



# Behaviour frequencies, spatial distribution and social network of Grimaud geese during the laying season

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## ABSTRACT

Most domestic goose breeds were domesticated from the Greylag goose. Even though domestication resulted in a change in the production and behaviour of birds compared to their ancestors, geese are relatively recently domesticated and less intensively selected for production compared to other species (i.e. chickens or dairy cattle). In this respect, we hypothesised that the territorial defence of ganders would be present during the laying season similar to the wild ones. The behaviour of birds was expected to differ by sex, the month of the laying season and the time of the day. We assumed that the hierarchy within a group would be affected by the influence of other groups. Altogether 150 birds in three fifty-bird groups were examined over five observation events indicating the onset (December), the peak (the start, the middle and the end of January) and the end (the end of February) of the laying season. Twenty behaviour elements classified into five categories (locomotion, static behaviours, feed intake, comfort behaviours and social behaviours) were examined regarding the three groups as replicates. The territorial defence of ganders was evaluated by spatial distribution analysis, and the relations within groups were investigated by social network analysis. Between sexes, only the frequency of social behaviours presented differences. Ganders showed social behaviour more frequently than geese (10.89% vs 1.49%,  $P=0.000$ ). The frequency of static behaviours was the lowest at the onset of January and the highest in February (21.18% vs 38.03%,  $P=0.000$ ). The frequency of feed intake was the highest in December and the lowest in February (18.33% vs 4.83%,  $P=0.000$ ). Comfort behaviours showed the lowest frequency in December and the highest at the onset of January (36.65% vs 57.63%,  $P=0.000$ ). The social behaviours were unchanged in December and January but decreased in February (4.40–6.37% vs 1.16%,  $P=0.000$ ). Only the frequency of social behaviours differed by the time of the day, indicating the highest frequency in the morning (55.60%,  $P=0.003$ ). The results of the spatial distribution analysis did not strongly support the presence of territorial defence of ganders. The structure within a group was the most explicit in Group 1 having an adjacent large group and another small group by which it was likely to be influenced. It might be concluded that domestic geese ganders did not keep their territory-holding ability to a full extent during domestication and the behaviour (mainly social interactions) of domestic geese is influenced by sex, the month of the laying season and the time of the day. The structure within a group was somewhat influenced by the adjacent groups.

## 1. Introduction

Most domestic goose breeds were domesticated from the wild Greylag goose (*Anser anser*) in around 4000 B.C. (Matolcsi, 1975). Domestication and selection had a significant influence on the phenotype of the goose. During its domestication, its live weight increased (Schneider, 1995) and the domestic goose became a non-migratory and polygamous species (Pingel, 2000; Kozák, 2019). The domestication process has resulted also in accelerated growth (Pingel, 2000), a

moderate increase in prolificacy, egg production (Bogenfürst, 2000) and mating activity (Kozák, 2019).

Regarding behavioural changes, wild individuals show more activity, preening and pecking and consume more during the rearing period compared to the domestic geese (Molnár et al., 2002). The level of aggression has also reduced due to domestication thereby mitigating social interactions between animals (Molnár et al., 2002). Also, the sexual behaviour of geese became more pronounced. Wild geese mate only in spring but domestic breeds show sexual activity through the

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whole laying season (e.g. Akesson and Raveling, 1982).

Wild geese species are considered to have strong territorial defences (Hanson, 1953);

Weiß et al., (2011)). For example, the wild Ross's goose (*Anser rossii*) ganders are reported to show more aggression in the first half of the laying season towards predators and other males (Owen and Wells, 1979). However, to our best knowledge, no information is available on the territorial behaviour of domestic geese. This fact suggests that the examination of the territorial defence of ganders is important.

