Faculty of Biosciences, Fisheries and Economics

Department of Arctic and Marine Biology

Autumn staging behaviour in Pink-footed Geese; a similar contribution among sexes in parental care

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Henrik Langseth Kristoffersen

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Abstract

Geese are social birds and form pairs that can last a lifetime, being together throughout the year. Forming pairs and maintaining family groups increase the individual's social status, giving it easier access to resources and more time to exploit them. Hence, social behaviour is favourable when pairs are building up body reserves before migrating to the breeding grounds as well as after breeding, helping the geese to easier replenish depleted reserves. Parents spend much time on vigilant behaviour, an activity that is costly, as it will reduce the time available for foraging. In geese, vigilant behaviour is more frequent for males than for females. Female geese have an extra high cost during the breeding period, resulting in an urgent need to replenish body reserves after the eggs are hatched. The male takes on the responsibility of vigilant behaviour during brood rearing, giving the female time to replenish her reserves. We studied the behaviour of Pink-footed geese in Mid-Norway on their way from the breeding grounds in Svalbard in the autumn, 2015, in order to evaluate whether this behaviour between sexes has changed after the breeding period in Svalbard. We hypothesized that the processes at the autumn stopover site are different compared to processes in the breeding grounds. We also evaluated the gain in body condition for parents as well as for the juveniles and for geese without young. We predict that the females contribute more to the guarding of young due to a more relaxed pressure on body mass accumulation in the autumn season. Juveniles were expected to increase in body condition over the staging period, and if males were rebuilding the reserves we also predicted that their body condition would increase. We expected to find a clear difference between non-breeding pairs and parents with young, as parents need to spend more time on vigilance behaviour at the expense of the time spent on feeding. Pairs with young expressed by their behaviour a clear cost of having young, as they spent less time on feeding and more time being alert compared to the corresponding behaviour of pairs without young. Since no significant difference in behaviour between males and females were found, our hypothesis that there are different selective processes at an autumn stopover site compared to the processes at the breeding season is supported.

Key words: Pink-footed geese; *Anser brachyrhynchus*; foraging behaviour; aggressiveness; vigilance; autumn; inter-parental difference; cost of brood rearing; Mid-Norway; body condition.

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1. Introduction

Geese are social birds and form pairs that can last a lifetime, being together throughout the year (Black, Prop, and Larsson 2007). This perennial monogamy is a favourable mating strategy for several reasons. Migratory geese are capital breeders and females rely on stored lipid and protein reserves for both the production and incubation of a clutch (Ankney & MacInnes 1978, Tombre and Erikstad 1996, Tombre et al. 2012). Forming pairs and maintaining family groups also increase the individual's social status, and gives easier access to resources and more time to exploit them (Hanson 1953). Hence, such social behaviour is favourable when pairs are building up body reserves before migrating to the breeding grounds (McLandress & Raveling 1981) as well as after breeding, helping the geese to easier replenish their depleted reserves (Sedinger & Raveling 1990). During breeding and nesting, pair formation ensures paternity as well as protecting the female on the nest (Mineau & Cooke 1979). Juveniles stay with their parents for a long period of time. In geese, young can be with their parents also during the winter (Black, Prop, and Larsson 2007). Parents can tolerate the cost caring for the goslings through winter, and some families stay together through spring and also when migrating back to the breeding grounds. This has been shown to be favourable for both parents and young, increasing the social status and foraging time (Black, Prop, and Larsson 2007).

Parents spend much time on vigilant behaviour, an activity that is costly, as it will reduce the time available for foraging. In geese, vigilant behaviour is more frequent for males than for females, (Black, Prop, and Larsson 2007), and has been shown both during winter (Austin 1990), and during the breeding and brood rearing periods for several goose species (Lazarus & Inglis 1978, Sedinger & Raveling 1990, Black, Prop, and Larsson 2007). Geese are capital breeders depending on their body's lipid and protein reserves for migrating to the breeding sites, for nesting and brood rearing. Females have an extra high cost during this period. In addition to laying the eggs, the female incubates the clutch. Females may lose as much as 30% of her body weight during the breeding period, whereas males may lose 17% (Lazarus & Inglis 1978). Although the females leave the nest to feed during incubation, she spend a significant amount of body reserves on incubation (Tombre and Erikstad 1996, Tombre et al. 2012), and once the eggs are hatched these must be rebuilt. The males guard the nest but can also feed nearby when the females incubate. After the eggs have hatched the males put more effort in the young than females in terms of guarding. For instance, in a study on Pink-footed

Geese it was found that the male spends four times more on vigilance behaviour after the eggs were hatched compared to the female (Lazarus & Inglis 1978). This demonstrates the different roles as parents in the breeding period where the males guard the goslings whereas females prioritise foraging behaviour to gain body reserves. The same pattern was also found for Cackling Canada geese *Branta canadensis minima*. Sedinger and Raveling (1990) recorded that males were more vigilant than females after hatching, allowing females to build up their lipid and protein reserves.

