

Globally threatened Lesser White-fronted Goose *Anser erythropus* nesting in association with Peregrine Falcons *Falco peregrinus* in southern Yamal, Russia

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Abstract

Knowledge about the breeding biology and potential threats on the breeding grounds is important for conservation of threatened species. The main breeding range of the Lesser White-fronted Goose *Anser erythropus* (LWFG) forms a belt along the southern part of the Russian arctic and, although their main nesting habitat has been described based on observations of broods or pairs with breeding behaviour, only very few observations of confirmed nests have been reported. Since 2006, we have encountered 36 nests of this rare species in the Erkuta River basin (in the southern part of the Yamal Peninsula), described their nesting habitat and found that 71% of nests were associated with territorial Peregrine Falcons *Falco peregrinus*. Such a nest association, already described for other Siberian wildfowl, is assumed to increase the nest survival of LWFG in areas with high predation rates, but also raises indirect conservation concerns since the Peregrine Falcon is itself a rare species in many regions of Russia.

Key words: arctic, breeding biology, nest association, nest protection.

Detailed knowledge about breeding biology, habitat requirements and ecological interactions are important for understanding the variables that drive the dynamics of bird populations. In addition to food and habitat availability, predation can affect breeding success for some species, which in turn may result in protective breeding associations (where the proximity of a predator reduces the risk of predation by other predators) being essential for successful reproduction (Blanco & Tella 1997; Quinn & Ueta 2008). Understanding key factors affecting breeding outcomes is particularly important for the protection of endangered species. Nevertheless, for many rare species such knowledge is still very limited, especially for species breeding in low densities (by virtue of their rarity) and in remote areas.

The Lesser White-fronted Goose (LWFG; *Anser erythropus*) is a globally threatened species. It has been rapidly declining since the middle of the 20th century and is currently classed as “Vulnerable” by the International Union for Conservation of Nature (IUCN Red List 2022). Three natural populations are recognised (Jones *et al.* 2008): the Fennoscandian, Western Russian and Eastern Russian population. The most dramatic decline occurred in the Fennoscandian population (probably including those on the Kola Peninsula); in 2008, fewer than 20 pairs of native birds were still breeding in Norway, although the population may have recovered slightly since then (Marolla *et al.* 2019). In the Russian arctic, a western and an eastern population have been described, distinguished by their different flyways and wintering grounds. The western population, which breeds in

European Russia east to the Taimyr Peninsula, declined considerably in the 1990s, with numbers of nesting pairs reduced in several key breeding areas (Morozov & Syroechkovsky 2002). The eastern population, which extends from east of the Taimyr peninsula to Chukotka (Tian *et al.* 2021), is also in decline (Fox & Leafloor 2018).

In Russia, LWFG breed mainly in the shrub tundra and forest-tundra zones. Most data on habitat use by breeding birds are based on records of broods, with few researchers reporting observations of incubated nests (Fig. 1A). The most typical breeding habitat of the species consists of river valleys, where steep cliffs provide nesting sites, and the floodplains (with willows *Salix* sp., grasses and sedges) or sand banks (mainly with horsetails *Equisetum* sp.) provide feeding grounds (Morozov 1999; Rozenfeld 2001; Krechmar & Kondratyev 2006; Tian *et al.* 2021). In some areas, such as the Bolshezemelskaya tundra (Fig. 1A; Mineev 1987; Mineev & Mineev 2013), and in the southern part of the Yamal Peninsula (Morozov 1995; Morozov & Kalyakin 1997; Mechnikova *et al.* 2005), LWFG have been reported nesting under the protection of birds of prey such as falcons (Peregrine Falcon *Falco peregrinus*, Gyrfalcon *F. rusticolus* and Merlin *F. columbaris*) or Rough-legged Buzzards *Buteo lagopus*. Nesting under the protection of avian predators is well documented for many goose species as a strategy to avoid predation from foxes *Vulpes* sp., skuas *Stercorarius* sp. and other predators, and is especially common among *Branta* species (Ebbing & Spaans 2002; Quinn *et al.* 2003; Kharitonov *et al.* 2008). For larger geese such as *Anser* species,