Nowadays, the concept of animal welfare is even more emphasised than it was in the past. It presents the freedom to express normal behaviour as one of the Five Freedoms of animal husbandry. It means that the husbandry system in which animals are kept should allow the birds to show species- and breed-specific behaviour elements. Therefore, the evaluation of goose behaviour helps to understand the physiological needs of birds and enables the establishment of an animal-friendly environment and husbandry system (Molnár et al., 2002). Though many authors investigated the social behaviour of wild greylag geese (e.g. Rutschke, 1982; Schneider, 1995; Lamprecht, 1991; Fox et al., 1995; Kotschal et al., 2005), little is known about the domestic geese. It is known that wild geese form large flocks with complex social links (Frigerio et al., 2001) and higher survival of goslings is associated with more frequent vigilance and aggression and less frequent foraging by individuals (Szipl et al., 2019).

The cohesion of a group is dependent on the social interactions between the individuals (Rueden et al., 2015) but physiological differences (Conradt and Roper, 2000) can also influence it. In general, the higher the connectivity between the group members is, the better the fitness and survival of the individuals are (Nagy et al., 2010).

We aimed to investigate the frequency of behaviours by month and by the time of the day to reveal any patterns in the diurnal routine of domestic geese. It was assumed that the frequency of feed intake would be high and that of the social behaviours would be low at the onset of the laying season (in December). However, we supposed that at the peak of egg production (in January), we would experience the reverse of this. In February, the frequency of feed consumption and social behaviours was expected to decrease. We also hypothesized that there would be a diurnal change in the activity of geese. Considering that ganders and geese have sexually dimorphic endocrine physiology (i.e. the operation of the hormonal system), the frequency of behaviours was expected to differ also between the sexes. Since the instinct of territory defence in wild ganders is strong, our hypothesis was that the ganders of domestic goose breeds, which have been less intensively selected than a species such as chickens, would show this type of behaviour during the laying season similar to the wild ones. The spatial distribution analysis was used to reveal if the ganders of domestic geese show territory-holding behaviour during the laying season and whether it is present in geese. The social network analysis was used to demonstrate the interactions and bonds (hierarchy) between individuals (Whitehead, 2008) and sexes to have an insight into the social life of domestic geese (Dunbar, 1998).

There has been no other comprehensive research conducted on the daily routine, spatial distribution, territory-holding ability and social behaviour of domestic geese, so our study can be gap-filling in this respect.

## 2. Materials and methods

The experimental conditions described in the manuscript have been reviewed and approved by the animal welfare committee of the University of Debrecen (number of ethical permissions: 23/2023/DEMÁB). The research methods met the requirements of the Hungarian animal welfare legislation (11/2019. (IV. 1.) AM, 40/2013, and XXVIII/1998.), and followed the general practice and husbandry technology applied on the farm.

### 2.1. Experimental animals and housing

The experiment was carried out on 150 four-year-old individuals of a Grimaud goose parent stock (Tranzit-Ker Ltd., Érpatak, Hungary), between December 2020 and February 2021. The Grimaud is a French white-coloured meat-purpose hybrid. The weight of adults over 30 weeks of age in both sexes ranges between 4.68 and 6.40 kg (Bernard, 2017). At the beginning of November (out of laying season housing) 1000 four-year-old individuals (from which we randomly chose 150 individuals making up the study population) with a 1:4 (gander:geese) sex ratio were moved from the grazing field into a building of 1000 m<sup>2</sup> (10 m x 100 m) for the laying season. An artificial lighting program was applied along with natural light. Until the middle of November, only natural lighting was used. From the second half of November, 10 hours of artificial daily lighting was provided and the light period was increased by half an hour two times a week. The length of the light period reached the maximum on 21st December (13 hours 30 minutes; from 7 am to 8:30 pm). The length of the light period was decreased to 12 hours by the end of January and was unchanged until the end of the laying season. The light intensity was 100 Lux during the whole laying season. From November until the end of December, goose layer feed was provided *ad libitum*, after that the daily feed allowance was decreased to 180 g/bird/day until the end of the laying season ( $\leq 40\%$  of laying intensity, which occurred at the end of February). Birds had free access to gravel from separate feeders during the whole laying season. The barn was deeply bedded with straw, and additional straw was added weekly.