There are few studies on goose behaviour in the autumn after the breeding season. The Svalbard-breeding population of Pink-footed Geese *Anser brachyrhynchus* stages in the autumn in Mid-Norway on their way to their wintering grounds in Denmark, the Netherlands and Belgium (Madsen et al. 1999). Gundersen et al. (2016) measured the body mass of shot Pink-footed Geese during their stopover in Mid-Norway. They found differences between age and sex-classes. Since males late in the season had a higher body mass than those shot early, the authors assumed that this was due to an increase in body reserves over the stopover time. An increasing trend was also found for juveniles shot during the season, but not for females. Gundersen et al. (2016) measured shot birds and were unable to distinguish between breeding and non-breeding birds. At this stopover site in autumn, a goose flock is a mixture of pairs with young and non-breeding adults. Based on the trade-off for the parents in the family between foraging behaviour and vigilance, differences are expected between geese with and without young to care for.

In the present study, we have looked at the behaviour of Pink-footed Geese during their autumn stopover in Norway. The behaviour and body condition, in terms of abdominal profiles, were recorded for goose families, with and without young, as well as behaviour of the juveniles. Based on the study by Gundersen et al. (2016) we hypothesize that the processes at an autumn stopover site are different compared to processes in the breeding season. Females may already have gained the sufficient level of reserves due to a higher fraction of time spent foraging in the brood rearing period at the breeding grounds. The young need to grow and the males need to rebuild reserves after the energy-demanding brood rearing period at the breeding grounds. We therefor predict that the females will contribute more to the guarding of young due to a more relaxed pressure on body mass accumulation in the autumn season. Juveniles are expected to increase in body condition over the staging period, and if males are rebuilding the reserves we also predict that their body condition will increase.

We expect to find a clear difference between non-breeding pairs and parents with young, as parents need to spend more time on vigilance behaviour at the expense of the time spent on feeding.

2. Material and Method

A. Study species and study area

The Svalbard-breeding population of Pink-footed Geese has its wintering grounds in Belgium, the Netherlands and Denmark. The population stages in the western parts of Denmark in spring before migration to the breeding grounds. During the migration north it utilizes stopover sites in central and northern Norway. The geese depart from Svalbard in mid-September and migrate through Norway and Denmark, stopping primarily in three regions; along the west coast of Jutland in Denmark, the area around the Trondheimsfjord in central Norway and in Vesterålen North Norway (Madsen et al. 1999). In the autumn the Pink-footed Geese stay in central Norway from the end of September and throughout October, and some flocks can stay to the beginning of November (Tombre et al. 2009). The current size of the population is approximately 70,000 geese (J. Madsen, unpublished data). This study took place in Levanger municipality in Nord-Trøndelag County, Norway (Figure 1). The region lies next to the Trondheimsfjorden and is in the relatively flatter parts of Norway. The area is ideal for agriculture providing an excellent place for the Pink-footed Geese to stop on their way south from Svalbard after breeding. The study area comprises of agricultural lands with a large percentage of cereal crops. When the geese arrive in the autumn, most of the crops are already harvested, or in the process of being harvested, when the pink-footed geese arrive to Nord-Trøndelag in the autumn. The geese come during the day to feed on spilt grain in the stubble fields, and then returns to surrounding lakes and sheltered bays used as roosting sites in the evening (Madsen et al. 2015). Most of the roosting sites are protected from hunting, which is a source of disturbance and stress for the geese. Goose hunting is a popular activity in Nord-Trøndelag, the county in Norway where most of the Pink-footed Geese in Norway are harvested (Jensen, et al. 2012).

Figure 1: Illustration map over the study area in Levanger municipality (main figure), and its location in Norway (left side).

B. Fieldwork

Most of the fields where the geese foraged was accessible by car. The data was collected through observing the geese from a parked car with a telescope (20x60 mm.) mounted on the car window. During the autumn in 2015 registrations were conducted between 24 September and 15 October. The geese were located by searching among the harvested fields of cereal crops were they spend the day feeding. The geese were apparently used to traffic and passing pedestrians along the roads, and were not disturbed by the parked car or observer when they foraged on the field. Pairs and families of geese were observed in groups from two individuals, in pairs and up to thousands of birds. The observer identified a pair or a family group in the flock, usually in the outskirts of the flock, and observed the birds continuously as long as possible (up to 30 minutes). Each minute the behaviour of each individual was noted (using a stopwatch). Six different behaviours were recorded: Eating, alert (head up), resting, preening, walking and aggressive behaviour. For analyses we categorized behaviours to either eating, alert and other activities, where the latter summarises walking, preening and resting. Since aggressive behaviour was not very frequent compared to the other behaviours, and when occurring, not lasting for longer times, notes were taken of every attack made by an individual. The body condition of the geese was also assessed, using an abdominal profile index (API) (Madsen & Klaassen 2006). The index has seven levels (Figure 2) ranging from lean (score 1) to very fat birds (score 7), and is a tested and widely used measure of body condition in geese in the field (Madsen & Klaassen 2006). The scores were calibrated among observers before the study.

