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Download date: 05 Mar 2021

BOX B

Migration schedules and stopover site use during spring migration of Russian barnacle geese

Thomas K. Lameris

Introduction

Electronical devices to track the migratory journeys of animals are becoming increasingly accurate, light-weight and affordable, and the number of species and individuals which are tracked during migration is constantly increasing. While it seems that the revolutionary data comes from tracking increasingly smaller species, which the migratory flyways are revealed by light-weight GPS tracking devices (Egevang et al. 2010; Thorup et al. 2017), the increasing accuracy and additional measurements of modern GPS-loggers may be even more important for increasing our knowledge on migratory birds.

The migration route of barnacle geese to the Russian Arctic has been well-documented already over a decade ago (Eichhorn 2005; Eichhorn et al. 2006) using a combination of data from geolocators and implanted satellite transmitters and observational data. These data allowed closer examination in changes in the use of temperate stopover sites in the Baltic (Eichhorn et al. 2009), but due to constant sunlight in the Arctic summer, data from geolocators did not provide information on Arctic stopover sites. Another study tracked barnacle geese from their wintering grounds in the Netherlands in 2008 and 2009 (Ens et al. 2008), and provided the first complete individual migration tracks of barnacle geese up to their Arctic breeding grounds, including several individuals which were tracked for multiple years in a row. These data was used by multiple studies concerning the stopover routines of barnacle geese in relation to the green wave (Shariatinajafabadi et al. 2014; Kölzsch et al. 2015). Although stopover sites can be identified using this data, the rather low frequency of data collection does not enable identification of stopover sites which are used for less than 8 hours.

In the summer of 2014 we deployed UvA-BiTS GPS-loggers (Bouten et al. 2013) on barnacle geese in a breeding colony in the Russian Arctic. These loggers provided accurate GPS-positions, with short intervals between fixes (between 5 – 60 minutes in this study). In addition, an integrated accelerometer can be used to identify movement and behaviour of the bird during migration. Here I use GPS and acceleration data to study the migration schedules and stopover site use during the spring migration of barnacle geese. I combine this with data on energy intake on staging sites to shed new light on changes in stopover site use in the past decades.

Methods

In June and July 2014 we deployed GPS-loggers on female barnacle geese in the breeding colony located at the edge of the Kolokolkova Bay, North-Western Russia (68°35'N, 52°20'E). We captured female geese on their nests during the incubation phase. We placed remote-controlled clap nets at their nests, while replacing their eggs with dummy eggs to prevent damage on the eggs, which we kept warm by placing them in a down-lined shelter together with hot water bottles. We then waited until the female returned to the nest, after which we triggered the clapnet using a remote control. In cases when the female did not return within 60 minutes from placing the trap, we removed the trap from the nest and replaced the eggs. In this way we were able to catch 63 females. We banded every goose with a metal ring and plastic leg rings with engraved markings, and measured biometry (tarsus length, size of the head and length of the wing) and body mass. We equipped 41 geese with 19 grams UvA-BiTS GPS-loggers (Bouten et al. 2013) which we attached using a backpack harness constructed from Teflon, Tygon and nylon (16 grams) (Lameris et al. 2017a). Average body mass of geese was 1495 ± 121 grams, and the mass of the logger and harness relative to the body mass of the bird was on average 2% (3% for the lightest bird). GPS-loggers were programmed to collect GPS positions at an interval of 30 to 15 min in the wintering region, 15 to 7.5 minutes during migration and 5 to 2.5 minutes in the breeding grounds. Following each GPS-fix, 10 samples of tri-acceleration data were collected at 20 Hz. In the summer of 2015 at the Kolokolkova Bay we could remotely download data from GPS-loggers of birds which returned to the breeding grounds, using Zigbee wireless antennas and base station (Bouten et al. 2013). This resulted in 23 complete migration tracks.

