Schleswig-Holstein.

In winter 2015/2016, one Bewick's Swan (y 950A) stayed for 85 days in Schleswig-Holstein; in earlier winters one birds was seen over a 69-day period, and a few others spent *c.* 40 days in the area.

Discussion

Numbers and distribution

Bewick's Swans have been counted in Schleswig-Holstein since 1953, with increasing

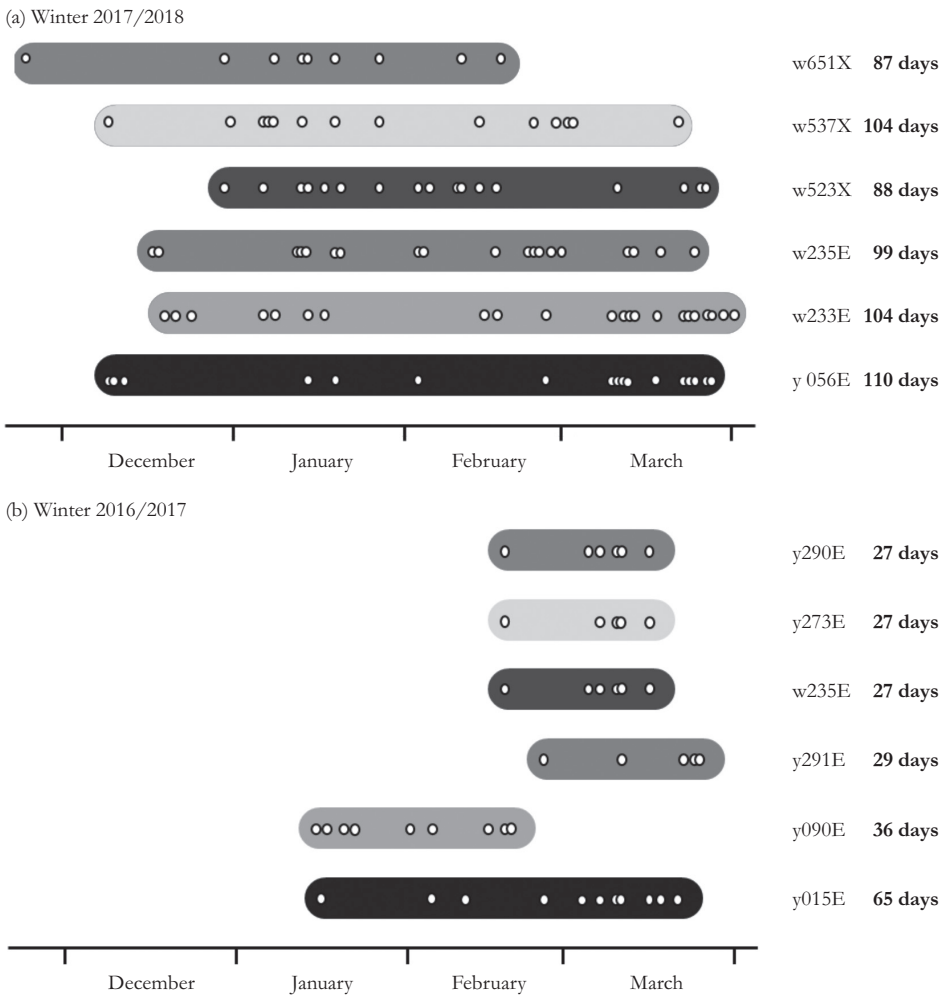

Figure 7. Duration of stay for 11 individual Bewick's Swans identified by their neck-collars in Schleswig-Holstein in (a) winter 2017/2018 and (b) winter 2016/2017 (swan w235E was seen in both years). The maximum number of days between the first and last sightings of each bird in each winter and the number of days on which the birds were sighted during this period are indicated. o = date of the sighting; y = yellow neck-collar; w = white neck-collar; combination of numbers with a capital letter = the neck-collar codes.

intensity over the years, culminating in 9–10 counts per winter in 2016/2017 and 2017/2018. During these last two winters, a systematic monitoring programme was put in place, with volunteer observers coordinating their counts to cover the whole region. Before and also between the censuses, Schleswig-Holstein's ornithologists provided information on new sites potentially being used by Bewick's Swans, resulting in