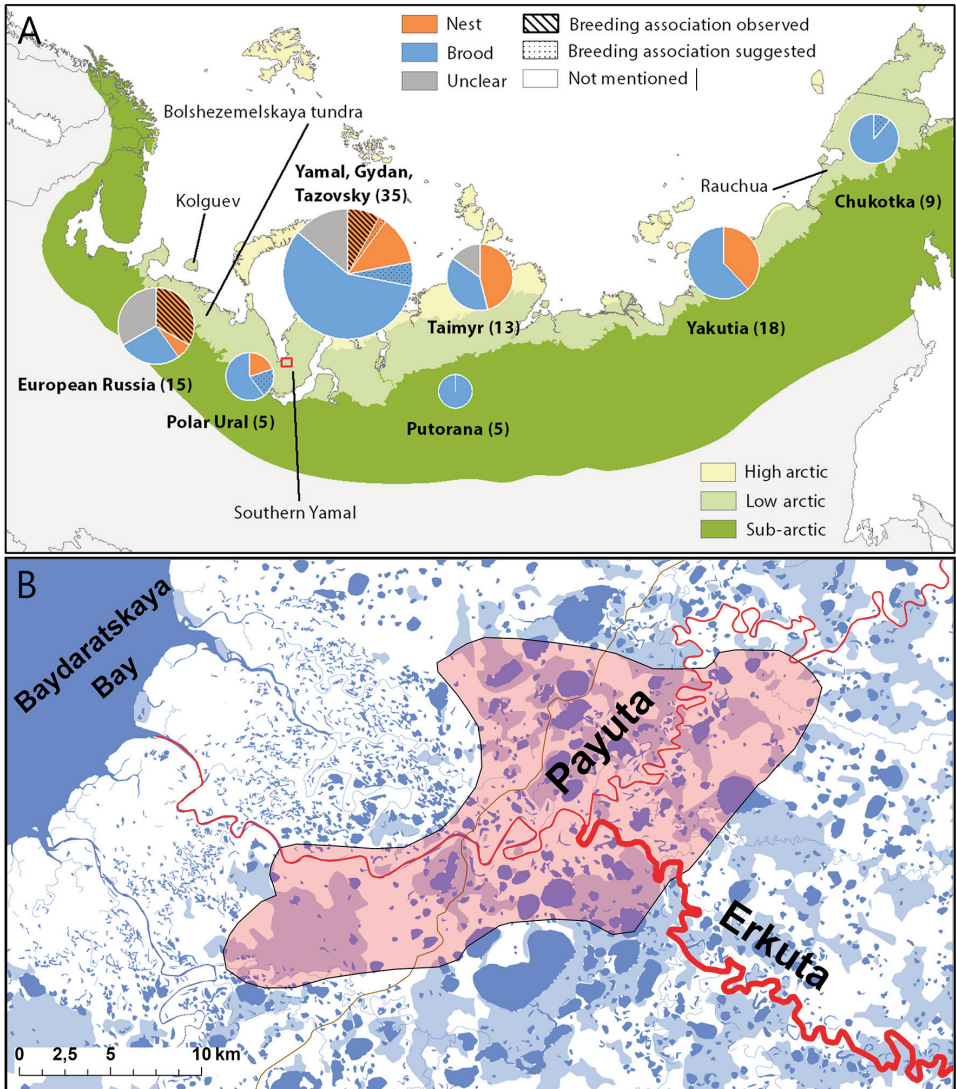


Figure 1. (A) Map of the Palearctic showing the sub-arctic and low arctic zones. Pie charts summarise the available information on breeding of Lesser White-fronted Geese in different regions according to categories reflecting how well the observations were documented and described (see Supporting Materials Table S1). The pie charts are based on the number of reports about a certain place in a certain period, which are given in parenthesis after the names of the regions. All references are provided in Supporting Materials Table S2. The red square shows the location of our study area in southern Yamal. (B) Map of the study area in southern Yamal with the upper reaches of the River Erkuta in red and the main study area shaded in pink.

protected nesting is not so common but has also been recorded. Greater White-fronted Geese *A. albifrons*, for instance, sometimes breed close to Rough-legged Buzzards or Peregrine Falcons on Kolguev Island (Kondratyev & Zaynagutdinova 2008) and on the Taimyr Peninsula (Kharitonov *et al.* 2009), and colonial Snow Geese *Chen caerulescens* have a tendency to concentrate around Snowy Owls *Bubo scandiacus* on Wrangel Island (Litvin *et al.* 1985; Svyrochkovsky 2016).