### 2.2. Data collection procedure

In the barn, three 50 m<sup>2</sup> (10 m x 5 m) sections were separated by wooden fences (Fig. 1) each containing 50 animals with the remainder of the population housed in a fourth section (n = 850) adjacent to Group 3. In total 150 birds were involved in the trial, with a 1:4 gander:geese ratio and 1 m<sup>2</sup>/bird stocking density. The large group was adjacent to Group 3 and had the same goose:gander ratio and stocking density as the experimental pens. Two weeks after housing (acclimatization period), each goose was marked with an individual combination of seven different colours of enamel paint on its head to make the identification of birds feasible. The process of painting was not invasive since it did not harm the animals, or cause injury to them, but lasted till the end of the experiment. Knowing the natural behaviour activities of geese, according to our observations, the marking did not affect their behaviour. They displayed natural behaviours without any abnormalities.

Each pen was visually split into 50 cells (sized 1 m x 1 m), the rows and columns were marked with well-visible numbers from one to five on the short walls of the pen and with letters from A to J on the long walls. The pens were divided into cells to enable the recording of bird locations for the evaluation of spatial distributions and social networks. The observations were recorded from 9:00 a.m. to 3:00 p.m. Thirty minutes were spent on the observation of each group, beginning with Group 1 and continuing with Group 2 and Group 3 (three times/bird/day, altogether fifteen times for each bird). One recording was carried out per individual in each group in the 30-minute time interval. Altogether three records (morning, noon, and afternoon) were provided on the behaviour and location of each bird per day and fifteen records per animal in total. On the data collection sheet, the position of each bird and the expressed behaviour were recorded. If the act was linked to another goose or other geese, we also registered the code of the individuals concerned. For the observation points, the barn door (five meters apart, in order to have no effect on the behaviour of the birds) and the side windows were used, when necessary with the aid of binoculars. Five days were selected for data collection: one at the beginning of the laying season (middle of December), three during the peak laying period (January), and one at the end of the laying season (at the end of February).

Table 1 presents the ethogram of the behaviours recorded. Altogether 20 behaviours were selected and categorised based on the



**Table 1**  
Description and categories of the observed behaviours.

Behaviour	Description	Category
Walking	Moving by lifting one leg after the other.	Locomotion
Standing	Standing on one or both legs.	Static behaviour
Sitting	Sitting on the ground.	Static behaviour
Eating	Eating feed and/or gravel.	Intake
Drinking	Drinking from the troughs and drinkers.	Intake
Preening	In the course of preening, the birds put their head on their back and sweep their nape alongside the back, so rearranging and greasing their feathers. Preening starts from the neck below and continues to the breast and finishes on the end of the wings, arranging their coverts. Preening is carried out both when sitting and also while standing and is usually followed by wing flapping.	Comfort behaviour
Picking	Picking straws or some elements (e.g. fence, items) of the housing system. Does not include the picking of feed.	Comfort behaviour
Scratching	Scratching its head with its leg.	Comfort behaviour
Bathing	It is displayed in the bedding with wave-like body movements or at the drinker by diving its head under the water and continuing with preening.	Comfort behaviour
Stretching	Stretching its wings and legs.	Comfort behaviour
Yawning	The beak is open for a few seconds.	Comfort behaviour
Honking	The head is high, the neck is extended and a loud tone is emitted.	Comfort behaviour
Resting	The beak is under one of the wings and also one foot is uplifted, similar to the chicken (Hamadani and Khan, 2016; Cornetto and Estevez, 2001).	Comfort behaviour
Pecking others	The manipulation of feathers of group mates on their nape and back with the bill	Social behaviour
Hissing	The sound is emitted with open beak and an extended tongue. The head is lowered.	Social behaviour
Chasing	Running after others.	Social behaviour
Attacking	Between ganders, striking the other gander, without running after each other. Sometimes followed by a fight, where the initiator wins the conflict	Social behaviour
Courting	Ganders playing with pieces of straw and pecking the feathers on the head and nape of the female geese.	Social behaviour
Mating attempt	No cloaca contact, unsuccessful mating.	Social behaviour
Successful mating	Cloaca contact (Gillette, 1977; Gumulka and Rozenboim, 2013).	Social behaviour