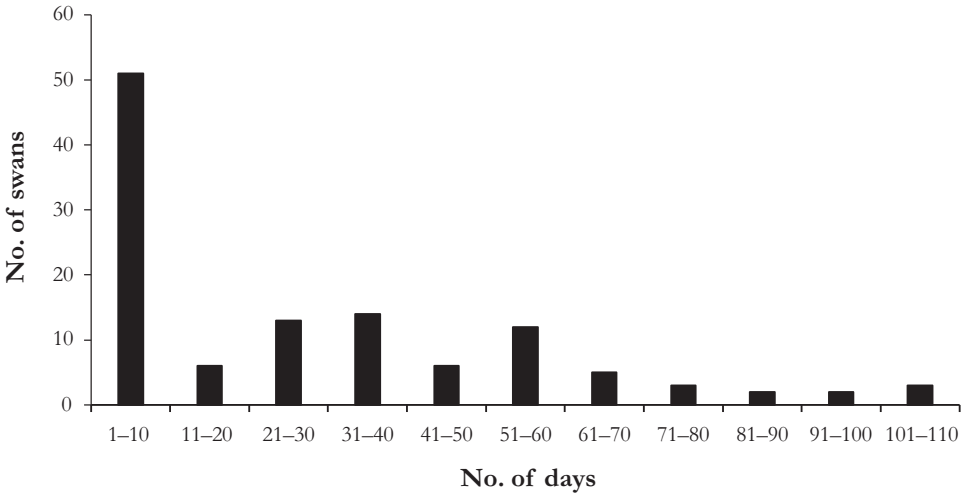

Figure 8. Duration of stay (time spans) by all individually identified Bewick's Swans in Schleswig-Holstein in winter 2017/2018.

10 areas being counted within two days of the census weekend, and nine within 3–4 days of the weekend (*cf.* Appendix 1). There is of course a small possibility of double-counting, but there was little/no evidence for it during 2016/2017–2017/2018; *e.g.* there were no sightings of individual swans seen at a different site on the following day. Given that swan flocks may be overlooked, especially outside the census units, the numbers reported here therefore should be considered as minimum estimates.

The phenology of the Bewick's Swans' use of sites in Schleswig-Holstein in winter 2017/2018 is discussed here in detail. Numbers in December 2017 were twice as high as in the previous year (Fig. 2), and there was a record count of 8,354 at the end of February 2018 (Fig. 2), when most Bewick's Swans were in the Treene, Haaler Au and Sorge count units (Fig. 3a). Freezing conditions and snow cover on 3 March 2018 saw not only a drop in numbers to 6,744 but a relocation of swans from the northern part of Schleswig-Holstein to areas west and south. Roost sites were nearly completely covered by ice, and many swans did not leave their roosts (behaviour also described for swans experiencing cold weather conditions in Denmark and Lower Saxony during the 1990s; Laubek 1995; Degen 1996). By 10 March 2018 some northern areas had thawed and highest numbers of swans were recorded in the northern part of the Treene unit (Fig. 3c). An increase in swan numbers recorded on 24 March 2018 (Fig. 2) corresponded with warmer temperatures (6°C; H-J. Augst, pers. obs.) and incoming swans from the south/southwest included four swans identified by leg-ring code in Lower Saxony earlier in the winter. Rising temperatures and westerly "tail" winds in early April (H-J. Augst, pers. obs.) were favourable conditions for most of

the Bewick's Swans to continue migration and depart for more north-easterly stopover sites.

Most Bewick's Swans in Schleswig-Holstein rest and feed in the Eider-Treene-Sorge Lowlands, north of the Kiel Canal, and also at the Haaler Au Lowland south of the canal (Fig. 3a,b,c), where their feeding and roosting sites are largely located within areas designated as Special Protected Areas under the EU-Bird Directive (Romahn *et al.* 2008). A smaller proportion of Bewick's Swans usually remain in the Hörner Au Lowlands, on the Danish border, and on the Baltic Coast near Kiel. The Fuhlenau counting unit held up to 762 swans in February 2017, but hardly any were seen there in winter 2017/2018; the reason for their apparent abandonment of this area is not known. Former staging sites along the Lower Elbe west of Hamburg are now completely empty, a pattern which commenced in the 1990s (*cf.* Jeromin & Jeromin 2009) and the reasons for this are also unclear, but may perhaps reflect a shift in preferred feeding areas from aquatic (*cf.* Busche 1991) to terrestrial habitats.

