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Greenland White-fronted Geese *Anser albifrons flavirostris* benefit from feeding in mixed-species flocks

JENS N. KRISTIANSEN[1]*, ANTHONY D. FOX[1], HUGH BOYD[2] & DAVID A. STROUD[3]
[1]*National Environmental Research Institute, Department of Coastal Zone Ecology, Kalø, Grenåvej 12, DK-8410 Rønde, Denmark*
[2]*Canadian Wildlife Service, Ottawa, Ontario, Canada K1A OH3*
[3]*Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough, PE1 1JY, UK*

Studies have revealed that, for many bird and mammal species, individuals often benefit from enhanced feeding time and/or reduced predation risk by joining mixed-species flocks (e.g. Byrkjedal & Kålsås 1983, Metcalfe 1984, Thompson & Thompson 1985, Fitzgibbon 1990, Arévalo & Gosler 1994, Jacobsen & Ugelvik 1994, Larsen 1996). Most bird studies have concerned waders or passerines (e.g. Morse 1970, Byrkjedal & Kålsås 1983, Metcalf 1984, Thompson & Thompson 1985, Arevalo & Gosler 1994) and only a few recent studies have described advantages of such interspecific relationships in waterfowl (Jacobsen & Ugelvik 1994, Larsen 1996).

Geese, which have inefficient digestive systems and feed on relatively poor quality food, need to spend much of their time feeding in order to obtain sufficient energy and nutrients (Owen 1980), especially just prior to migration (Owen 1980, Krapu & Reinecke 1992). Therefore, any mechanism which enhances energy intake, for example by increasing feeding time at the expense of scanning for potential predators, should be advantageous to the geese.

This paper describes how Greenland White-fronted Geese *Anser albifrons flavirostris* benefited from an association with prebreeding Greylag Goose *Anser anser* pairs during spring migration in Iceland.

METHODS

The study was carried out from 16 April to 9 May 1997 at Hvanneyri Agricultural College (64°34′N 21°46′W), Iceland where Greenland White-fronted Geese stop off for about three weeks en route to their breeding grounds in west Greenland after leaving their wintering grounds in Britain and Ireland (Francis & Fox 1987, Fox *et al.* 1994). The area is a hunting-free zone, which offers safe roost sites and good feeding opportunities on hayfields dominated by *Poa pratense, Deschampsia caespitosa, Agrostis* sp. and *Phleum pratense.* Two potential avian predators are present in the area: White-tailed Eagle *Haliaeetus albicilla* and Gyr Falcon *Falco rusticolus.* Apart from humans, only one potential ground predator, the Arctic Fox *Alopex lagopus*, was present in 1997, though not very common.

During daily counts of birds in the area, repeated at different times of the day, activity budget data were c ompiled every time we approached a flock of geese. Scan samples were carried out with behaviour of individuals assigned to the following categories: feed, alert, wing stretch, aggression, sleep, walk, preen, drink, other. This note deals only with the two categories *alert* (*vigilant*) and *feed*, which included most (90%) of the records. All the other categories were pooled as other behaviours. For each scan, presence and number of Greylag Geese and total flock size (Greylag Geese and White-fronted Geese combined) were recorded. Greylags had to be clearly associated with a flock of White-fronted Geese (within 20 m in the same field) to be considered as part of the flock. Observations were made from a car using telescope (20–60×) or binoculars (10 × 40) at a distance of at least 150 m to minimize disturbance.

A basic assumption of multivariate statistical analysis is that samples are independent. In studies such as this, it is impossible to know how often many of the (unmarked) individuals have been recorded more than once. To minimize the effect of this potential departure from independence, we sampled flocks in as many different fields as possible.

We tested for the effect of the presence of Greylags on the behaviour of the White-fronted Geese, as well as the effect of flock size, which can affect the alertness of individuals (e.g. Caraco 1979). We also tested for the effect of date and time of the day. The statistical analysis was performed by using multiple regression with the percentage time spent vigilant (arcsine transformed) as the dependent variable and presence of Greylag Geese, flock size, date and time of day as the independent variables. Time of day was also entered in the analysis as $time^2$ and $time^3$ (polynomial trends) due to the presumed non-linear pattern of this variable.

*Corresponding author. Present address: University of Copenhagen, Zoological Institute, Department of Population Biology, Universitetsparken 15, DK-2100 Copenhagen ø, Denmark.
Email: JNKristiansen@zi.ku.dk

Table 1. Relationship between time spent alert of Greenland White-fronted Geese and specific variables. Variables tested include: the number of Greylag Geese; total flock size (White-fronted Geese and Greylag Geese summed); date; time of the day; time^2; and time^3. The analysis was done by multiple regression. $n = 261$, $r^2 = 0.138$ (all variables included).

Predictor (mean; range)	Estimate ± se	*t*-ratio	*P*
Constant	–34.49 ± 24.741	–1.39	ns
Greylags (0.54; 0–10)	–1.91 ± 0.491	–3.89	< 0.001
Flock (31.44; 2–142)	–0.07 ± 0.025	–2.85	< 0.01
Date (16 April–9 May)	–0.09 ± 0.152	–0.58	ns
Time (05:40–21:17)	0.22 ± 0.096	2.28	< 0.05
Time^2	–0.0003 ± 0.0001	–2.38	< 0.05
Time^3	$1.1 \times 10^{-7} \pm 0.5 \times 10^{-7}$	2.39	< 0.05