**2.4. Statistical analyses**

As a null hypothesis for behaviour frequency, we expected that the frequency of the examined behaviours by sex, during the laying season and at different times of the day is unchanged. Significant differences were evaluated by the Chi<sup>2</sup>-test of independence with the use of the IBM SPSS Statistics 23.0 program with a 0.05 significance level (P ≤ 0.05). Chi<sup>2</sup> values were calculated from the theoretical distributions.

All computations for spatial distribution analyses were performed in the R interactive statistical environment (version 4.0.4, R Core Team, 2021). When we compared distributions, we used only visual inspection of the plots of the distributions because one of the distributions occurring in each comparison represents simulated birds where the sample size is arbitrary. Therefore, the application of any formal statistical test is meaningless because any small difference can be made significant by increasing the number of simulated cases.

The effects of sex and group ID on the network measures were investigated by using randomised two-way ANOVAs where p values

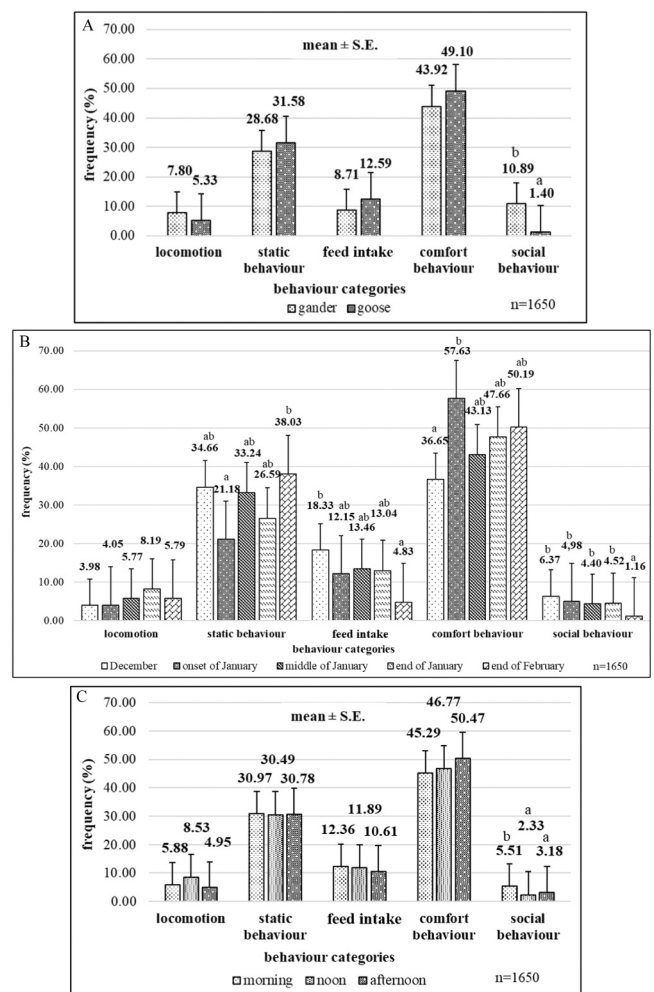
were obtained by creating random permutations of the measures 1000 times and fitting the ANOVA to these randomly permuted measures.

Network analyses were performed with the 'igraph' package in R (version 1.3.1, Csardi and Nepusz, 1695).