From GPS-locations we determined the time which individual birds spent on stopover sites. We considered a bird to be on a stopover when it resided in an area with a maximum size of 10 by 10 km (as birds can travel from roosting to foraging sites within a stopover) for at least 6 h. Birds often made shorter stops on the water, mostly on the Baltic Sea, which they spent largely being inactive (probably resting, see below). We classified the regions in which the bird was located as being situated in the North Sea region (< 10˚ E longitude), in the Baltic Sea region (between 10° E and 30° E longitude), in the Barents Sea region (> 30 ° E longitude), around the Kolokolkova Bay (within 35 km great circle distance from the breeding colony), or in the breeding colony.

We classified behaviour from tri-axial accelerometer data to calculate time budgets for the spring of 2015. This allowed us to distinguish grazing, active (walking and preening), inactive (resting and standing) and flying. After calibrating the accelerometer to classify these behaviours for every GPS-fix (full explanation in methods Chapter 6 and 7), we assigned the time between one GPS-fix and the next as the time which a goose spent performing this behaviour. We constructed time budgets for staging sites in the North Sea (starting from April 15th), Baltic Sea, Barents Sea, Kolokolkova Bay, the breeding colony, and in the breeding colony after birds had started laying their eggs. We determined the laying dates in the field, following methods described in Chapter 7.

To collect data on energy intake at staging sites we conducted measurements on foraging plants, goose droppings and dropping rates of barnacle geese. We conducted measurements on two representative temperate staging sites for migratory geese, on salt marshes (n = 3 plots) and agricultural fields (n = 3) on the island of Schiermonnikoog, The Netherlands (Eichhorn et al. 2012) and the natural grasslands (n = 3) at Grötlingbo-ud on the island Gotland, Sweden (van der Graaf et al. 2007). We conducted measurements every 1 – 2 weeks in 2016, between early March – mid-May at Schiermonnikoog and between mid-April – late May at Gotland. From sampled forage plant and dropping material we analysed nitrogen content, energy content, digestibility, dropping mass and eventually metabolisable energy intake. Full methods in sampling methods and analyses are described in the supplementary materials of Chapter 6.

Results and discussion

Migration route and stopover sites

The migration route (Figure B.1) taken by tracked geese does not differ from routes described in earlier publications (Eichhorn et al. 2006; Ens et al. 2008). After departing from staging sites in the Dutch and German Wadden Sea, geese stages at stopover sites in Gotland, Sweden and at various locations along the Estonian coast. After departure from the Baltic Sea, some geese made a stopover on islands in lake Ladoga or in the surroundings of this lake. Few geese made a stopover at the White Sea, a staging site previously reported as important for barnacle geese (Drent et al. 2007; Shariatinajafabadi et al. 2014)Most geese however made their first stop along the Barents Sea coast, most of them on the Kanin peninsula. In addition, many geese stopped close to the breeding colony, on staging sites along the Kolokolkova Bay, before arriving in the breeding colony.

Migration schedules and stopover site use

Average departure from the staging sites along the Wadden Sea was at 15th of May (Figure B.2). Barnacle geese have delayed their departure since the 1990s, likely following increased competition for food on staging sites along the Baltic Sea (Eichhorn et al. 2009). We find that most individual geese spent only 2 – 3 days in the Baltic Sea region, and average departure from the Baltic Sea took place at 20th May. Unlike presented in previous tracking studies (de Boer et al. 2014), not all geese staged for longer times on stopover sites along the Barents Sea, but some took an almost direct flight to staging sites close to the breeding grounds in the Kolokolkova Bay (Figure B.3). Many geese spent a long period on staging sites around the Kolokolkova Bay, which is likely an alternative to staging along stopovers along the Barents Sea coast. Extensive use of these 'pre-breeding sites' has not become apparent from earlier tracking studies on barnacle geese (de Boer et al. 2014). If food quality is high enough (Ganter & Cooke 1996) geese can indeed stage at pre-breeding sites, from which they may be better able to accurately predict conditions in the breeding colony (Hübner 2006). This may especially be the case in years with an early Arctic spring, such as was the case in 2015 (Chapter 7).

