

Summaries

Johnson and Raveling (1988)

find that cackling Canada geese form family groups at their breeding grounds, but that the pressure of constant foraging and the advantages of foraging in large flocks offset the benefits of maintaining these family units while at wintering grounds. Social organisation in small grazing geese might be determined by immediate food availability.

Ely et al. (2005)

found significant morphological differences between the proposed subspecies of *Anser albifrons*. The largest geese were from around the Bering Strait, and body size, while not correlated with breeding latitude, was positively correlated with temperature at the breeding grounds, breeding habitat, and migration distance.

Boyd (1965)

report on the age composition and thereby breeding success of Whitefront flocks wintering in England that originate from around the Barents and Kara Seas. Low variation in annual brood size (3.24) accompanies a 0.33 proportion of first-winter geese. Peak breeding success seemed to be between the ages of three and seven. The phenology of Whitefronts is presented, including that from Kolguyev.

Kondratyev and Zaynagutdinova (2008)

have the most recent breeding data for geese on Kolguyev, and seem to be the best source on the presence, movements and condition of different age and social classes of Whitefronts on the island. They find that while the population of Whitefronts has held steady, that of Bean Geese (*A. fabalis*) and goose predators has increased since 1995. Predation on a non-lemming island is posited as a cause for failed breeders to move farther north east to areas with fewer predators.

Jónsson and Afton (2008)

studied Lesser Snow Geese (*Chen caerulescens caerulescens*) and the smaller Ross' Geese (*C. rossii*) and posited that larger goose species were likelier to maintain family groups in winter, and that this conferred benefits when antagonistically encountering the smaller species over resource patches. Mixed-species flocking accrued benefits to both, but Ross' Geese had a clear subordinate social status, and preferred larger groups over the maintenance of families.

Miller and Dzubin (1965)

document the reformation of family groups after the single release of Whitefronts, and note that this cohesion is common to other genera of geese as well.

Fox et al. (2003)

reported some of the data on satellite tracked Whitefronts of the Greenland subspecies (*A. a. flavirostris*) wintering in the British Isles, and correlated the onset of migration with assisting tailwinds.

FOX et al. (1995)

posit that the most likely reason for association between first-year non-breeding birds and adult breeding pairs was the increased foraging time afforded to each party by distribution of vigilance costs. Alloparental care if present was posited to be in the form of parent-offspring relationships and to confer better nest defence.

Warren et al. (1993)

similarly note guiding of first-winter offspring, teaching foraging and social skills and the locations of feeding and roosting sites as common explanations for the extended relationships between parents and offspring in Whitefronts.

Wilson et al. (1991)

discuss winter site fidelity in the Greenland subspecies of Whitefront. They reported that around 85% of birds were observed at the same sites over successive winters, and that within each winter, negligibly few geese moved between sites. Overall, this points to extreme site fidelity in the population, if not the species, and could explain why no neat correlations can be drawn between winter site conditions and family size. Such site fidelity would have to be looked for in banded geese in the Netherlands.

Choudhury and Black (1994)

show that Barnacle geese pair preferentially with individuals from their own breeding areas, but that this pair formation occurs off the breeding grounds. The two possible mechanisms underlying this assume that geese can either identify individuals they have previously encountered in the breeding grounds, or that geese can identify phenotypic traits carried by individuals from their breeding grounds, and are selecting based on one or the other. In experiments with 78 young geese, it was found that

while geese pair at random with unfamiliar individuals irrespective of the population they were from, they pair preferentially with 'known' individuals, when capable of making this choice.

Rees (1987)

studied which of the individuals in a newly formed pair of Bewick's swans would determine the choice of wintering ground. Swans are said to remate in spring. There is a case of apparent conflict within the pair, since both individuals of the pair are likely to be highly faithful to their traditional wintering grounds, and would prefer to winter in them. It was seen from a study of ringed bird dispersal that the male in a pair was responsible for leading flight to the wintering grounds, and also maintained his arrival time at those grounds, while the female in a new pair was less likely to determine the wintering ground and more likely to arrive at a different time than when alone. This pattern was reversed as winter progressed, with the female initiating flight after the new year. Females are also shown to dominate movements to the breeding grounds in other waterfowl.