Given the scarcity of nest observations, it remains unknown how common and important such a breeding association might be for LWFG in different parts of their breeding range. The status of the species in the vast Russian arctic is indeed poorly known (Jones *et al.* 2008) and very few data about the breeding biology of LWFG have been published during the last 20 years (Supporting Materials Tables S1 & S2). Here we report on observations of breeding LWFG in the southwest of the Yamal Peninsula over a 14-year period. Most LWFG nests were found in close vicinity to Peregrine Falcon nest sites providing new data about the breeding biology of this rare species. Moreover, we investigate the variability in breeding of both species over nine years and discuss how important the breeding association with Peregrine Falcons may be for LWFG.

Methods

The study area in the southwestern Yamal lies around the confluence of the River Erkuta and River Payuta, in the low arctic erect shrub tundra (subzone E, Walker *et al.* 2005; Fig. 1B). The landscape is

characterised by gently rolling hills, numerous lakes and occasional sandy cliffs up to 30 m high along rivers or lakes (Sokolov *et al.* 2012). The wide river valleys have productive floodplains with willow and alder thickets up to 3 m high and extensive wetlands. Since 1999, we have monitored birds of prey in the area, notably Peregrine Falcons that nest exclusively on high sandy cliffs (Sokolov *et al.* 2014, 2018), mostly by following the main rivers (Fig. 1B). Since 2012, a systematic survey of 20 nesting sites of Peregrine Falcons has been carried out (Sokolov *et al.* 2014) covering the lower and upper parts of the River Erkuta (110 km in total), the River Payuta 45 km upstream from its confluence with the Erkuta River (Fig. 1B), as well as an associated group of lakes. As far as possible, all sites were visited each year in the second part of June and checked for nesting pairs. The presence of adults without a nest at the cliffs was also recorded. For logistical reasons, the surveys were not performed in 2013 and 2020.

During the Peregrine Falcon nest survey, we occasionally found goose nests (Greater White-fronted Geese, Red-breasted Geese *Branta ruficollis*, Bean Geese *Anser fabalis* and LWFG) close to breeding falcons. Thus, from 2016, we initiated a more focused monitoring of goose nests around Peregrine nests. In June every year, we carefully searched all river and lake cliffs within the study area, where Peregrine Falcon nesting has been recorded at least once. For all goose nests, we recorded the exact position with a handheld GPS and measured the distance to the Falcon nest nesting on the same cliff, which we define as a nest

association. For each nest, we recorded clutch size and measured length and width of every egg, as well as its weight. In addition, we recorded all goose nests encountered during the course of our ecosystem monitoring programme in the core study area (Fig. 1B), initiated in 1999 and continued with more or less constant effort (c. 450-person days per year between 15 June and 15 August) since 2007 (Sokolova *et al.* 2014; Ehrich *et al.* 2017).

Results

Since 1999, we have been working in the main monitoring area (Fig. 1B) with increasing numbers of researchers and failed to find a single LWFG nest outside the upper Erkuta river despite the presence of 14 other known Peregrine nests. In the early years (1999–2003) we observed several LWFG broods on the River Payuta (close to its confluence with the River Erkuta) in July, confirming that the species already reproduced successfully in the area at that time (Sokolov & Sokolov 2004). The first LWFG nest was found in 2006 on a cliff bordering the upper Erkuta River, 10 m from a Peregrine nest. In 2012, we started surveying the upper Erkuta River, where we found seven more LWFG nests over three years (2012, 2014, 2015), all associated with Peregrine nests (Fig. 1B, Fig. 2).