Age assessments

Although ageing Bewick's Swans becomes more difficult as the winter progresses, particularly in March as young birds' grey plumage progressively becomes whiter, the percentage of juveniles recorded in winter 2017/2018 was consistent at around 4.7%, in contrast to the previous year (Table 1, Fig. 4). This was the second lowest rate in Schleswig-Holstein since 1964/65 (Jeromin & Koop 2014), but was in the same order as estimates made in Britain, Germany and across Northwest Europe. Bewick's Swans therefore appear to have had an exceptionally poor breeding season in 2017 which can probably be attributed to conditions on their breeding grounds in the European Artic in Russia. Wood *et al.* (2016) found evidence of reduced juveniles in winters following low temperatures during the swans' breeding season and, although mid-summer temperatures on the breeding grounds were warm in both years (1–2°C above the mean temperatures of 1994–2003; www.arcticbirds.net), onset of spring in June/July was earlier than average in 2016 but later than average in 2017, which could contribute to the low proportion of cygnets seen in flocks across the wintering range in 2017/2018.

Feeding habitat

Maize stubble was more commonly used by the swans for feeding in 2017/2018 than in 2016/2017, when they mainly grazed on grasslands. Four possible reasons may explain this behaviour. First, there are numerous maize varieties in use, and the likelihood of cobs falling to the ground on coming into contact with harvesting machines may be greater for some varieties than for others. Second, autumn 2017 was very wet and many maize fields could not be harvested on schedule due to flooding. Standing maize plants therefore remained unharvested for a longer period, and were chaffed or threshed during January or February in preparation of further ploughing, making the grain accessible on the ground for the swans in mid–late winter; for instance, a large flock of swans depleted a freshly chaffed cornfield within just a few days in February 2018 (H.

Jeromin, pers. comm.). Third, on wet fields with standing water, it was difficult for farmers to operate harvesting machines properly and sometimes they could not follow a straight line, so the throw-off often did not reach the trailer being driven alongside, resulting in more grain than usual falling to the ground. Fourth, autumn and winter storms may have flattened unharvested maize fields (*cf.* Clausen *et al.* 2018). All four possibilities would increase harvest waste, making more grain available to the swans.

According to Clausen *et al.* (2018), in late autumn, and probably throughout the entire winter, maize is a high-quality food with an energy content of 13.7 kJ/g, compared to grass (6.7–7.5 kJ/g) and winter cereals (7.3–10.6 kJ/g). They report average energy densities of 3.42 g dry weight/m² (ranging = 0.37–6.52 g dw/m²) for corn in Denmark. Maize is not accessible when frozen into the ground, however, in contrast to the grass sward. Moreover, in mild winters the sward regenerates quickly and is of greater importance for fuelling the swans' onward migration to their breeding grounds in arctic Russia (Beekman *et al.* 2002). Freezing conditions in March 2018 meant that grass growth started later in this year, on 8 April 2018 (A.K. Orthmann, pers. comm.), and Bewick's Swans used mainly maize in winter 2017/2018. Contrastingly, unpublished data from winter 2018/2019 showed comparably high numbers of swans in Schleswig-Holstein, which primarily fed on grasslands rather than maize. There was an expansion of maize growing in Schleswig-Holstein between 1999 (80,000 ha) and 2011 (188,000 ha), followed by a steady decline to 160,000 ha in 2017 (Statistisches Amt 2018) but, although the number of Bewick's Swans in Schleswig-Holstein has increased since the early 1990s (Fig. 9), there is no corresponding decrease in line with the reduction in maize production in recent years. Bewick's Swans are generalist herbivores that feed on a wide range of terrestrial and aquatic plants including crops (Rees 2006; Wood *et al.* 2019a), and changes in swan numbers wintering on the Ouse Washes, an internationally important site for the species in southeast England, were not related to changes in food resources (Wood *et al.* 2019a). This seems similar to the situation described over three winters in Schleswig-Holstein. The Bewick's Swan is a highly mobile herbivorous species which can move readily between different food resources within a landscape (including roost sites, see below), and so it is able to track the most profitable resources (Wood *et al.* 2019b).