Owen (1972)

The work described was part of a feeding ecology study at the New Grounds, Slimbridge, on white-fronted geese, which are primarily grazers. The geese usually arrive at the feeding grounds 30 min before sunrise and leave 30 min after sunset. In short days they spend over 90% of their day feeding, and most of the remainder in other essential activities. In longer days they spend more time on the feeding grounds and rest for longer. Feeding rate was extremely rapid and increased with time of day to a mean maximum of just over 130 pecks/min. This allows food, which is digested on the roost, to accumulate in the oesophagus. White-fronted geese eat between 650 and 800 g of fresh food per day, which is over 25% of their bodyweight. The rate of feeding increases to compensate for a decrease in the food supply towards the end of the winter. At times the geese use clover stolons as a source of food. Stolon feeding is less efficient than grazing and was an infrequent activity. There are indications of food selection on a small scale but it is concluded that maintaining a high rate of food intake is more important to geese, which digest their food inefficiently, than is selecting the most nutritious diet possible. Juveniles feed faster, are less selective and walk more quickly than do adults. They also spend less time being alert for possible dangers. This probably means that young birds are at an advantage and are able to increase their bodyweight in most winters.

Fox and Madsen (2017)

is an introduction to an full supplement of Ambio (edited by the same authors) which deals entirely with goose populations and management. They present a clear timeline

for trends in goose populations of western Europe, which they show from counts of species in both *Anser* and *Branta* to be largely increasing exponentially across much of their winter range. They draw a link between this increase and the winter availability of highly productive agricultural areas in western Europe. These croplands are suspected to be replacing, or to have largely replaced, natural goose winter habitats in their importance as foraging grounds.

Fox and Abraham (2017)

use a number of examples from the literature to illustrate the claims made in Fox and Madsen (2017), showing that in a number of species across continents, there has been a shift from 'traditional' foraging areas to monoculture croplands. Touching upon the energetics of foraging on natural habitats as compared to agricultural fields, they show that it is much more profitable for species to feed on crops and related residues, such as spilled grains. They posit that current agricultural practices and output in North America and Europe offer goose populations a growth rate uncoupled from resource availability, thus leading to the exponential increases reported in Fox and Madsen (2017). While the shift in goose foraging has allowed for a more effective intake and storage of fats required for energy intensive activities such as the two annual migrations and breeding, it is also possible that this has come at the expense of protein intake which is higher from natural, unmanaged landscapes (Prop and Black 1998). However, this does not appear to have impacted the reproductive success of geese, nor the composition of their amino acid intake, leading to the conclusion that irrespective of where geese forage, they are capable of maintaining a 'balanced' diet (Eichhorn et al. 2012). Indeed, the trend for reproductive success to be increased for Barnacle geese and Greenland whitefronts feeding on agricultural fields seems to have increased (Fox et al. 2005), and this appears to be part of a larger trend in European goose populations – foreshadowed by similar populations in North America – to change their ecology, particularly their winter ranges and spring staging areas to exploit available agricultural food sources (Madsen et al. 2014)]

Koffijberg et al. (2017)

studied the effects of a Dutch national policy in which certain areas of cropland as well as the existing Natura 2000 network were designated as goose foraging areas, into which it was hoped to concentrate geese through their displacement from no-go, or non-forage areas by scaring them using a range of methods up to and including lethal deterrence shooting. They found that over the decade preceding the policy and the eight years following it, the number of goose-days (not clearly defined) spent in designated goose areas was not significantly changed, ie, that the policy had not had the expected teaching effect on geese that would lead them to seek out designated goose accommodation areas in favour of non-designated areas. This policy failure was proposed to be chalked up to one or more of a number of reasons, including the

increase of goose abundance in the winter in Holland, the lack of a definite and absolute distinction for geese between go and no-go areas due to either or both insufficient scaring from no-go areas, or perceived danger in go areas, and the disproportional designation of go and non-go areas within the Netherlands as compared to the regions' share of wintering geese.