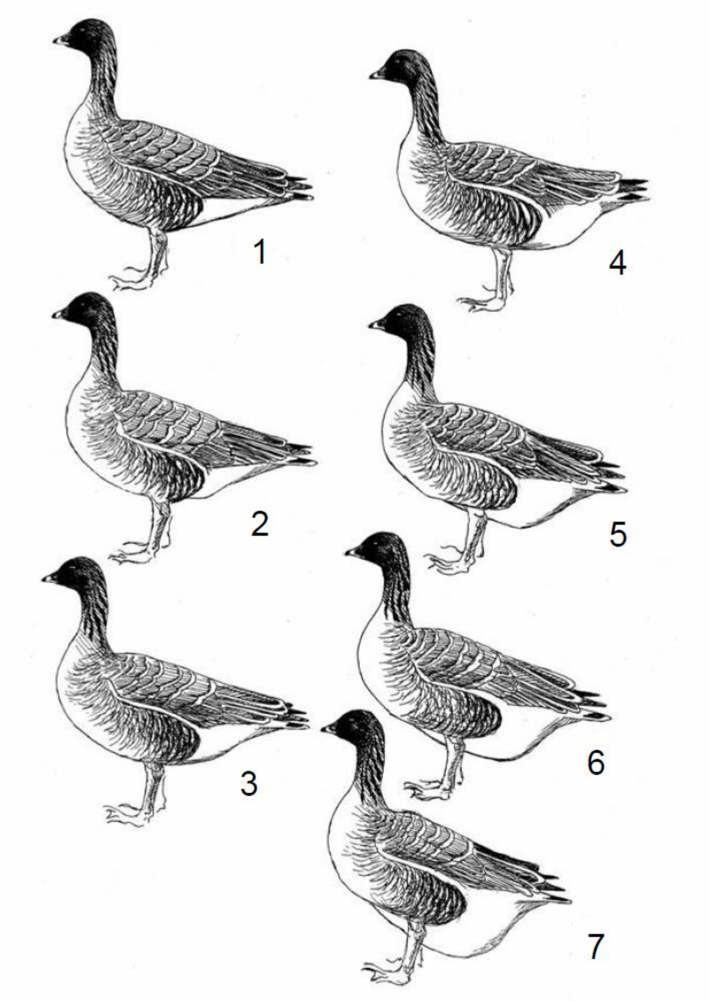

Figure 2. Abdominal profile index for pink-footed geese used during field work.

The observer was trained to identify the sexes of the adult pairs, and they were identified when the pair was close to each other and had an upright position at the same time. The gender were separated by size (the male is about 10% larger than the female) (Cramp & Simmons 1977) and by the thickness of the neck (females slightly thinner) (J. Madsen, pers. comm.).

C. Statistical analysis

Data was sorted and statistical analyses were carried out in SAS statistical software (SAS Institute 2008). Based on predicted behaviour, the geese were categorised in five groups; juveniles, females and males with young, and females and males without young, hereafter referred to as goose category. The fraction of each behaviour in each observation period was compared among the different goose categories (a total of 260 observation periods).

The length of the observation periods for each individual varied, either because the goose flew away, started to sleep or disappeared within the flock out of sight for the observer. In order to evaluate whether all observations could be used, linear regressions were conducted for each behaviour category against the length of the observation period. For males with young, there was a significant negative relationship between the length of the observation period and the time spent feeding, suggesting a higher proportion of time spent feeding in the shortest observations periods. Hence, in order to use a representative dataset, i.e. results not influenced by the length of each observation period, the shortest periods were deleted (stepwise, until there was a non-significant relationship) and only observation length from 11 minutes or longer were included in further analyses. No significant relationship was found for the other behavioural categories, neither for the other goose categories, and all the remaining data was therefore used in further analyses (average time length 21 minutes, stderr = 0.474).

Student T-tests were used for comparing the fraction of time spent on each behaviour (eating, being alert, other behaviour) between the adult geese with and without young, separately for each sex. ANOVAs were used to compare the fraction of time spent on eating, being alert and other behaviour among the five goose categories. An ANOVA was also conducted for females and males with young separately to examine potential differences in behaviour when having one, two, three, four and five young. As the date and the ambient temperature could affect the behaviour, General Linear models (GLMs) were conducted. The behaviour variables where included as dependent variables in separate models, with goose category (treated as class variable), date (treated as a continuous variable) and ambient temperature as independent variables. Temperature data was downloaded from the Norwegian Meteorological Institutes web-pages (www.eKlima.no) and average ambient temperature at the hour of the observation from the nearest weather station (Mære, in Steinkjer municipality) was used.

In order to evaluate potential differences in behaviour during the day, all observations were categorised to the nearest hour. Observations conducted between 8 30 and 9 30 a.m. were grouped to “9”, observations between 9 31 and 10 30 a.m. were grouped to “10”, and so on. Sample sizes become limited when splitting up in groups and hence no statistical analyses were conducted for these data. Averages for the three behaviours were presented in 100% stacked columns with one column for each hour. Geese were observed when day light made it possible. In September and October in Nord-Trøndelag this means between 8 30 a.m. 18 30 p.m. I order to test whether the size of the flock had any impact on the foraging behaviour, linear regressions were conducted separately for the three behaviours (eating, being alert and other behaviour) and flock size.