**3. Results**

**3.1. Behaviour frequencies by sex, month and the time of the day**

As shown in Fig. 2, altogether 1650 cases were observed. The frequency of behaviours significantly differed by all examined factors. The frequency of social behaviours was almost eight times higher in ganders than in geese revealing that ganders made interactions with other birds more frequently than geese. Social interactions included mostly mating and mating attempts, attacks between males, courtship, chasing, and pecking of females. Regarding females, chasing and attacking other geese were also present but at a lower frequency, as well as mating with ganders. By month, we found a difference in the frequency of static behaviours, feed intake, comfort behaviours and social behaviours. Birds stood and sat the least at the onset of January and the most at the end of February. The feed intake was the most frequent in December and occurred least frequently at the end of February. The frequency of comfort behaviours was the lowest in December and the highest at the onset of January. Among comfort behaviours, at the onset of January,



**Fig. 2.** Behaviour frequencies by sex (A), month (B) and the time of the day (C). a,b different letters indicate significant differences. Behaviour frequencies show the mean frequency of each of the five behaviour categories presented as a percentage of all observations in that period.

pecking, resting and preening were the most frequent behaviour elements. The frequency of social behaviours was unchanged in December and January but significantly decreased in February. Mating was displayed five times in December, eight times at the onset of January, seven times in the middle of January, seven times at the end of January, and twice in February. Only the frequency of social behaviours showed a difference by the time of the day. Social interactions were displayed the most frequently in the morning, however, significantly dropped at noon and in the afternoon. Regarding social behaviours, mating, mating attempts, attacks and courtships were the most common ones. In the morning, birds mated twice more (18 events) than in the afternoon (nine events) and also the number of mating attempts was higher in the morning (seven events) than in the afternoon (five events). Mating was observed only twice at noon and there was no mating attempt (unsuccessful mating) at that time. Attacks occurred six times in the morning and in the afternoon but only three times at noon. Courtship showed five occasions in the morning, two at noon and it was not displayed in the afternoon.

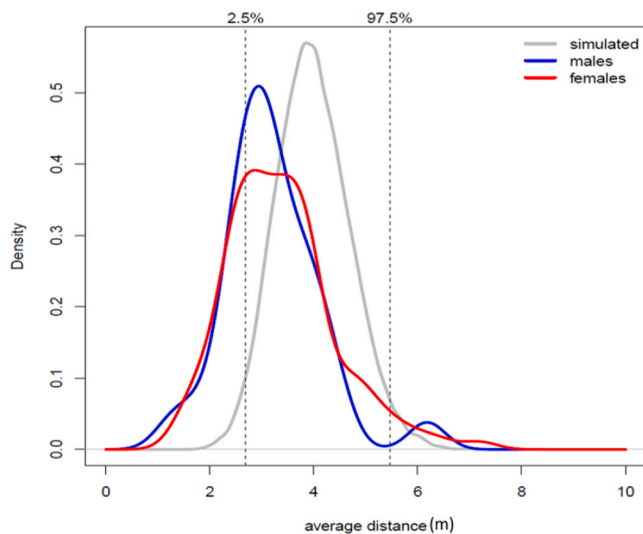
### 3.2. Spatial distribution

The distributions of the average distance moved between the consecutive observations (Fig. 3) indicated that many observed birds walked less on average than their simulated companions. Nevertheless, the distance of observed and simulated birds are still considerably overlapping and hence it is difficult to draw firm conclusions about the territoriality of birds. The distributions did not reveal any strong difference between the sexes.

Observed birds were found (Fig. 4) to be somewhat closer to the feeders and gravel than the simulated individuals, while they were further away from the drinkers. Nests had no obvious effects. Furthermore, the sexes seemed not to differ in their position from the furniture of the pen.