Since 2016, we systematically searched for goose nests on all Peregrine cliffs in our study area and found 28 more LWFG nests. All LWFG nests were found on cliffs along the River Erkuta, upstream from the confluence with the River Payuta (Fig. 1B), despite intensive field work in other parts of the study area, where nests of other goose

species were found every year. All LWFG nests were situated in similar habitats on steep sandy river cliffs up to 30 m high. These were adjacent to a wide floodplain and sand banks with horsetail *Equisetum* sp. on the other side of the river, which were most likely used as feeding areas. According to some literature sources, *Equisetum* sp. is not particularly important in the diet of LWFG (Rozenfeld 2001). Nevertheless, our general observations on different goose species in Yamal suggest that some lawns of *Equisetum* sp. are very attractive for geese, as illustrated by an associated density of goose faeces. Moreover, Danilov *et al.* (1984) found *Equisetum* sp. in the stomachs of eight LWFG individuals shot in Yamal. Usually, nests were located in the middle or the upper part of the slope. Most nests were constructed in open places almost devoid of vegetation, but sometimes nests were situated in soil depressions, patches of grass, sedge or between low shrubs (Dwarf Birch *Betula nana* or *Salix* sp.). Since 2016, 20 of 28 nests of LWFG (71%) were found in association with Peregrine nests.

In 2018, for the first time we found two nests of LWFG on a cliff not occupied by Peregrines. However, these nests of LWFG were situated near (29 and 52 m) from a Peregrine nest location last occupied in the four years prior to and including 2016. In 2019, out of nine LWFG nests, only four were located close to active Peregrine nests. In that year, only one pair of Peregrine Falcon was found nesting along the upper Erkuta River, although two other non-breeding pairs were present (Table 1). Three LWFG nests were located within these

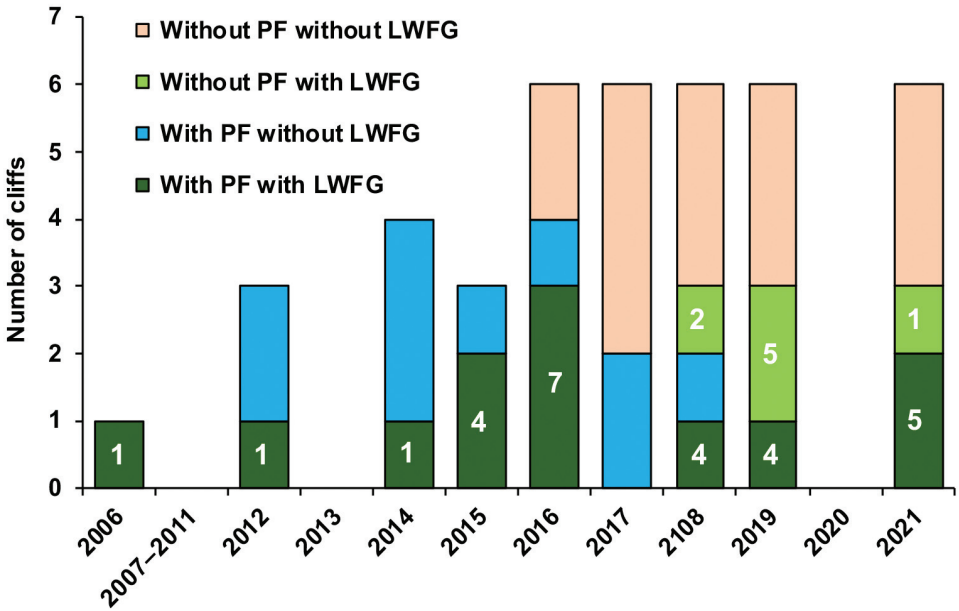


Figure 2. Long-term results from monitoring the associations between Lesser White-fronted Goose (LWFG) nests and Peregrine Falcon (PF) nesting on cliffs along the upper Erkuta River. Histogram columns represent the numbers of cliffs monitored, showing the different numbers characterised by the presence and absence of both species. White digits indicate the numbers of Lesser White-fronted Goose nests found in each category. Note that no observations were carried out in 2007–2011, 2013 or in 2020.

territories. Two more nests of LWFG were found on cliffs without Peregrines, but close to their previous nests (*i.e.* 71 and 186 m from nests used in 2018) (Table 1). Peregrine nest sites #5 and #6 were never occupied simultaneously and were only 1.5 km apart. LWFG were, however, breeding on both cliffs in 2018 and 2019 (Table 1).