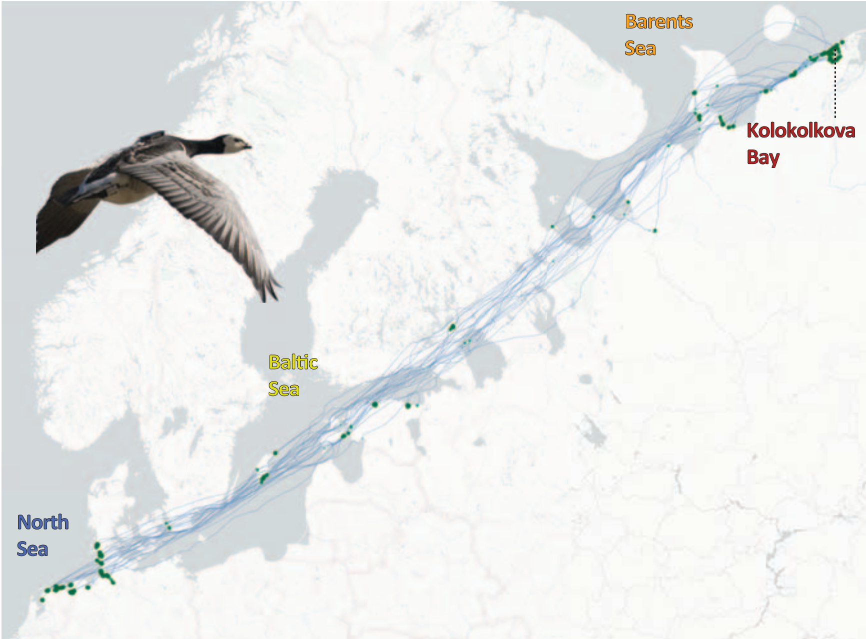

Figure B.1: Tracks (blue lines) of spring migration for 23 barnacle geese breeding in the Kolokolkova Bay. Dots show important stopover sites, with their size dependent on the time which geese spend at these sites.

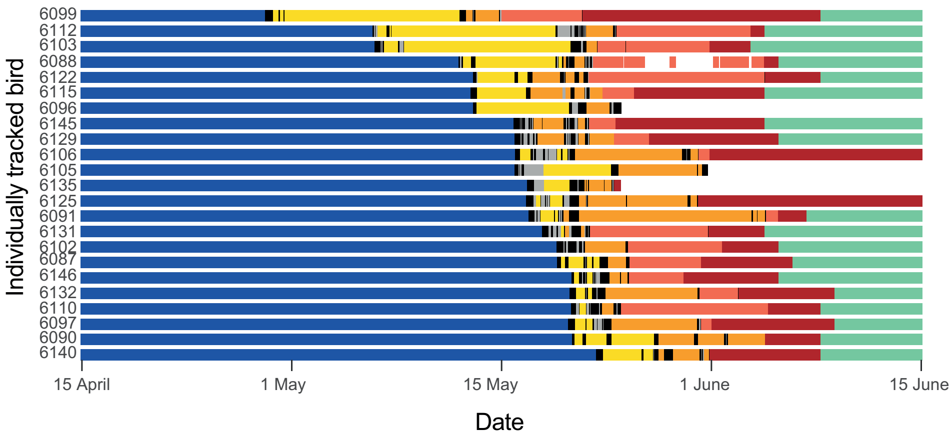

Figure B.2: Timing and stopover site use in the spring migration tracks of 23 individually tracked barnacle geese. Colours show the time spent in staging sites in the North Sea region (blue), Baltic Sea region (yellow), Barents Sea region (orange), staging sites around the Kolokolkova Bay (light-red), in the breeding colony (dark-red), and incubation (green). Black bars denote periods of flying, grey bars denote short stopovers during which geese only rested. White bars show missing data. Individual tracks are ordered by date of departure from the North Sea.

