The effect of neckbands on the pairing status of Greater White-fronted Geese *Anser albifrons*

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Abstract

Individual marking is an essential method in avian ecological research, yet the potential ecological effects of tagging remain a concern. In this study, we investigated whether the presence of neckbands on Greater White-fronted Geese *Anser albifrons* affected the probability an individual was paired to another at a spring migratory stopover. Videos (15–30 min in duration) were recorded for 25 neck-banded and 25 randomly selected unmarked geese. From visual assessment of the behaviour of focal birds, pairing status (single or paired) was assessed for each. Our results found that over 70% of the neck-banded Greater White-fronted Geese were paired, and that there was no significant difference in pairing status between neck-banded and unmarked geese. Further studies with bigger sample sizes and using more advanced methods are needed to assess potential impacts of neckbands on the pairing status of Greater White-fronted Geese in greater detail.

Key words: individual marking, neck collars, necklace, pair bonds, pairing status.

Plastic coloured neckbands have been widely used for marking and thus identifying individual geese and swans (Marion & Shamis 1977). In recent decades, they have become even more popular as a method for attaching tracking devices to birds (Kays *et al.* 2015). Yet, as shown in many previous studies, neckbands (like other marking methods) can affect different aspects of birds' biology, including performance of different types of behaviour, reproductive success, body condition and survival (Calvo & Furness 1992; Barron *et al.* 2010). Moreover, the same marking technique can have varying effects across species, even closely related ones, due to differences in anatomy, feather colouration, ecology and behaviour (Clausen & Madsen 2014; Thaxter

et al. 2016; Eldegard *et al.* 2024). The effects of neckbands on survival in geese are complicated and appear to vary between species. For example, there was no evidence found for them influencing survival in a study on Greater Snow Geese *Anser caerulescens* (Reed *et al.* 2005), but an increase in mortality related to neck-banding was demonstrated in some other goose species including Canada Geese *Branta canadensis*, Greater White-fronted Geese *Anser albifrons* (Alisauskas & Lindbeg 2002) and Ross's Geese *Chen rossii* (Caswell *et al.* 2005). Among the reasons for enhanced mortality, the authors mention icing of the neckbands, increased risk of predation and extra energetic costs arising from wearing the neckbands, as well as hunters selectively shooting neck-collared birds.

Several studies of various goose species have shown that neckbands can also affect their reproductive success. For example, marking individuals with neckbands was associated with a decrease in body mass in Greater Snow Geese, resulting in reduced breeding propensity (Reed *et al.* 2005; Legagneux *et al.* 2013). Decreased reproductive success was similarly attributed to increased energy demands caused by wearing a neckband in Emperor Geese *Anser canagicus* (Schmutz & Morse 2000), but no effects of neckbands were found on a visual score of body condition recorded for Pink-footed Geese *Anser brachyrhynchus* (Clausen & Madsen 2014). Another mechanism by which neckbands can have a negative effect on reproductive success was found in Brent Geese *Branta bernicla*: by covering the necklace, which is important for mate choice and individual recognition, neckbands lowered the social rank of competing birds (Abraham *et al.* 1983) and reduced nesting success (Lensink 1968). In contrast, no effect of neckbands on reproductive success was found in Canada Geese, which also have contrasting neck feathers colouration (MacInnes & Dunn 1988). In Greater White-fronted Geese, the impact of neckbands on reproductive success remains unexplored. In addition, the majority of studies reporting neckband-caused decreases in reproductive success have focused on nesting success and clutch size (MacInnes & Dunn 1988; Schmutz & Morse 2000; Reed *et al.* 2005) rather than on pairing status itself (single or paired), despite pair bond interactions being crucial throughout the year in geese, which are lifelong monogamous birds (Black & Owen 1988; Black 2001).

As an initial step in studying the impact of neckbands on reproductive success in Greater White-fronted Geese, it consequently seems worthwhile to assess whether neckbands influence pairing status in this species. Here, we define the term "pairing status" as whether a focal goose has a social mate or not, based on persistent close association in the field (in contrast to "mating status" which relates to whether copulation has occurred or not). In this study, we compared the proportion of single and paired birds between samples of neck-banded and random unmarked Greater White-fronted Geese.

Methods

Data collection

Fieldwork was carried out in 2022 (30 April–9 May) and 2023 (29 April–10 May) in the

"Kologrivskaya Poima" Regional Nature Reserve located in the Kostroma region of Russia (58.816°N, 44.300°E; Supporting Materials Fig. S1). This nature reserve covers the right-bank floodplain of the River Unzha, opposite the town of Kologriv, and is known as an annual spring migratory stopover for 10,000–15,000 wild geese, mainly Greater White-fronted Geese (Glazov & Loshchagina 2022).