RESULTS

White-fronted Geese spent significantly less time alert in flocks when Greylags were present, although alertness also decreased with increasing flock size (but explained considerably less variance in the model). The time of day seemed to have a non-linear bimodal effect but this variable did not contribute much variance to the overall effect on the behaviour of the geese (Table 1). A univariate test showed that the time spent vigilant by the White-fronted Geese with and without Greylag Geese was highly significant (ANOVA, $F_{1,260} = 42.9$, $P < 0.001$). Figure 1 shows the average percentage time spent vigilant by White-fronted Geese with and without Greylags associated. The presence of Greylag Geese allowed the White-fronted Geese almost 9% more time for other activities, including significantly more time (6% extra) spent in additional feeding (ANOVA, $F_{1,260} = 5.5$, $P < 0.05$). In both situations, feeding was the predominant activity of geese whilst on the fields: 76.9% ± 1.35 se ($n = 211$) in flocks without Greylag Geese and 82.4% ± 2.33 se ($n = 50$) in flocks associated with Greylag Geese. On average Greylags spent 37.8% ± 5.62 se ($n = 36$) time alert.

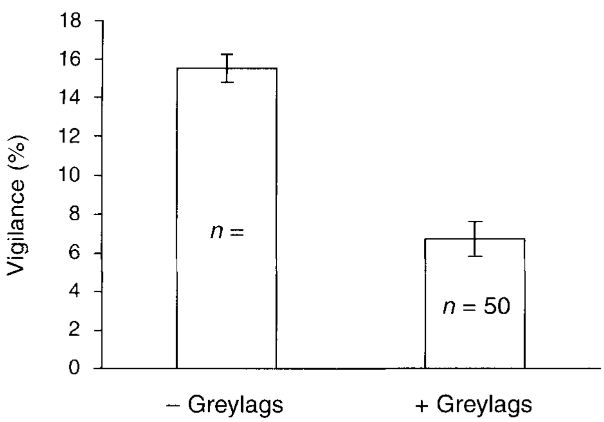

Figure 1. Mean percentage time (± se) spent vigilant by Greenland White-fronted Geese in flocks with and without pairs of Greylag Geese.

DISCUSSION

The present study confirmed previous observations that the overall alertness of the goose flocks decreased with increasing flock size (e.g. Caraco 1979, Bertram 1980). Results also suggested that there was an effect of time on the alertness of the geese. Geese tend to show highest levels of vigilance in the middle part of the day, since feeding tends to be most intense early and late in the day (Owen 1972, Summers & Grieve 1982). However, what seemed to be the most important factor affecting the vigilance of the White-fronted Geese was the presence of Greylag Geese. The Greylag Geese seen on fields were usually breeding pairs not in flocks. On average they spent about 38% of their time alert and although the times spent by males and females were not recorded separately, male Greylags during the prenesting phase on the study area are known to spend up to 73% of daylight hours vigilant in attending their females which feed intensively at this time (unpubl. data). We never recorded interspecific aggression while the geese were feeding and the only agonistic interaction between the two species seen was the defence of a drinking site by a White-fronted Goose against an approaching Greylag Goose. Most aggressive interactions between White-fronted Geese also occurred at the limited numbers of drinking sites in the fields.

The reduced vigilance of the White-fronted Geese associating with Greylag Geese could of course be due to Greylags tending to feed in better (and/or safer) habitats, in which case habitat differences would be the cause rather than the presence of Greylag Geese. However, we tested for differences in the behaviour of the White-fronted Geese on the same fields with and without Greylag Geese and, although none of these tests was significant, the tendency was always that White-fronted Geese spent more time vigilant in the absence of Greylag Geese.

Hence, associating with Greylag Geese seemed to have insignificant costs in terms of interspecific interactions, but gave the White-fronted Geese more time for feeding due to a decrease in scanning for potential predators, even though these were rarely recorded by us. We only saw a Gyr Falcon once attempting an unsuccessful attack on a flock of about 40 White-fronted Geese and three Greylag

Geese. All the geese took flight before we were even aware of the presence of the falcon.

We suggest that the White-fronted Geese were aware of the predictable high level of vigilance by the Greylag Geese and used this to increase their own energy intake. We did not determine whether the Greylag Geese benefited in any way from the presence of White-fronted Geese, because we did not make comparable observations on Greylag Geese feeding alone. However, being part of a large flock might decrease the predation risk due to the dilution effect (Krebs & Davies 1987) and reduce the average scanning time of the individual while benefiting from higher surveillance from the group (Caraco 1979). Much of the enhanced vigilance of a Greylag gander in spring is thought to prevent extra-pair copulations between his mate and neighbouring males (e.g. Mineau & Cooke 1979), nevertheless in the situation we describe, it also benefits White-fronted Geese.

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Co-ordinated food provisioning in the Little Shearwater *Puffinus assimilis haurakiensis*: a previously undescribed foraging strategy in the Procellariidae

ANDREA M. BOOTH[1]*, EDWARD O. MINOT[1], ROBIN A. FORDHAM[1] & MIKE J. IMBER[2]

[1]*Department of Ecology, Massey University, Private Bag, Palmerston North, New Zealand*

[2]*Science and Research Division, Department of Conservation, PO Box 10-420, Wellington, New Zealand*

Several studies of the Procellariidae have shown that adults feed the chick independently of one another (Ricklefs *et al.* 1985, Chaurand & Weimerskirch 1994, Hamer 1994). There are, however, few data on the provisioning strategies of individual adults. Chaurand and Weimerskirch (1994) found that adult Blue Petrels *Halobaena caerulea* alternate long trips (LT) and short trips (ST) to sea while rearing the chick. A similar dual foraging strategy has also been recorded for Thin-billed

*Corresponding author. Current address: Department of Conservation, PO Box 842, Whangarei, New Zealand.
Email: abooth@doc.govt.nz