Chapter 7

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Arctic geese: quick meals for predators

Geese, the green wave and the price of parenthood

"Oh to be as free as a bird" may be the poet's envious thought, but biologists tend not to share this romantic view of nature. To breed in the Arctic, geese must migrate and in doing so are among the top long-distance travellers in the bird world, stopping to feed and rest en route. Then soon after the young hatch, the parents drop their flight feathers in the annual moult and face seven weeks as pedestrians on the tundra, while the goslings increase their mass twenty-fold. All this occurs within a very restricted area, as the families must remain near the safety of open water. The geese need to be vigilant and ready to plunge into the water to escape prowling arctic foxes, and the narrow bands of vegetation that provide their food become depleted. It seems that geese trade the freedom of flight for a long imprisonment on the breeding grounds!

We now know that small coastal geese, like brent and barnacle geese, migrate in spring to their breeding quarters in the Far North and return to Northwest Europe with their young in autumn. But back in the 16th century their annual disappearance and return was explained by a fanciful legend. It was said that some trees in Scotland grew curious fruits. When these fruits were ripe, they fell into the water and passed through a barnacle-like phase before returning in autumn as fully developed geese. Drawings illustrating this unusual process were concocted (see Fig. 7-1).

The first eyewitness account to dispute this legend came from the records of the pilot on Willem Barents' famous expedition. On 21 June 1596 the explorers (taking what they thought was a shortcut to Java!) discovered brent geese nesting on Spitsbergen, and found that the geese laid eggs like other birds – but it took years before these facts were generally accepted. In the meantime thanks to the legend which classified these geese as fish, Catholics could continue to enjoy roast geese on Fridays!

But why do geese make these long migrations to Arctic sites such as Spitsbergen to breed (Fig. 7-2)? Their seasonal movements are closely tied to their diet (mainly grasses). The plants that geese forage on contain a lot of cellulose, which can only be digested by bacteria. Large herbivores have extensive 'fermentation chambers' in their digestive tracts where bacteria can break down cellulose, which is retained in the gut for several days. In cows this bacterial breakdown takes place in the rumen, in horses in a huge caecum.

Geese are among the smaller herbivores and follow a different strategy. In their gut there is limited opportunity for the long retention times needed for bacterial breakdown, so the geese have opted for rapid tran-

Figure 7-1.
An illustration from Gerard's Herbal (1633) showing how barnacle geese develop from barnacles in early life, a persistent myth.

Figure 7-2.
Migratory flyway of the barnacle goose population wintering in southwest Scotland and breeding on Spitsbergen. In early spring they track the spring flush in grass growth to the Norwegian coast near the Arctic Circle where they stop to fatten up. From this stopover they fly directly to Spitsbergen. On the southward journey they often stopover on Bear Island before resuming their flight to Scotland. This journey with long sea crossings is an energetic challenge that many goslings do not survive.

sit times instead. With few exceptions the ingested plant matter leaves the goose's body after just 90 minutes! Cellulose is not digested at all, and the related hemicellulose only partly. This means that geese must select the most digestible grasses they can find. Like other animals, geese cannot synthesise the essential amino acids that make up proteins so they are especially choosy in selecting plants with a high protein content.

Early spring grass growth is ideal goose food as it is easily digestible and packed with protein. Further north spring arrives later, which means that the peak in 'goose food' is also later. By migrating north along with the spring flush of plant growth and stopping en route, the geese can 'ride a green wave' on their way to the breeding grounds. Actually they overtake the wave of spring growth and arrive in the Arctic well in advance of the local development of grasses. When the eggs hatch the goslings can profit from the first wave of grass growth, and there will be food for all until autumn frosts herald the start of the southward migration.

This temporal and geographical pattern in the availability of highly nutritious forage plants (mainly grasses) must be the evolutionary force behind the annual migration pattern in geese. Possibly these seasonal opportunists face less competitors in the Arctic where the harsh winters reduce the numbers of resident herbivores. Another important factor is the 'midnight sun', as the constant daylight makes it possible for the geese to alternate feeding and resting pauses over 24 hours to maximise effective searching and subsequent digestion. Without continuous daylight it would be impossible for geese to utilise the Arctic landscapes as fully due to the predators that are also searching for a digestible package!

Spitsbergen

Biologists from Groningen have been on the track of migrant geese for many years now probing the mysteries of the goose breeding grounds. The archipelago of Spitsbergen, north of Norway, is ideal for such research because it is one of the most accessible sites in the Arctic. Of the three goose species breeding there the barnacle goose offered researchers the best prospects. Their breeding colonies on the west coast provided good observation opportunities and the entire Spitsbergen population winters at a single site in Scotland. This makes it feasible to watch the same individuals in both sum-

Figure 7-3.
By season's end the barnacle goose feeding grounds are covered in droppings.

mer and winter, and with a marking program breeding success and survival can be related to the observations up north.