### 3.3. Social network analysis

Interestingly, the social networks of the groups showed remarkable differences (Fig. 5). Quantitatively, degree and closeness values



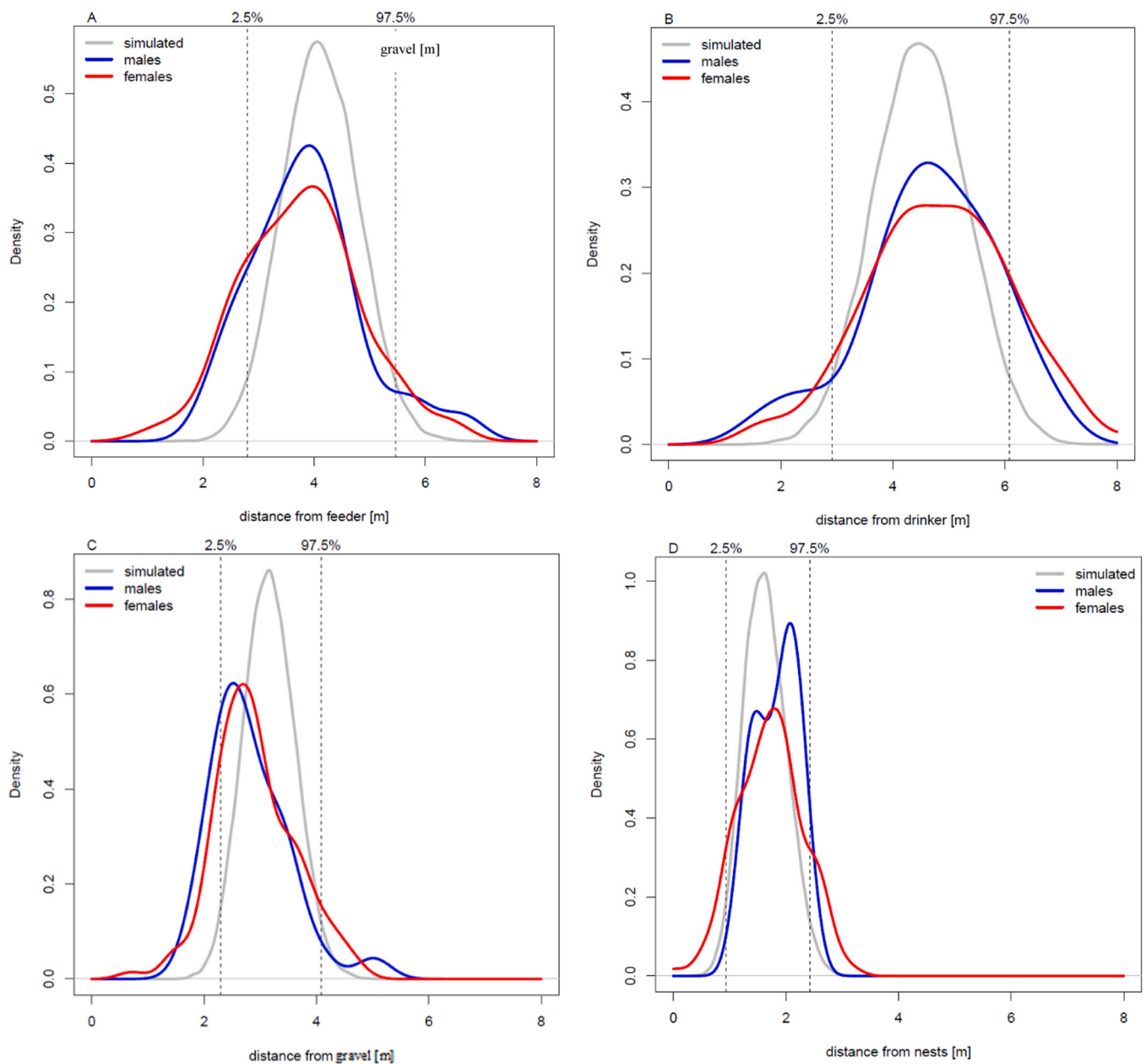
**Fig. 3.** Average distance moved by simulated and observed individuals. The distribution of average distances moved between two consecutive observations regarding two consecutive observations across the entire observation period. The distributions were plotted as densities; the grey line corresponded to simulated individuals, the red one to observed females, and the blue one to observed males. The interval delineated by the dashed vertical lines contains 95% of the distribution of simulated values.