3. Results

The number of Pink-Footed geese with detailed behavioural observations observed is shown in Table 1, including the mean length of the observations. The length of the observations was set at a maximum of 30 minutes, but varied due to environmental conditions and goose behaviour.

Table 1. The number of males, females, with and without young, and the number of juveniles of Pink-footed Geese observed in Nord-Trøndelag the autumn 2015 and the average length of the observation periods of the different categories.

	N	Mean observation length (minutes ± stderr)	Range (min) (min-max)
Males without young	22	20.68 ± 1.52	6-30
Males with young	54	22.11 ± 0.98	11-30
Females without young	22	20.68 ± 1.52	6-30
Females with young	57	21.37 ± 1.03	11-30
Juveniles	105	21.33 ± 0.79	5-30

Behavioural observations

There was a clear behavioural difference between geese with and without young (Table 2). Females with young spent considerably less time eating (expressed as the fraction of the whole observation length for each individual) than did females without young. The tendency was the same for males, although not significant. Correspondingly, the fraction of the observation length spent being alert was significant higher for both sexes when not having young. No significant differences were found between geese with and without young in the fraction of time spent on other behaviour, regardless of sex.

Table 2. The average fractions of the observation periods spent on eating, being alert and on other behaviours for male and female Pink-footed Geese with and without young (significant values in bold).

	Males with young (n51)	Males without young (n22)	T-value	P-value
Eating	0.4 ± 0.04	0.8 ± 0.04	-6.43	0.097
Alert	0.5 ± 0.03	0.1 ± 0.01	6.05	**<0.0001**
Other Behaviour	0.15 ± 0.02	0.11 ± 0.03	0.89	0.746
	Females with young (n55)	**Females without young (n22)**	**T-value**	**P-value**
Eating	0.5 ± 0.04	0.8 ± 0.04	-5.4	**0.009**
Alert	0.4 ± 0.03	0.1 ± 0.01	5.84	**<0.0001**
Other Behaviour	0.14 ± 0.02	0.1 ± 0.03	1.15	0.127

An analysis of variance (ANOVA) tested the relationships between all the different categories, including the juveniles. The differences between geese with and without young were also illustrated here, but the test also revealed that there were no differences between females and males regardless of having young or not (Figure 3, 4 and 5).

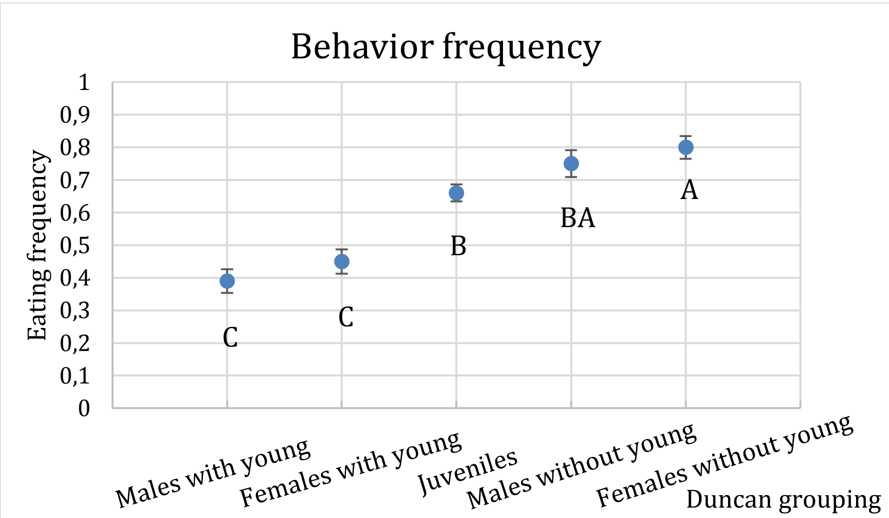

Figure 3. Relationship between the different categories of Pink-footed Geese in the time-fractions spent on eating during the observation periods. Values are means of the observation trials for each group. An ANOVA gives a significant result (F=19.79, df= 4, 259, p= <0.0001). Different letters represent significant differences (Duncan's multiple range test). Vertical lines are standard errors. For sample sizes see Table 1.