Use of roost sites

The number of roost sites where Bewick's Swans were recorded doubled in winter 2017/2018 compared to the preceding year, perhaps simply reflecting the rise in numbers occurring in the region. This may well have occurred, because there were many areas of water suitable for roosting which had not previously been used. Flooded grasslands in low-lying areas and alongside river banks were particularly extensive following heavy rainfall in autumn and early winter 2017, which was 50% above the 20-year average for Schleswig-Holstein (Deutscher Wetterdienst 2017), and the main habitat at the swans' roosts was grassland (25% of roosts). Eighteen of 51 roost sites held > 200 Bewick's Swans

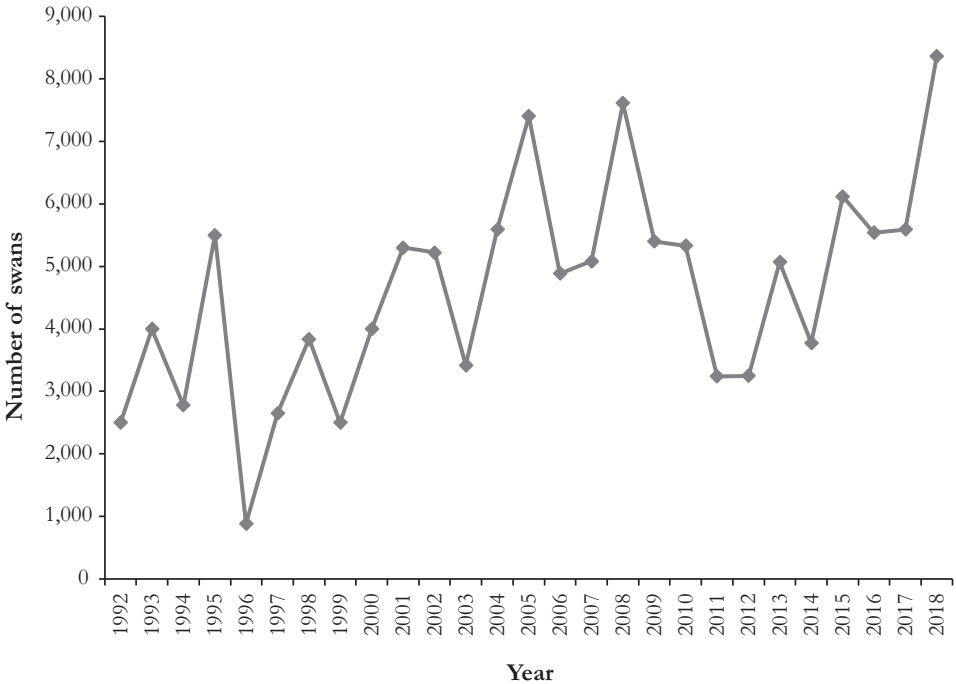

Figure 9. Maximum numbers of Bewick's Swans counted in Schleswig-Holstein each year during 1992–2018 (Bruns *et al.* 2001; Jeromin & Koop 2007, 2014; Wolff 2015, 2016; this study).

(Appendix 2), which is the current threshold for sites of international importance for the species in Northwest Europe (Beekman *et al.* 2019). Most are part of seven Special Protected Areas under the European Bird Directive (compare Romahn *et al.* 2008), but some are not, for example in the Northern counting unit or at Hörner Au. Swan numbers at the roost sites are sometimes a minimum count or an estimate because trees or reed beds made it impossible for ornithologists to see the whole area on counting the birds. Beltringharder Koog on the North Sea coast, a new roosting site, received up to 1,530 Bewick's Swans in winter 2017/2018, particularly during freezing and snow cover in the Northern and Treene count units.

Duration of stay

Marked individuals provided a valuable source of information on the swans' movements and duration of stay at key sites. Neck-collars are usually easier to detect than leg-rings as they are more visible to the observer (Degen 1996; Wood *et al.* 2018), and not all leg-rings could be detected. Hence, the length of stay given here is normally longer than the detection period and the timing should be taken as a minimum number of days, albeit bearing in mind that the time between two sightings should not be too long because this raises the possibility that the individual could have left Schleswig-Holstein during the intervening period. This region is small (*c.* 200 km from north to south) and a

Bewick's Swan is able to cross or leave the region within one day. In 2018 the Bewick's Swan with white neck-collar 231E was seen in northeast Lower Saxony on 8 February and two days later was in the Northern count unit of Schleswig-Holstein. The maximum numbers of days between two sightings in Schleswig-Holstein (and nowhere else in other regions) for six swans seen over the longest period in winter 2017/2018 (mean duration of stay = 99 days; range = 87–110 days) was on average 26.6 days (range = 21–35 days), indicating that these birds were present for most of the winter. There remains the possibility, however, that they could have left the region briefly and not been sighted before returning to Schleswig-Holstein.