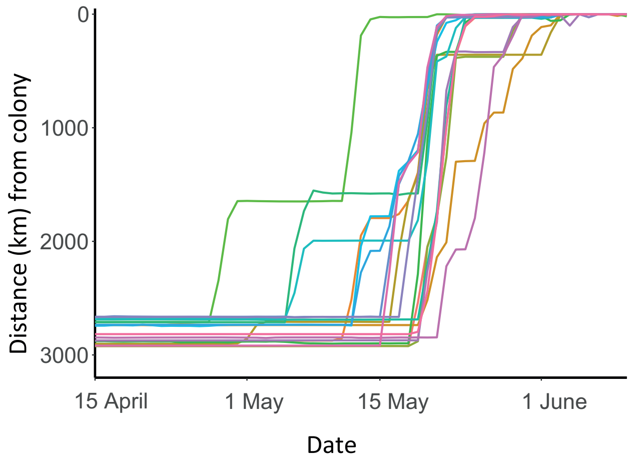

Figure B.3: Timing and migration distance in the spring migration of 18 barnacle geese which bred in the colony at the Kolokolkova Bay. Colours denote different individual birds, lines show the track in time and distance from the breeding colony.

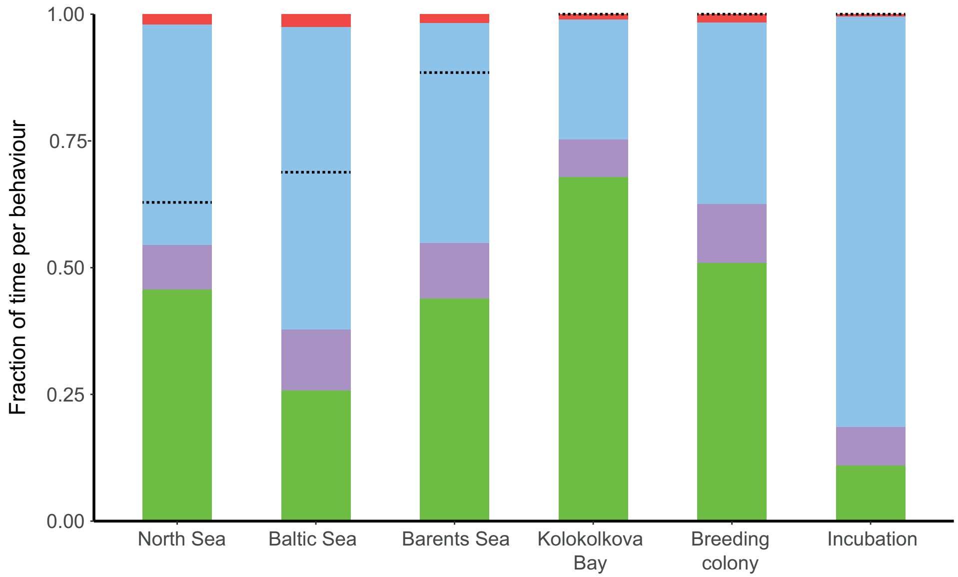

Figure B.4: Time budgets of geese at stopover sites showing the fraction of time spent grazing (green), active (purple), inactive (blue) and flying (red). Black dotted lines show the fraction of daylight as measured on the median day of presence for every staging site.