Cameras (a Nikon D7500 with an AF-P NIKKOR 70–300 mm 1:4.5–6.3 ED lens, and a Canon EOS 1100D with a Canon EF 75–300 mm 1:4–5.6 III lens) and smartphones attached to telescopes (Zeiss DiaScope 65 FL) were used to make 15–30 min (mean ± s.d. = 24 ± 4.6 min) video recordings of neck-banded and randomly selected unmarked geese. To keep disturbance to the birds to a minimum, all video recordings were taken from the roadside at a distance of 50–250 m from the focal geese. A total of 50 different birds were filmed, of which 25 had neckbands and a further 25 were unmarked geese. Unmarked geese were filmed only once, while for each neck-banded goose there were 1–6 different videos, each filmed on different days (1 video for each of 9 geese, 2 videos for 7 geese, 3 videos for 3 geese, 4 videos for 3 geese, 5 videos for 1 goose, and 6 videos for 2 geese).

To ensure that unmarked geese chosen as focal birds for observation were selected at random from within the flock, a special technique was developed: before the recording started the camera lens was pointed towards the flock, then covered with a lens cap, zoomed in, and the lens cap was then removed. The bird which appeared in the centre of the camera screen was chosen as the focal bird. Since several thousand Greater White-fronted Geese were observed simultaneously every day during the study, the chance of recording the same unmarked focal bird in different videos was insignificant. Thus, we considered all the focal unmarked geese to be different individuals.

Greenland White-fronted Geese *Anser a. flavirostris* usually form pairs in their second or third year, with the mean age of pair formation being 2.46 years (Warren *et al.* 1992). This can be assumed to be true for other Greater White-fronted Goose subspecies and, therefore, to ensure that only geese of suitable age for pair formation were analysed, young birds without a clear black belly bar were not filmed. Since the black pattern on the bellies of Greater White-fronted Geese does not normally appear until their second year (Boyd 1953), all birds recorded were considered to be no younger than in their second spring.

Using the geese.org database (at https://www.geese.org), the ringing location, age of the geese at the time of ringing and the time since first fitted with a neckband were determined for each of the neck-banded individuals (Supporting Materials Table S1). All the filmed geese were neck-banded on their wintering grounds, at the migratory stopover site (this study site) or on the moulting grounds, where geese of all ages and different pairing status are equally likely to be captured. The neck-banded geese had all been wearing their neck collars for > 1 year before the start of this study, and the time that each had worn a neckband ranged 1–10 years, with a mean (± s.d.) duration of

4.1 ± 2.5 years. Geese ringed one year prior to our study were already adults at the time of capture. Thus, the neck-banded geese were at least in their third spring, although the ringing data available did not allow us to obtain a more accurate estimate of the age structure of the birds sampled.

Pairing status analysis

According to a previous study of Greater White-fronted Geese at the same migratory stopover site, paired birds kept a distance ≤ 2 m from each other for at least 74% of the time during 20 min observation periods (Polikarpova *et al.* 2024). That study found a significant difference in the percentage of time that focal geese spent at a distance of ≤ 2 m from their partners (74%–100%), in comparison with other random geese in the flock (1%–65%), with 74% being the lowest value recorded for paired birds. In the current study, if a focal goose was accompanied by another bird, which stayed within 2 m of the focal bird for > 74% of the time, the focal goose therefore was considered to be paired. This method was used for both marked and unmarked birds.

For additional validation of the accuracy of pair identification by this method, we also used repeated observations of the same marked birds (we had repeated observations for 16 of 25 marked geese). Additional videos of the same marked birds were recorded on different dates in the same year and at the same site. Since the black barring pattern on the bellies of Greater White-fronted Geese does not change during the season and varies between individuals (Kristiansen *et al.* 1999), these patterns can be used for individual identification of geese. The pattern of the black belly bars on birds spending > 74% of the time near the focal bird was compared in videos recorded on different days. In all cases, geese spending > 74% of the time near the focal birds had the same black barring pattern in the videos recorded on different days. Therefore, the method of 74% of the time was considered to be appropriate for determining the pairing status of Greater White-fronted Geese.

Statistical analysis

Statistical analysis was conducted in PAST software, using a χ^2 test to evaluate the difference in pairing status of neck-banded and unmarked geese. The assumptions of χ^2 test were met (McHugh 2013).