Overall, *c.* 5% of marked Bewick's Swans observed in Schleswig-Holstein were present for 3–4 months during winter 2017/2018. This percentage was lower in the preceding winters, and it is important with the increasing numbers wintering in Germany to monitor how this pattern develops in future years. It is not easy to quantify changes in observer effort and how this may influence re-sightings rates because distances covered and the personal interest of the observers may vary, but we consider that ring reading activity in Schleswig-Holstein has been consistent for the years described in this study.

Overview

We suggest that the study indicates three trends for Bewick's Swans staging and wintering in Schleswig-Holstein, as follows:

1) *An increase in numbers.* Maximum Bewick's Swan counts for Schleswig-Holstein (recorded during the January–March censuses) doubled between winters 2017 and 2018. Numbers in winter 2016 were somewhat similar to those of winter 2017 (Wolff 2016), and counts made in winter 2015 (Wolff 2015) were between those of 2017 and 2018. Numbers in winter 2019 (Ornithological Working Group of Schleswig-Holstein and Hamburg, unpubl. data) remain high and are comparable with those of 2018. Before the coordinated counts were initiated in 2015, yearly maximum numbers (during 2002–2014 inclusive) ranged from 4,000–5,000 birds in mild winters (*cf.* Fig. 9), with an overall maximum of 7,611 in 2008. The lowest peak count during the 2002–2014 period was 3,243 in 2011, when the winter was very cold (Jeromin & Koop 2014).

The peak number of 8,354 at the end of February 2018 was the highest recorded for Schleswig-Holstein (Busche 1991; Bruns *et al.* 2001; Jeromin & Koop 2014; Wolff 2015, 2016). Even in former years, Schleswig-Holstein held up to a third of the Northwest European population of Bewick's Swans during some weeks, especially in March, when *en route* to other stopover sites and breeding grounds in the European Russian Arctic (Jeromin & Koop 2014). The maximum numbers of Bewick's Swan counted in Schleswig-Holstein (in March, *cf.* Fig. 9), when considered in relation to population size estimates recorded for the Northwest European population during the 5-yearly international censuses of 1995–2015 (Beekman *et al.* 2019), represented on average 25.8% of the total population size (range = 17.0–34.4%), with the proportion increasing over the past two decades. In

contrast to this positive development in Schleswig-Holstein, Bewick's Swan numbers have been declining in the western part of the wintering range (seen Frost *et al.* 2019 for the UK; Koffijberg 2018 for the Netherlands; Beekman *et al.* 2019 for the population as a whole), suggesting that a higher proportion of the swans are now wintering in Germany.

2) *Earlier arrival and peak counts*. In addition to the higher peak counts, numbers recorded in December 2017 were also higher than usual at comparable times in previous years (*cf.* 2016 in Fig. 2; 2011–2015 in *ornitho.de*). Moreover, yearly maximum numbers appeared in late February in 2017 and 2018, whereas in former years they peaked only in March. In February 2017, the maximum number of Bewick's Swans recorded in Schleswig-Holstein (5,591 birds) appeared 10 days earlier (25 February) than the mean date of the peak counts (7 March) across nine former winters for which exact records are known (*cf.* Jeromin & Koop 2014).

3) *Longer duration of stay in Schleswig-Holstein*. As a consequence of 1) and 2), swans seem to stay longer in Schleswig-Holstein for the winter, a view supported by ring re-sightings (*cf.* Fig. 7 and explanatory text). These trends coincided with mild temperatures in the autumn and early winter of 2017/2018; from October 2017 to January 2018 it was 1–3°C warmer than the 30-year average (Deutscher Wetterdienst). Although longer-term data and statistical analyses are needed to confirm factors affecting the swans' duration of stay in Schleswig-Holstein, previous studies have shown that, in general, mild climate can allow migratory birds to remain closer to their breeding grounds (Guillemain *et al.* 2013), especially through indirect changes in availability of food (Månnson & Hämäläinen 2012).