Arctic summers are short and crowded: after the four to five eggs are laid (which normally takes one week) it takes another 23 days to incubate them, and then the goslings must grow from a 70 gram downy ball to a 1,400 gram flying machine within just six weeks. As soon as snow-free sites can be found on the rocky islets where the geese breed, the nests are refurbished and egg laying begins (early June). There is hardly any food to be found at that time, and the birds must draw on the fat stores they laid down back in Norway (see Fig. 7-2).

The pair divides the chores. The female lays and incubates the eggs while the male stands guard (Fig. 7-4). The female forms a *brood patch* on her belly: a bare area with a network of blood vessels that transfers her body heat to the eggs so that the embryos can develop.

The female can only leave the nest for a few minutes each day to feed and drink and by the time the clutch hatches she has used up all her fat. As soon as the family reaches a safe place after leaving the rocky nesting islet, the male guards the brood and the female can spend all her time feeding to catch up. At this time it is usually easy to identify the male and female when they accompany their new brood, even from a distance. The male is on the alert, while his partner has her head down pecking continually.

Even on the nesting islets the nests are not entirely safe, and every time the female leaves there is a chance that a glaucous gull will investigate and help itself. A female goose with a good fat supply, who does not have to

Figure 7-5.
This arctic fox has just captured a large gosling (note the leg-ring).

Figure 7-4.
A pair of barnacle geese at the nest. The engraved leg-ring of the guarding male makes him individually recognisable.

leave often, has the best prospects of hatching her brood. The normal feeding break is only 20 minutes a day. By watching marked birds we noticed that some individuals were better than others at detecting new food supplies. When *Equisetum* blades and willow buds appear from under the snow the first bird to find them is rewarded with a rich meal, but the supply is soon exhausted. Some 'knowledgeable' females were consistently first, and these were successful in raising their clutches.

By the time the eggs hatch in early July, the female has reached the lowest body mass of her annual cycle, but spring has now arrived in Spitsbergen and there are fresh blades of new grass to be found. The parents guide their young to the richest feeding grounds along the margins of the tundra lakes. Here they extract grass blades from a spongy blanket of moss that covers the ground.

The geese are highly effective at harvesting these tiny shoots from the surrounding moss. At first glance it appears as if there isn't any grass at all, but if you erect a temporary wire fence to exclude the geese you will end up with a small lawn by the end of the season.

Arctic foxes for neighbours

By marking individual shoots and taking repeat measurements each week, we found that grasses in the Arctic had only a short spurt of growth. The growth rate has already slowed by mid-July, and the growing season is over by mid-August. At this time the geese have to go further and further away from the lake margins in search of food. But out on the tundra the arctic fox is waiting for them.

The foxes pose a real danger to the goose families, both parents and goslings (Fig. 7-5). As soon as an opportunity arises, a fox will dash into a group of feeding geese and bite off the goslings' heads. By playing dead, a gosling can sometimes evade the attentions of the fox who rushes on in pursuit of the escaping brood mates.

Meanwhile the rest of the flock sprints towards the nearest water at top speed (they can easily outrun athletic biologists!) where they withdraw to safety. The fox licks his chops and returns to retrieve the dead goslings, perhaps taking one or two to his own family, and burying others for later use. These cached geese are an important food supply for the fox during the lean winter months. In a single season one arctic fox can kill hundreds of goslings, so the geese do not normally venture far from water and are continually on the lookout when in 'dangerous country'.

With all the goose families crowded together on the few safe sites, competition for food is intense. There is not a moment's peace, especially for the males. Males are continually busy threatening and fighting the neighbours, trying to clear a space where their family can feed. Large families are usually the winners in these contests. Dominance is directly related to family size, and if, for example, one gosling is lost to a fox, the whole family drops in dominance status. Parents of large broods are more often on the alert and engaged in threat, and the males hardly find time to grab a bite.

Moulting and flightlessness

As well as the need to care for their eggs and goslings, the annual moult looms large in the parents' summer routine. All birds must moult at least some of their feathers every year, and for long-distance migrants such as geese this cannot be avoided. Perhaps you have a pet bird at home, and have noticed that some birds are still able to fly while moulting. Geese, however, drop all their flight feathers *in a single day*, then renew them all in a simultaneous moult.

In some ways this is a clever arrangement, since the moult as a whole is kept as short as possible, and the parents are already restricted in their movements while the goslings cannot yet fly. Due to their limited mobility the moult is a stressful time for the geese with a heightened risk of predation adding to the problem of food shortages.

Parents regain the ability to fly at about the same time as the goslings first take to the air. They have around a month of practise and

fattening before it's time to set off for Scotland. This vital phase of 'filling the flight tank' is closely linked to an increased foraging area now that the whole family can fly. The families can visit the grassy slopes below the local seabird cliffs where natural fertilisers promote rich grass growth. Arctic foxes patrol these slopes on the lookout for young guillemots as well as unwary goslings, but the geese can take to the wing if danger threatens. Time is at a premium, for the days are getting shorter and the nights colder. Once the winds are right for departure the 3,000 kilometre journey to Scotland, much of which is over the ocean, proves the ultimate fitness test for the right combination of timing and body condition. In 'late' seasons with food shortages and when departures are behind schedule as many as one-third of the goslings do not reach the wintering grounds, and some of the parents are lost as well.