Bêty et al. (2001)

studied Greater Snow geese in the Canadian Arctic to determine what link existed between goose nesting success and the lemming cycle, and tested two hypotheses, the Alternative Prey Hypothesis and the Nesting Association Hypothesis. Goose nesting success varied between 22% and 91% between years, with the main egg predator being the Arctic fox, and the nesting association being with Snowy owls. There was a negative association between goose nesting success and lemming abundance, and nest failure was highest in low lemming years. Nest failure was also higher at high nest densities. However, nesting close to owls conferred some advantages, up to a distance of 550m, since owls excluded other predators from this radius, reducing the egg predation rate. This led to the conclusion that the APH was the main link between goose nesting success and lemming abundance, and that the NAH boosted this effect within the vicinity of the predator nest.

Madsen (1985)

looks at the impact that roads and other disruptive features have on the utilisation of fields by Pink-footed geese. This was done in the context of identifying factors that contribute to the use, and thus design, of wintering goose refuges, with the general aim being to improve their carrying capacity. Measuring the flight distance of geese using a car as a stimulus, it was found that on Jutland, geese had a flight distance of around 500m. This is of note as being in the 1980s, possibly prior to some conservation efforts, or prior to the habituation of geese to cars. A moderate positive correlation was found between the size of a flock and the flight distance (0.431), but the relationship was likely non-linear. Roads had a depressing effect on the utilisation of fields by geese, even a low volume of use, ie, 0 - 10 cars a day, and this effect was serious when the traffic volume increased to 20 - 50 cars a day, with the peak of the distance of fields utilised from roads was 500 - 600m.

Van der Zande et al. (1980)

analysed the relationship between flight distance, flock size and season using a log-linear model, and found that flight distance was related to both season and flock size, where a flock of around 500 geese would have a slight higher flight distance in autumn than in spring. This was attributed to the timing of the hunting season, which begins in autumn.

Owens (1977)

found that in brent geese, *B. bernicla bernicla*, there was a linear relationship between flock size and flight distance. This relationship is more likely to have some upper limit as Van der Zande et al. (1980) show in the study above.

Gerdes and Reepmeyer (1983)

find that following a ban on the shooting of whitefronts and bean geese in West Germany, the flight distances of wintering flocks of comparable sizes as in the studies above (Van der Zande et al. 1980, Owens (1977)) – around 500 - 1000 geese – decreased from ~500m to ~200m, leading to a local scale range expansion closer to roads and banks where geese had not fed before.

Mooij (1982)

presented the habitat of geese, mostly bean and whitefronts, from the Rhinelands in West Germany, now the state of North Rhine Westphalia. The wintering grounds were said to lie on both sides of the Rhine, between Nijmegen in the Netherlands, and the German city of Bonn. The major part of this was between Nijmegen and the city of Duisberg, mostly in NRW. Geese were reported feeding in the immediate vicinity of the Rhine, on regularly flooded grassy banks and on grass fields beyond the dykes. Roosts were said to be the banks of the Rhine and its branches. A change in the landuse pattern is noted, with grasslands being converted into highly productive agricultural areas to grow grains, sugar beet and maize, and a concurrent increase in the number of wintering geese is also noted. A historical reconstruction of the abundance of goose counts from the NRW region is presented in @

Mooij et al. (1996)

analysed the leg rings recovered from birds ringed in the Taimyr peninsula (80°E) in northern Russia. They found that between 1953 and 1986 in the Netherlands, and on Taimyr between 1966 and 1970 and 189 and 1992, there was a great degree of interchange between the historically delineated populations of whitefronts. The fact that Taimyr birds were visiting western Europe as far as the Netherlands at all is a new development from the standpoint of the much earlier study of ring recoveries by Boyd (1965), who identified the Ob river delta (70°E), well short and south of Taimyr, as the eastern limit of the population of whitefronts that reached Slimbridge via western Europe. It was also found that Taimyr whitefronts were distributed over several sites in winter, and this coupled with wintertime pair formation could maintain effective genetic exchange between the wintering ground populations, preventing the emergence of races or subspecies. In addition, rings showed that in the early

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