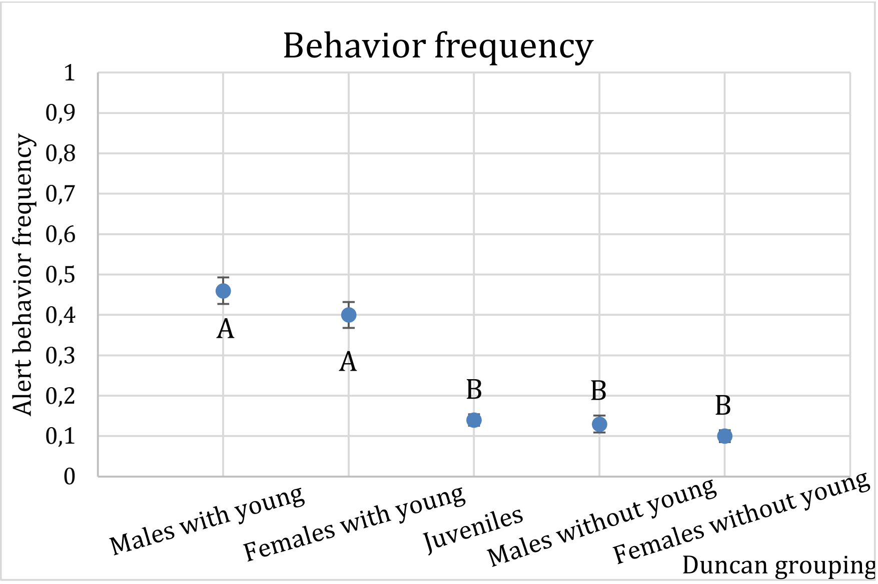

Figure 4. Relationship between the different categories of Pink-footed Geese in the time-fractions spent on alert behaviour during the observation periods. Values are means of the observation trials for each group. An ANOVA gives a significant result (F=41.49, df= 4, 259, p <0.0001). Different letters represent significant differences (Duncan's multiple range test). Vertical lines are standard errors. For sample sizes see Table 1.

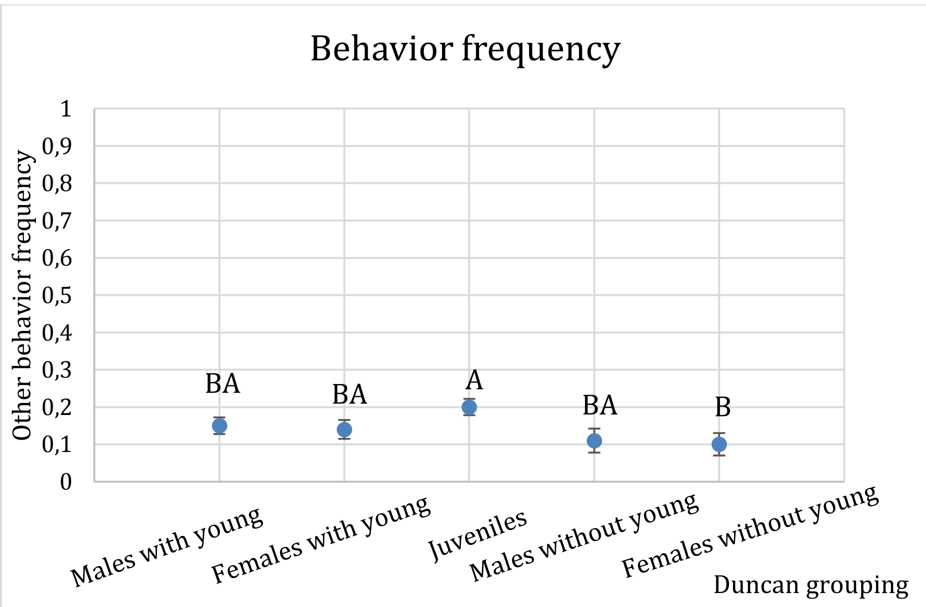

Figure 5. Relationship between the different categories of Pink-footed Geese in the time-fractions spent on other behaviour during the observation periods. Values are means of the observation trials for each group. An ANOVA gives a significant result (F=2.12, df= 4, 259, p=0.0789). Different letters represent significant differences (Duncan's multiple range test). Vertical lines are standard errors. For sample sizes see Table 1.

The observation date and temperature had no significant effects on any of the three behaviours when included in models with goose category (Table 3). Hence, the behaviour depend on goose category, not the date or the ambient temperature as such.

Table 3. Results from analyses on the behaviour of Pink-footed Geese, in relation to the goose category (see methods for definition), date of observations and average ambient temperature of the hour when the goose is observed. Type III Sum of Squares values are presented Significant values in bold. The models for eating and alert behaviour are significant (Eating: F= 11.87, df = 6, 244, p<0.0001, Alert: F= 24.65, df= 6, 244, p <0.0001), whereas the model for the other behaviour is not significant (F= 1.51, df= 6, 244, p= 0.176).

	F-values	P-values
Eating		
Goose category	17.6	**<0.0001**
Date	0.77	0.6
Temperature	0.88	0.35
Alert		
Goose category	36.8	**<0.0001**
Date	0.01	0.92
Temperature	0.65	0.42
Other behaviour		
Goose category	2.24	0.065
Date	0.35	0.55
Temperature	0.22	0.64

For geese with young, there were no significant relationship between the brood size and the behaviour of the parent (each sex analysed separately for the average fraction of eating, being alert and other behaviour, all p-values > 0.11). This suggests that goose parents spend the same amount of time on eating, being alert or other behaviour regardless of the number of young.