For LWFG nests associated with those of Peregrine Falcons, the mean (\pm s.d.) distance between LWFG and active Peregrine nests was 82 ± 46 m in the years 2016–2021 inclusive (range = 3–148 m, $n = 19$ nests). Mean clutch size was 4.5 ± 1.46 eggs/nest

(range = 2–8 eggs, $n = 36$ clutches). Average egg size ($n = 117$) was 74.8 ± 3.45 mm (length) to 49.3 mm (width) (Supporting Materials Table S3). We have no data on hatching success because the upper River Erkuta cannot be reached by boat during the hatching period due to extremely low water levels (Fig. 3).

Discussion

Our review of the Russian literature (Fig. 1A, Supporting Materials Table S1) revealed that the nesting association between LWFG and birds of prey (mainly Peregrine Falcon and Rough-legged Buzzard) has only been

Table 1. Presence of Peregrine Falcon and breeding Lesser White-fronted Geese monitored on six cliffs along the upper River Erkuta. N = presence of breeding pair of Peregrine, nest found; 0 = no Peregrines observed; 1P = one Peregrine present, no nest found; 2P = two Peregrines present, no nest found; nd = no nest but neither presence nor absence of peregrines was recorded; na = nest site not visited that year. Numbers after the slash indicate the number of LWFG nests.

Year	Peregrine nesting sites					
	#1	#2	#3	#4	#5	#6
2006	N/1	nd/0	na	na	na	na
2012	N/0	0/0	na/0	N/0	na/0	N/1
2014	N/0	2P/0	N/0	N/0	0/0	N/2
2015	N/0	1P/0	2P/0	N/1	0/0	N/3
2016	N/0	2P/0	N/1	N/3	0/0	N/3
2017	1P/0	0/0	N/0	0/0	N/0	0/0
2018	2P/0	N/0	1P/0	0/0	N/4	0/2
2019	0/0	0/0	0/3	0/0	0/2	N/4
2021	0/0	2P/0	N/1	0/1	N/4	0/0

reported from two important breeding areas, *i.e.* Bolshezemelskaya tundra and Southern Yamal. Furthermore, general observations made in Chukotka (Rauchua river basin) in August 2010 during moulting and brood rearing periods suggest that LWFG nesting distribution is also linked to the presence of cliff nesting Peregrines (Solovieva & Vartanyan 2011) in this region. Unfortunately, many sources did not mention the exact number of nests, broods recorded, or the number of nests found in association with birds of prey. Prior to our own study, the strongest connection between nesting LWFG and birds of prey was described in the 1970s

for Bolshezemelskaya tundra (Mineev 1987; Mineev & Mineev, 2013). In that area, breeding LWFG were found along several rivers, and nesting associations with Peregrines, Gyrfalcon, Merlin and Rough-legged Buzzards were described (Supporting Materials Table S1).

The part of the southern Yamal Peninsula where breeding LWFG have been studied most intensively is in the basin of the Shchuchya River, *c.* 100 km south of our study area, where surveys have been carried out since the 1970s. Yet protective breeding association with birds of prey was only mentioned in 1996 and 1997 (Morozov & Kalyakin 1997; Morozov & Syroechkovsky



Figure 3. Nests and nesting sites of Lesser White-fronted Geese in the study area in the southern part of the Yamal Peninsula. Top: birds on a nest on sandy cliffs along the river. Bottom: large angle (left) and closer view (right) of one of the cliffs monitored along the River Erkuta; arrows point to the exact locations of Peregrine Falcon and Lesser White-fronted Goose nests.

Jr. 2002). In 1996, three nests of LWFG (out of five) were found at distances of 5, 20 and 40 m from Rough-legged Buzzard nests, and two other LWFG nests at 3 and 6 m from Peregrine Falcon nests. In 1997, six out of eight LWFG nests were found in “close vicinity” of Peregrine Falcon or Gyrfalcon nests (Morozov & Kalyakin 1997). In earlier times, LWFG were so numerous that it may not have been possible for the majority of pairs to breed close to predators because of the limited availability of such nesting sites (Danilov *et al.* 1984; Morozov & Kalyakin 1997). Morozov and Kalyakin (1997) suggest that the tendency

for a breeding association only became apparent when numbers in the LWFG population dramatically decreased. Not far from southern Yamal, on the Tazovsky Peninsula, the only LWFG nest ever recorded there was also found close to a Peregrine Falcon territory, in 2019 (Kostenko 2019).