In summary, recent observations found an increasing importance of the lowlands of Schleswig-Holstein as a suitable over-wintering area for Bewick's Swans, perhaps combined with a decreasing function of Schleswig-Holstein as a short stopover area for the species during spring migration. These findings correspond with Beekman *et al.* (2019), who showed by analyses of all international censuses in mid-January some evidence of a shift in the winter range over time, and that such variation between censuses in the proportion of swans in different parts of the range could be attributed to weather conditions. Lehikoinen *et al.* (2013) found such a north-eastward shift of the wintering distribution of three duck species in the Northwest European flyway over three decades (1980–2010) and Pavon-Jordan *et al.* (2015) had similar results for Smew *Mergellus albellus*. In North America, the winter distribution of the Pacific Brant *Branta bernicla nigricans* has moved northward from low-temperate areas to sub-Arctic areas over 42 years (Ward *et al.* 2009). Teitelbaum *et al.* (2016) show that older individuals of Whooper Cranes *Grus americana* with more experience are critical for innovating such a shift closer to the breeding grounds, and have used former stopover sites for overwintering in recent years. Comparably, the Bewick's Swan is a long-living and social species which should perhaps be able to adapt to some factors of climate change.

Although this study focusses mainly on the results of observations made in winters 2016/2017 and 2017/2018, it continues waterbird monitoring undertaken in Schleswig-Holstein since 1953. The older data lack the frequency and detail required to assess the historical situation, but substantial more recent data recorded in the online data portal *ornitho.de* since 2012, and ring readings of marked Bewick's Swans for over 20 years, should be analysed statistically to provide a more rigorous assessment of the swans' use of sites in the region.

Future research in Schleswig-Holstein will hopefully have the basis of regular censuses made by 70 or more volunteers coordinated by the Ornithological Working Group of Schleswig-Holstein and Hamburg. Given the seasonal changes observed, it is recommended that the censuses be started earlier, in autumn (*i.e.* end of October or November). The role of feeding habitats, especially maize, grain or types of grassland, in conjunction with weather conditions should be analysed; also the often varying locations and conditions of night roosts including their connections to feeding sites. A key method for assessing the significance of the region is evaluating re-sightings of marked Bewick's Swans. This could be addressed through further examination of existing data and of future (perhaps more frequent) observations. The number of re-sightings is dependent on the interests and skills of observers, but these re-sightings and analyses are important for assessing whether there is evidence for a shift of wintering grounds from west to east.

Better and more complete movement data could be gained by satellite-tracking individual birds, *e.g.* through the use of GPS-loggers (Griffin *et al.* 2016). In autumn 2017 (from 21 November to 2 December) there were signals from the Oberalster Lowlands in Schleswig-Holstein by "Maisie", a female Bewick's Swan marked as adult with a collar-mounted GPS-GSM logger at the WWT Wetland Centre in Slimbridge, UK, on 19 January 2015 (Griffin *et al.* 2016). As a result of these signals, a new counting unit was included in our study (Fig. 1) and two roost sites (Fig. 6) were discovered that no one had ever seen from the ground. These satellite signals make it easier to plan the next censuses and give hints to observers about sites being used by the birds. In particular, transmitter data could give information on unknown roost sites, which is important for site management and conservation. Count units could be enlarged, or formerly-used units temporarily without swan observations could be used again. These signals therefore are very useful for analysing short-distance movements within the region, including for assessing site-fidelity, as well as for describing long-distance movements between regions. Fitting Bewick's Swans with GPS-GSM loggers in Schleswig-Holstein therefore is now being discussed.

The Northern count unit joins the Danish border, which is crossed daily by swans. Starting in autumn 2017, counts were made on the Danish side which were important obtaining complete information about the swans' use of the area. For a better understanding of the conditions in the eastern part of the wintering range for the Northwest European Bewick's Swan population, it would be useful to get data

from comparable censuses for the whole of Denmark, and of course from other regions of Germany (especially in Lower Saxony), as Schleswig-Holstein covers only a part of this wintering area. A good start for that could be the next international census, scheduled for January 2020.

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Appendix 1: Results of the Bewick's Swan monitoring programme in Schleswig-Holstein, Germany, in winters 2016/2017 and 2017/2018.