In addition to the different behaviour recorded each minute during the observation periods, aggressive behaviour occurring at any time during observation was noted. Figure 6 shows the average numbers of aggressive behaviour recorded for the different groups. There were apparently no differences between the groups, except that the juveniles showed no aggressive behaviour.

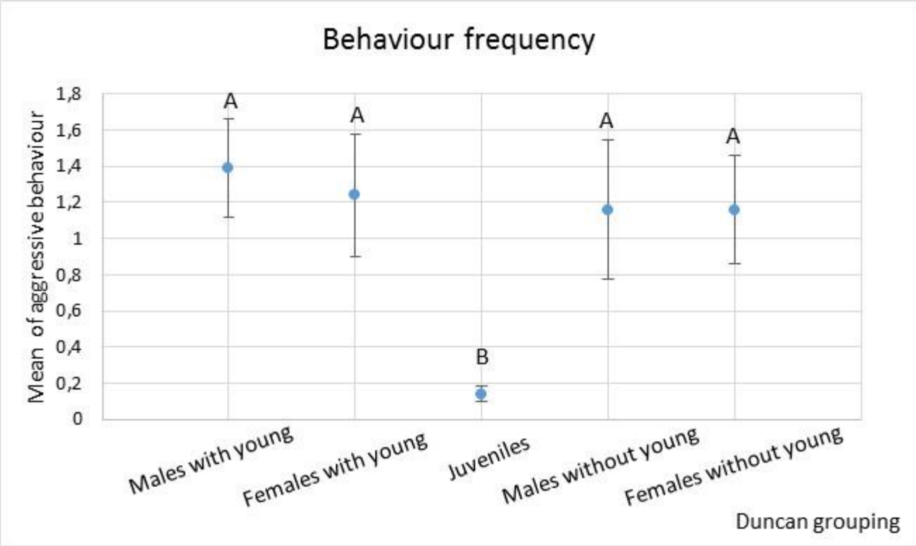

Figure 6. The average number of aggressive behavior displayed during the observation periods for Pink-footed Geese. Values are mean values for each group over all observation periods (Duncan's multiple range test).

Body condition

The body condition, expressed as the Abdominal Profile Index (API), showed that there were no differences among categories when pooling observations from the whole study period (Figure 7). The variation was small and most of the geese were scored to have profile 2 or 3. The average values ranged from 2.34 for juveniles to 2.95 for females without young (Figure 7).

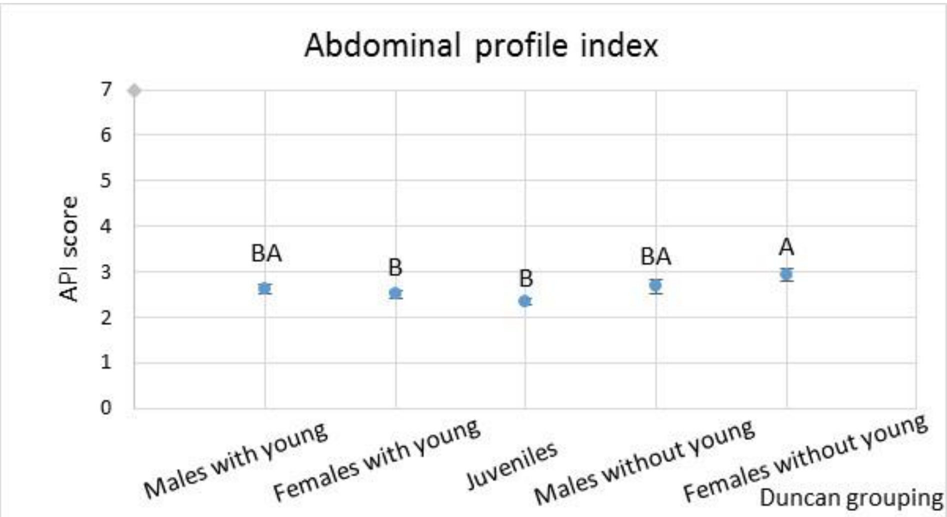

Figure 7. The average body condition (the Abdominal profile Index) for the different categories of Pink-footed Geese. Values are means of records over the entire observation period.

Juveniles were the only category that was found to have a significant increase in body condition (API) through the study period ($r^2 = 0.084$, P = 0. 0044, n = 95). For all other categories there were no change in body condition through the observation period (all p-values >0.054). Females with young showed a significant positive relationship between body condition and time spent on other behaviour ($r^2 = 0.07$, P = 0. 049, n = 55). No other significant relationships were found between API and the fraction of time spent on eating, being alert or other activities for any of the other categories (all p-values > 0.0896).

Behaviour and time of day

One factor that might affect the goose behaviour is the time of day, as the foraging in the mornings and evenings could be different from that during mid-day. Additionally, the different groups of geese might show different activities at different times. Due to limited sample sizes, no statistical tests are conducted for the adult geese, yet there are indications that there are at least no big differences in the time spent on each activity during the day (see Figure 8). However, for juveniles, average fraction of time spent on other activities appears higher during mid-day. Again, the differences between geese with and without young becomes apparent, i.e., geese with young spend less time feeding and more time being alert.