Results

Among the 25 neck-banded geese, 18 individuals (72%) were associating with a bird that spent > 74% of the recorded time within 2 m, and were therefore classified paired. Among the sample of unmarked geese, 20 of 25 (80%) individuals were paired according to this criterion (Supporting Materials Table S2). The proportion of paired and single birds did not differ between neck-banded and unmarked Greater White-fronted Geese ($\chi^2_1 = 0.44$, n.s.).

Discussion

In our study, more than 70% of neck-banded birds were paired, slightly fewer (but not statistically significantly so) than among unmarked birds. This indicates that neckbands do not have a strong and obvious impact on an individual's pairing status through its main components: pair bond

maintenance and, to some extent (given the age of the neck-banded birds included in the study), pair bond formation in Greater White-fronted Geese. Nevertheless, a potential subtle effect of neckbands on pairing status may have been obscured by the limited sample size and possible age differences between the birds observed.

Neckbands have previously been shown to have an adverse effect on the pairing success of Brent Geese (Lensink 1968; Abraham *et al.* 1983). The authors suggested that neckbands may inhibit pair bonding of marked individuals by obscuring the contrasting white necklace, which in that species is thought to play an important role in intraspecific competition and mate choice. Furthermore, they assumed that the necklace phenotype is involved in individual recognition, and therefore marking with neckbands may cause pair bond breakdown in Brent Geese. The mechanism of mate choice in Greater White-fronted Geese remains unclear, but for some other goose species (Canada Geese and Greater Snow Geese), the image of a future partner has been shown to be based on parental imprinting (Cooke & McNally 1975; Fabricius 1991), so the appearance of an individual should in some way affect mate choice.

The lack of a significant effect of neckbands on pairing status in Greater White-fronted Geese allows us to speculate that individual recognition in existing partnerships and probably mate choice are less dependent on neck feather colouration in this species than in Brent Geese. It may well be the case that other individual features that are unaffected by tagging with neckbands should be more important in the mechanisms of pair bond formation and maintenance. Certainly young Greenland White-fronted Geese fitted with neckbands in their first-winter appear to have no problem finding mates after they disassociate from their parents (A.D. Fox, pers. comm.). However, it is important to note that in our own study we did not know whether pairs were established before or after neck-banding. Assessing the separate effects of neckbands on pair formation (mate choice) and pair bond maintenance (individual recognition) may reveal more information, which is not available when both aspects of pairing status are analysed together. Since our sample included mostly geese neck-banded as adults, our results primarily determine the effect of neckbands on pair bond maintenance and only to some extent on pair bond formation. To investigate the impact of neck-banding on the creation of pair bonds, a study on geese neck-banded as juveniles is required.

It should be noted that, in Greenland White-fronted Geese, parent-offspring and sibling-sibling associations may persist for many years (Weegman *et al.* 2016), which may also be true for other subspecies. In the current study, we did not distinguish between these possibly observed family associations and male-female pairs. However, the probability of observing another family association was the same in the samples of neck-banded and unmarked geese.

A serious limitation of the data is a potential age bias between the neck-banded and unmarked geese. While the age of marked geese all varied beyond their third spring, some of the unmarked geese in our

study could possibly have been in their second spring. Previously, Boyd (1954) reported that three of 27 (11%) three-year old or older Greater White-fronted Geese were unpaired on the wintering grounds, and one out of 20 (5%) was single in their fourth winter or later. Based on these data, it can be assumed that 90% of geese are paired after reaching their third winter and this proportion does not differ in older age classes. Hence, all geese older than their third winter have a similar probability of being paired; second spring geese less so. Boyd's (1954) age structure model of wintering Greater White-fronted Geese estimated that 21%–37% of adult geese (2nd calendar year and older) were second-winter birds, of which approximately half were already paired (Warren *et al.* 1992). Therefore, a third (or fewer) of the unmarked birds in our sample could have been less likely to be paired than the neck-banded geese. This bias should be considered as a significant limitation; however, most neck-banded birds were nonetheless paired. Further research on larger samples of known and similarly aged birds is needed for making more detailed conclusions about the potential impacts of neckbands on the pairing status of Greater White-fronted Geese.

In conclusion, this study shows that over 70% of neck-banded Greater White-fronted Geese were paired, a proportion consistent with that observed in unmarked geese, suggesting no obvious effect of neck-banding on pairing status in this species. However, the limitations of this study did not permit the detection of more subtle effects of neckbands on the birds' pairing status, including pair bond formation and maintenance. As a starting point for further research, this study provides a general understanding of the scientific questions being raised and highlights constraints that need to be overcome in future.

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Photograph: Greater White-fronted Geese in flight near Kologriv, Kostroma Oblast, Russia, by Olga Babkina.