Winter	Date of maximum count	Count dates (first and last)	No. count areas	No. observers	No. Bewick's Swans counted	% cygnets
2016/2017	03/12/2016	02/12 to 06/12	?	19	292	8.6
	17/12/2016	17/12 to 18/12	89	23	485	15.4
	14/01/2017	14/01 to 15/01	89	24	641	7.3
	11/02/2017	10/02 to 12/02	89	25	1,971	5.8
	25/02/2017	24/02 to 28/02	96	21	5,591	7.9
	04/03/2017	04/03 to 05/03	97	23	5,187	8.9
	11/03/2017	11/03 to 12/03	96	25	4,633	7.7
	18/03/2017	18/03	96	17	1,977	15.6
	25/03/2017	24/03 to 25/03	88	17	611	20.6
	31/03/2017	31/03 to 01/04	44	6	21	28.6
2017/2018	09/12/2017	09/12 to 10/12	99	30	1,027	4.7
	13/01/2018	13/01 to 14/01	99	29	3,183	5.1
	17/02/2018	17/02 to 18/02	104	33	5,732	4.4
	24/02/2018	24/02 to 26/02	103	28	8,364	4.4
	03/03/2018	03/03 to 06/03	78	30	6,744	3.9
	10/03/2018	10/03 to 12/03	106	31	6,184	4.2
	18/03/2018	17/03 to 20/03	107	31	5,161	4.4
	24/03/2018	23/03 to 27/03	112	27	5,799	4.2
	31/03/2018	30/03 to 02/04	78	27	4,964	7.1

Appendix 2. Bewick's Swan roost sites in Schleswig-Holstein where > 200 swans were counted in winter 2017/2018. * = new roosts (not known in winter 2016/2017); **roost site in bold font** = swans present for more than half a month.

Count unit	Roost site name and coordinates	Habitat type. Open water in:	Duration of roost, date and maximum no. swans counted
1) Northern	**Bramstedtlund**	Gravel pit	Beginning to end of December
	54°50'13.38"N/9°05'4.60"E		11/12/2017: **250**
	Hüllerup*	Gravel pit	End of December to mid-February, beginning of March
	54°44'20.57"N/9°21'17.34"E		21/01/2018: **>1,000**
	Süderhuus*	Pond	End of March
	54°42'0.58"N/9°09'4.34"E		25/03/2018: **220**
2) Treene	**Ipland, Treene near Geilwang***	Grassland	Mid-December to beginning of January, mid-March
	54°31'39.29"N/9°18'48.97"E	(riparian flooding)	18/03/2018: **542**
	Harenburg, Treene*	Grassland	Mid-December to mid-January, and mid to end of March
	54°32'52.59"N/9°19'52.52"E	(riparian flooding)	18/03/2018: **702**
	Bondelumer Moor*	Pond	Mid to end of March
	54°32'55.73"N/9°16'56.66"E		27/03/2018: **400**
	Treene-Sinuosity Winnert*	Grassland	Beginning February to end of March
	54°25'9.04"N/9°16'58.70"E	(riparian flooding)	02/03/2018: **350**
3) Sorge	Spieljunken	Grassland	December, and end of March
	54°21'48.18"N/9°20'46.65"E	(flooded)	18/12/2017: **242**
	2 **Polders at Alte Sorge-Sinuosity**	Grassland	Mid-February to end of March
	54°20'25.34"N/9°20'53.20"E	(flooded)	17/02/2018: **404**

Appendix 2 (*continued*).

Count unit	Roost site name and coordinates	Habitat type. Open water in:	Duration of roost, date and maximum no. swans counted
4) Eider	Eider near Wittenberge*	River	Mid-March
	54°11'58.25"N/9°28'14.81"E	(dammed)	18/03/2018: **200**
	Hohner See*	Lake	Beginning to mid-March, during frost
	54°18'15.32"N/9°28'25.10"E		18/03/2018: **490**
5) Haaler Au	**Haaler-Au-Polder**	River	December to March
	54°10'49.42"N/9°30'41.40"E	(dammed)	01/03/2018: **1,400**
6) Wildes	**Wildes Moor near Rendsburg**	Peatbog	December, and mid-March to beginning of April
Moor RD	54°15'26.52"N/9°43'11.38"E	(dammed)	31/03/2018: **263**
7) Hörner Au	**Breitenburger Moorsee**	Peatbog	End of November to beginning of April
	53°52'50.74"N/9°38'11.48"E	(excavated)	02/03/2018: **665**
8) Other areas	**Beltringharder Koog***	Brackish polder	Mid-December to beginning of February, end of February to mid-March
	54°33'57.69"N/8°53'59.17"E		03/03/2018: **1,530**
	Owschlag*	Gravel pit	Beginning to end of March:
	54°24'7.29"N/9°37'55.53"E		30/03/2018: **400**
	Westensee*	Lake	End of March to beginning of April
	54°16'44.17"N/9°57'30.36"E		01/04/2018: **450**