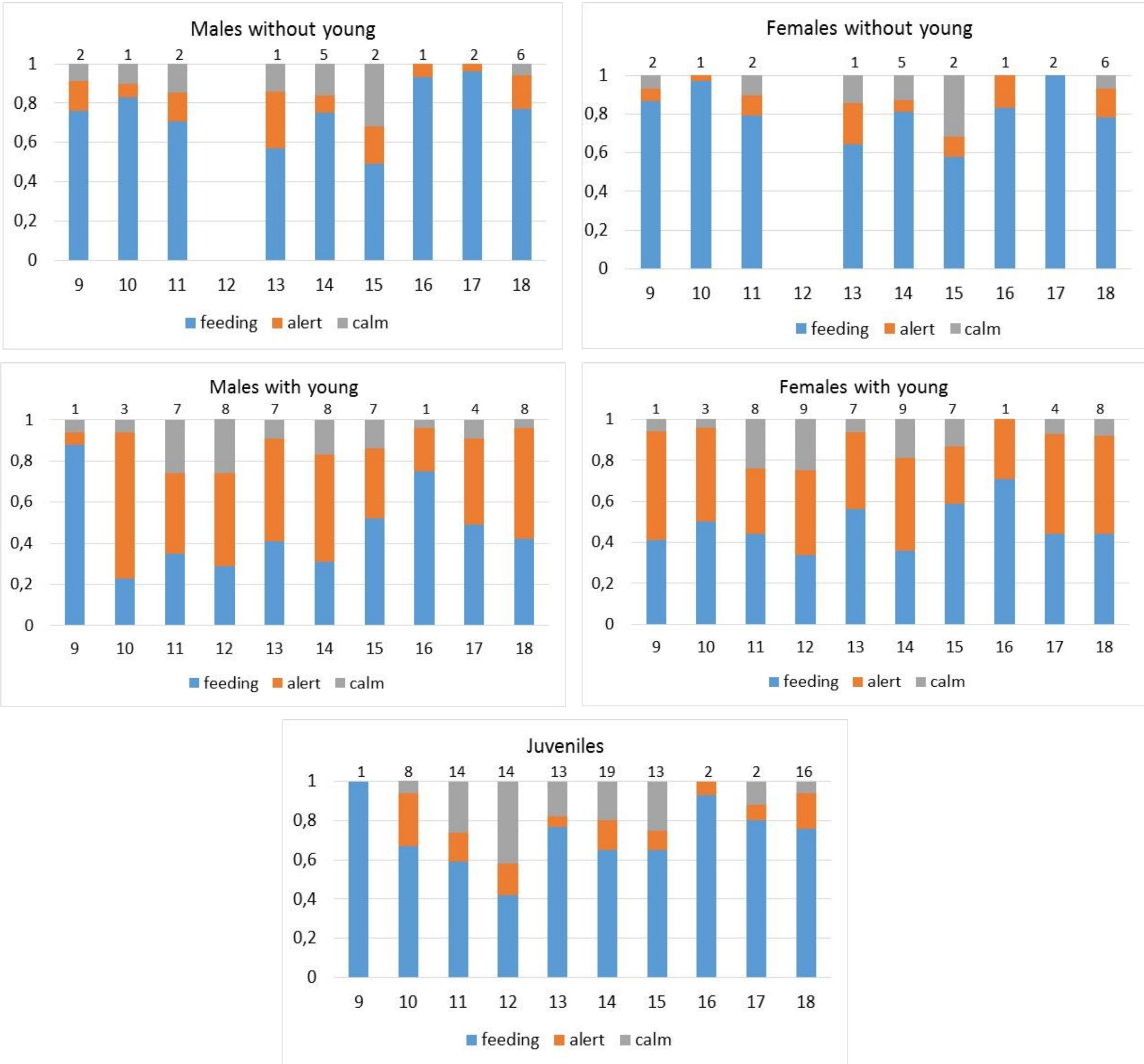

Figure 8. Behaviour of pink-footed geese through the day in the observation period in Nord-Trøndelag in the period 09.24.2015 - 10.15.2015. Numbers on top of bars are the sample size. Mean values are procured through ANOVA. No significant values was found between the time of day and behaviour, except for juveniles on all behaviours (P-values <0, 0116) and females without young and alert behaviour (P-values <0, 0497).

Flock size

Flock size had an effect on behaviour for juveniles and females without young. That is aggressive behaviour increased for juveniles as flock size increased (r^2 = 0.047, P = 0. 046, n = 86), and females without young had a higher average of the time spent on other behaviours (r^2 = 0,256, P = 0.019, n = 21) and ate less (r^2 = 0. 373, P = 0.0033, n = 21) when flock size increased.