In our study area, most LWFG nests were located close to Peregrine Falcon nests and all others were on cliffs that had been used as Peregrine nesting sites in the past. Until 2015, we only searched cliffs with Peregrine nests for breeding geese, but since 2016 all 24 cliffs included in the Peregrine

monitoring area were searched. On 21 of these 24 cliffs, breeding Peregrine Falcons had been recorded at least once. The three remaining cliffs were checked as potential breeding sites for Peregrines or Rough-legged Buzzards, and also searched for breeding geese. We therefore were able to document LWFG breeding without Peregrines only from 2016 onwards. In those cases when adult Peregrines were present but did not nest, it is possible that their nest had been destroyed prior to our visit, for instance, because it was placed on an exposed part of the sandy cliff that had collapsed. In such cases, as we witnessed several times, adult Peregrines can remain territorial at their breeding sites until mid-August. When LWFG were breeding in the absence of Peregrines, this might have occurred because the Peregrines deserted the site prior to our visit (since all sites were known as Peregrine breeding sites from previous years) or that LWFG “remembered” a Peregrine nest on that site from previous breeding years. Alternatively, they may have selected other suitable habitat characteristics, or specific conditions which might have made the protective breeding association less important for the geese in a particular year. No association between LWFG and other raptor species were observed in our study area.

The weak point of our study, and also in the knowledge about LWFG breeding biology more widely, is that most observations within the breeding range are associated with rivers (nests and broods) and lakes (broods) because field work in the Russian arctic tends to be strongly dependent on researchers being able to

access sites via waterbodies. For this reason, it is difficult to determine the extent to which LWFG occupy areas some distance from waterbodies, especially because the LWFG is a very rare species and the probability of finding a nest by chance is very low.

Breeding in association with raptors is not a behaviour characterising LWFG throughout their range (Fig. 1A). As suggested by Morozov & Kalyakin (1997), it is possible that the strength of this association increases when LWFG abundance declines. This might be because relatively small geese occurring at low densities are more vulnerable to nest predation than larger goose species, so dispersed nesting in areas with high predator densities could represent a much less favourable strategy for avoiding predation compared to seeking “protection” by nesting closer to birds of prey nests. The importance of this association in our study area may also be related to an overall high predation pressure. Interestingly, all four goose species present in the area (Greater and Lesser White-fronted, Bean and Red-breasted Geese) tended to nest close to Peregrines: 89 (93%) of 96 goose nests founded in 2016–2021 were located within potential Peregrine nesting territories, 74 of which (77%) were in close vicinity to active Peregrine nests or non-breeding/failed breeding birds still showing territorial behaviour (authors’ unpublished data). The high density of Peregrines in our study area (Sokolov *et al.* 2014) may also contribute to the high frequency of protective breeding associations by providing enough opportunities for geese to seek protection close to their nests.

The breeding sites where most LWFG nests were observed were characterised by extreme remoteness (> 160 km from human settlements), short distance to rivers, low altitude and the presence of wetlands, all of which fit well with optimal summer range habitats described for Eastern population (Tian *et al.* 2021) and general pattern of current breeding range known from the literature. The fact that LWFG were breeding only in part of our study area and not in association with all Peregrine nests suggests, however, that other factors may influence nest site choice and constrain the breeding range in general.

We are of course, aware that it is very likely that it is easier to locate goose nests, and especially LWFG nests near Peregrine Falcons nests than to find them without the falcons. The frequency of nests in association therefore may be somewhat overestimated. Nevertheless, our observations provide evidence that the Peregrine Falcon, a species of high conservation concern in Russia, can be a very (and maybe increasingly) important driver of the breeding distribution (and likely breeding success) of another endangered species, the LWFG. Most likely, Peregrines create “safe havens” around their nest sites by chasing away other predators (and especially egg predators like the Arctic Fox *Vulpes lagopus*). Owing to this interaction, the predicted climate-driven contraction of the Peregrine Falcon breeding range in the Russian arctic (Gu *et al.* 2021) could well also reduce the number and extent of potential LWFG breeding sites and in turn further accelerate the decline of this poorly studied endangered species in the future.

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