Getting the date right

To determine whether 'decisions' about the timing of breeding, clutch size and so on have repercussions for survival later on, or even for future reproduction, we need to be able to individually recognise the geese. Our method is to catch as many birds as possible during the moult. Since they are flightless at this time, we can herd them into a V-shaped corral of netting (Fig. 7-6). This sounds easy, but skill, patience, enough helpers, and a bit of luck are all needed to round up the birds with a minimum of stress.

After herding them into the net, we wait about 1.5 hours to allow any undigested food to be eliminated so that we can obtain body weights in a standard 'empty' state. Besides weighing and ringing there is an international routine of body size measurements to collect. This helps us to describe the body condition of the adults, and to build up a good data set on gosling growth. Some of the goslings will have already been given a provisional tag soon after hatching (and are thus of known age when caught). The length of the flight feathers (the primaries) is also measured, and if we succeed in recapturing some birds later we can determine the growth rates of the individual primaries. It turns out that each primary grows at the rate of 7 millimetres per day (Fig. 7-7). Despite this rapid growth, it takes 26 days for an adult goose to regain the power of flight.

What can we show for all these measurements? First, we found that local food conditions are an important determinant of gosling growth. Young born early in the season grow much more rapidly that those that hatch late. Since the grass growth, which provides their main food, declines soon after hatching, and late goslings are forced to feed on whatever is leftover from the first wave of goose visitation, it seems logical that the growth of late goslings will lag behind too. In fact, for every day later that they hatch, a gosling will be 12 grams lighter! The retarded growth of late-hatching goslings has enormous consequences. We know from our ring-reading that these late birds generally do not survive the migration to Scotland as well as the birds that hatched 'on time'.

Goslings in large families grow more rapidly than those in small broods. This result fits with our observations that parents of a large family more often win contests, so that their goslings can feed in the best locations. You might imagine that the 'best' parents always manage to have the biggest families, but this is an oversimplification. By experiments (manipulating family size) we found that the number of goslings itself is an important contributor to the success of the family: perhaps they signal the quality of the family unit.

Growth limits

Aside from this date effect within seasons, we found impressive differences in gosling growth between years. From 1991 to 1995 barnacle goose goslings lagged further and further behind in gaining weight. In 1991, goslings at 35 days (just before they can fly) weighed 1230 grams, but in 1995 this had dropped to 970 grams, only 80 percent of their 1991 mass!

It came as no surprise that these declines

Figure 7-6.
We round up the barnacle geese for marking and measuring during their flightless moult. For this catch we drove the birds off the lake in the background into a net. They will soon be released again.

Figure 7-7.
A moulting barnacle goose. Note the growing feathers emerging from their sheaths.

in growth rate equated to lower survival. In 1992 we found half of the original 1991 cohort back in our study area on Spitsbergen. In the following years with the curtailed growth, this proportion dropped to a quarter. But that was not all: the fully grown but small juveniles that we were able to remeasure had remained small. In other words, since departing from the Arctic there had been no compensation for the stunted growth on the breeding grounds.

This decreasing growth in subsequent years could be explained by the increasing density of the geese themselves. Our study population of adult barnacle geese increased from 246 in 1991 to 609 in 1995. More geese translates into less food for everybody. Not only were the goslings smaller than before with lower prospects of survival, but even the body mass of individual adults caught during the annual moult was lower in subsequent years! We wondered whether some form of self-regulation was acting to reduce the reproductive output.

Imagine our surprise when goslings in the 1996 summer grew as well as in the 'good old days' of 1991! What had happened? For unexplained reasons there were no arctic foxes in our study area in 1996 (although they had been present in 1992, 1993, 1994 and 1995). Even though there were a lot of geese in 1996, they could spread all over the tundra to feed. In areas that had been strictly taboo on account of fox patrols in previous years, goose families were quietly snoozing between foraging bouts! This extension of the feeding grounds had provided improved conditions for gosling growth. The arctic fox was thus not only a factor in direct predation of goslings, but had a strong negative impact on habitat use as well. As the fox-free year demonstrated, normally the foxes contributed to overcrowding on the goose foraging areas by restricting the geese to areas near water.

Our fascination for the barnacle geese on Spitsbergen lured us back year after year, and taught us something new each season. We have learned how the geese surmount the many problems the Arctic summer has in store for them, and this has deepened our admiration of their adaptations as successful foragers in such a variable environment. Perhaps the most important lesson for us was how the increase in numbers in our study area on the breeding grounds resulted in a reduction in the population's growth rate: self-regulation. The arctic fox is part of this equation. Not only is food supply a critical limiting factor, the regulation of this supply by the geese's assessment of the risk of fox predation is also important. Grass, geese and foxes are locked together in a chain of mutual limitation.

References
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