4. Discussion

We found a clear behavioural difference between geese with and without young in this study. The difference was apparent in eating as well as alert behaviour, where goose pairs with young spent less time on eating and more time on alert behaviour compared to those without. There were no significant differences in time spent on other behaviour between any of the five goose categories. The behaviour category consisted of the behaviours walking, resting and preening, and separate tests was conducted for these behaviours, showing the same results (all tests insignificant). This indicates that the foraging behaviour in the autumn apparently only affects the geese' most vital behaviours like eating and alert behaviour, since males and females with and without young had significant behavioural differences in the eating and alert behaviours. In the breeding season, on the other hand, parenting males have been recorded to spend four times more on vigilance behaviour after the eggs are hatched compared to the female (Lazarus & Inglis 1978). This demonstrates a more similar behaviour among sexes in the autumn, and shows that males and females apparently are under the same selective pressure at this time when it comes to rearing young. Except for the juveniles, there were no changes in the body condition, expressed as the Abdominal Profile Index, over the study period. Maintaining the body condition may be sufficient during this period, whereas juveniles must grow and build up reserves for the last migration back to the wintering areas.

The non-significant increase in body mass for males is in contradiction to the findings by Gundersen et al. (2016). When they measured body mass of Pink-footed Geese shot during their autumn-stopover in Mid-Norway, they found that males shot late in the season had a higher body mass than those shot early, and the authors assumed that this was due to an increase in body reserves over the stopover time. In their study they calculated the body mass of the birds with the aid of a scale weighing to an accuracy of 50 g. In the present study, body mass was scored following an index from 1-7 which is a rather wide scale. When most of the birds have a score between 2 and 3 it may be difficult to detect changes in body condition during the autumn period if the changes are small. In the study by Gundersen et al. (2016), it was impossible to separate the adults regarding having young or not. But in the present study, when pooling females and males in separate groups regardless of having of having young or not, we still found the same relationships (all p-values > 0.054). Interestingly, Gundersen et al. (2016) found that juveniles increased in body mass at a higher rate than did adult males. They suggested that this might be caused by that the juveniles by this time were not yet fully grown, and still in a phase of active growth. This was also found in the present study were we found a significant increase in body condition for juveniles, albeit with large variation demonstrated with low r^2-values ($r^2 = 0.084$).

Brood size was not found to have any significant effect on the behaviour of parents, suggesting that parents goose parents spend the same amount of time on eating, staying alert or relaxing regardless of how many young in the brood. Mulder et al. (1995) studied the relationship between brood size and social dominance in Lesser Snow Geese *(Anser caerulescens caerulescens)* during the brood rearing period at the breeding grounds. They found no clear dominance hierarchy in relation to brood size, but they found that pairs with young attained a higher status than did those without. In the present study we found no significant difference between aggressive behaviour, and pairs with and without young. This could be an indication that the need for aggressiveness ceases in the autumn period. This might be due to, or a combination of, that the young being large enough to forage by themselves, and a general lower pressure on acquiring food when the young are large compared to at the breeding ground.

An effect of flock size on the behaviour of juveniles and females without young was found in the present study. Juveniles showed an increase in aggressive behaviour as flock size increased, but there was a large variation in the relationship ($r^2 = 0.047$). Females without young showed an increase in time spent on other activities and ate less with larger flock size. Flock size did not have an effect on any of the other categories or behaviours. For juveniles, larger flocks probably also mean more interactions with other geese and can explain the relationship found with the aggressive behaviour. For females without young, there are no obvious reasons for the significant relationship since no such relationships were found for the other adults. One reason could be the lower social status for such females (Black, Prop, and Larsson 2007).

Due to limited sample sizes there were no statistical tests conducted for adult geese on the relation between behaviour and the time of day. Compared to females, the amount of time spent eating was larger for males with young at the end of the day. Time of day could affect behaviour as foraging in the mornings and evenings could be different from the foraging during mid-day (Chudzinska et al. 2013). This could be where the males increase the foraging to gain the body reserves and compensate for the loss at the breeding grounds, but the data in this study is too limited to demonstrate that. In addition, the ambient temperature and the day in the season could influence the feeding behaviour (Raveling et al. 1972). In models where these variables were included with the behaviour, no significant relationships were found. Hence, there were similar effects of date and temperature on the behaviour regardless of sex and age.

Conclusions

There was found a clear effect on the behaviour of Pink-footed Geese of having young during the autumn period. Pairs with young expressed through behaviour a clear cost of having young, observed in the time they spent on feeding and being alert during the study period compared to the time spent by pairs without young. There was no significant difference in behaviour between males and females within pairs of the same breeding category. This confirms our hypothesis stating that processes at an autumn stopover site are different compared to processes in the breeding season, were the males can spend four times more on vigilance behaviour after the eggs were hatched compared to the female (Lazarus & Inglis 1978). Hence, in the autumn, the parental care is apparently more similar among the sexes. The lack of difference between male and female with young, also serves as an indication that the females have managed to compensate for the energetically costly breeding period before the geese arrive the stopover during the autumn migration. Adult birds did not show an increase in body condition during the study period, nor did we find a significant difference between goose categories. This contradicts the study made by Gundersen et al. (2016), but they used a more exact measure of body condition and the same pattern cannot be excluded in the present study since a different method was used to measure body condition.

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