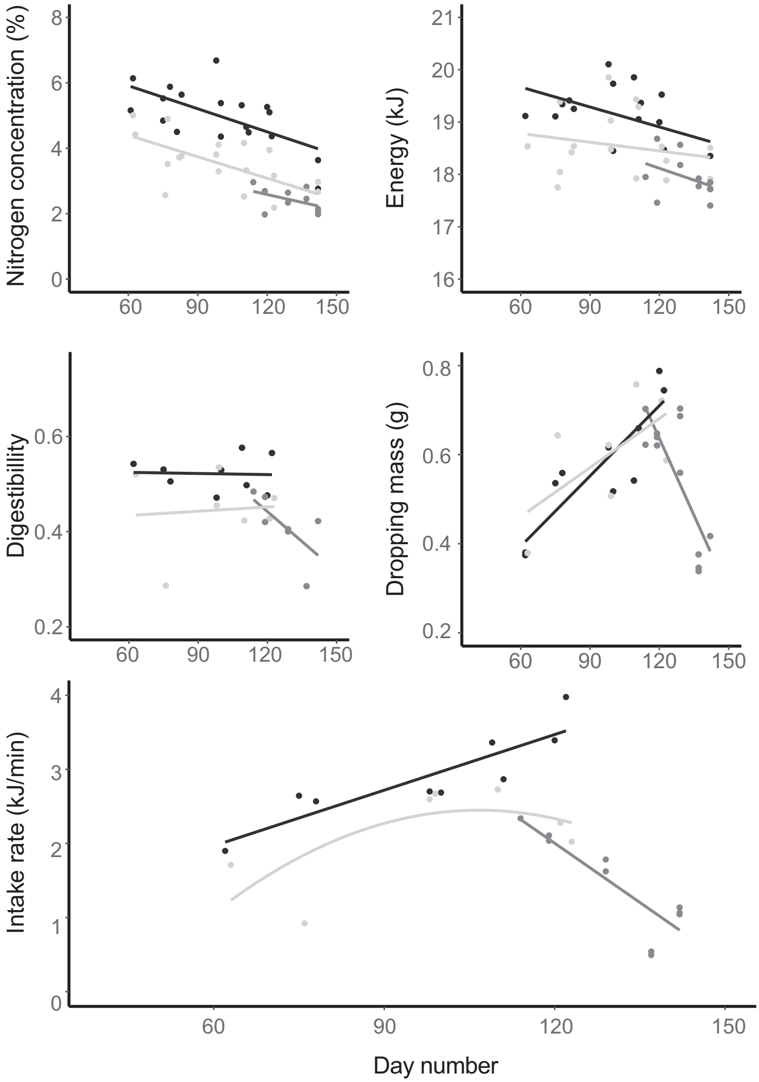

Figure B.5: Nitrogen concentration (%) and combustion energy (kJ) in forage plants of barnacle geese, digestibility, dropping mass (g) and metabolisable energy intake rate (kJ / minute) over time, at salt marshes (light grey) and agricultural fields (black) on a staging site in the North Sea region, and in natural grasslands (dark grey) in a staging site in the Baltic Sea region.

Time budgets on stopovers and food intake

Geese spent more time grazing on sites where more daylight hours were available. On stopover sites in around the Baltic and Barents Sea, geese spent relatively little time grazing relative to the number of daylight hours available, which is especially apparent in the Baltic Sea (Figure B.4). This may be explained as many geese spent long periods resting at these sites after long migratory flights. At the same time, low time grazing at staging sites in the Baltic Sea may reflect the changed function of this site, with geese spending their time mostly resting rather than grazing. We also find that food quality and metabolisable intake rates of geese are relatively low at a staging site in the Baltic Sea (Figure B.5), and geese may rather opt to stage longer in staging sites in the Wadden Sea, where food quality is higher. On the other hand, as we cannot distinguish resting behaviour from alert behaviour (both are placed in ' inactive' category), geese may spend more time being alert at staging sites in the Baltic, in response to increased predation danger from white-tailed eagles *Haliaeetus albicilla* at this site as suggested by Jonker et al. (2010). Geese spent the most time grazing at staging sites around the Kolokolkova Bay, where they prepared for reproduction, again pointing to the importance of these pre-breeding sites.

While the migration route of barnacle geese has not changed, barnacle geese seem flexible in adjusting the stopover sites they use and the time spent on these stopover sites, both in the temperate part of their migration flyway as well as in the Arctic part. This may be in reaction to changed food quality on sites as well as to local climatic conditions.