decreased significantly from Group 1 through Group 2 to Group 3 (Fig. 6; degree,  $F_{\text{group}} = 31.08$ ;  $P_{\text{rand}} < 0.001$ ; closeness,  $F_{\text{group}} = 72.05$ ;  $P_{\text{rand}} < 0.001$ ). These findings indicate that individuals in Group 1 were more closely connected than in the other groups. Groups were similar in terms of betweenness and eigenvector centralities (Fig. 6, none of the effects are significant). The sexes had similar network measure values in each group.

## 4. Discussion

### 4.1. Behaviour frequencies by sex, observation date and the time of the day

The most frequent behaviours from December to February were standing and sitting and comfort behaviours (Fig. 2). This suggests that geese spent most of their time inactive, without social interactions. In agreement with our hypothesis, the frequency of feed intake showed a decreasing tendency from December to February, however, the difference was significant only between December and February. The higher frequency of feed intake in December and in the following months can be explained by the higher need for energy and nutrients for a better condition (for egg production in the case of females and for mating and fights for ganders). To satisfy the higher nutritional requirement of geese (flushing effect) at the onset of the laying season, in December, the farm provided the feed ad libitum. Also, Gauthier (1991) observed a remarkably higher feed intake in pre-laying geese (75.5% of the day spent with foraging) compared to the laying ones (50% of the day spent with foraging). It was also reported that in laying hens, higher behavioural activity (higher frequency of eating, standing and pecking) was correlated with better egg production (Assersohn et al., 2021). The decrease in the frequency of water and feed intake in February was likely to be related to the lower need for energy and nutrients for egg production and activities (Dodu, 2010). In the study of Gillette (1977), the feed intake of domestic dry lot geese made up 40.4% and the comfort behaviours showed 58.3% of the frequency of all examined behaviours. Similarly to our findings, the author declared that comfort behaviours were predominant over feed intake. As we assumed, the frequency of social behaviours decreased in February (e.g. two matings altogether), however, from December to the end of January (e.g. 27 matings altogether: December - 5, January1 - 8, January2 - 7, January3 - 7), the frequency was unchanged. So, even if the egg production did not start in December, social interactions (courtships, matings, mating attempts, attacks) indicated that birds were close to the onset of egg laying. The decline in the frequency of social behaviours in February revealed the end of the laying season. Gumulka and Rozenboim (2013) in Poland declared that the frequency of copulations was low before the onset and at the end of the laying season and showed the highest frequency at the peak of production in March. In their case, the laying season started in February and lasted until June. Regarding their results, the authors assumed that ganders can sense the changes in the fecundity of geese during the laying season, this is why the frequency of copulations differs by month. They also suggested that there is a relationship between copulation frequency, fertility and plasma testosterone level which all show a decrease during the laying season (Gumulka and Rozenboim, 2013). Other authors also suggested that the hormonal status (e.g. FSH, LH and GnRH) of birds determines their courtship and mating behaviour (Riters and Alger, 2011). Regarding the frequency of social behaviours of geese, only the number of matings is reported in the literature. The Chinese geese ganders mate 2.5–5.5 times/day (Wei, 1994; Jing et al., 2010), while the mating frequency of the European geese is an average of 2.4 times/day (Pashchenko and Khranovskii, 1971). In our case, it is very low for one gander/day, however this may underestimate the total number of matings since our observations did not cover the whole day. According to Gillette (1977) in dry lot geese, two-thirds of matings are displayed in the morning which is in accordance with our results. However, Bao et al. (2022) stated that the Sichuan and Zhedong geese

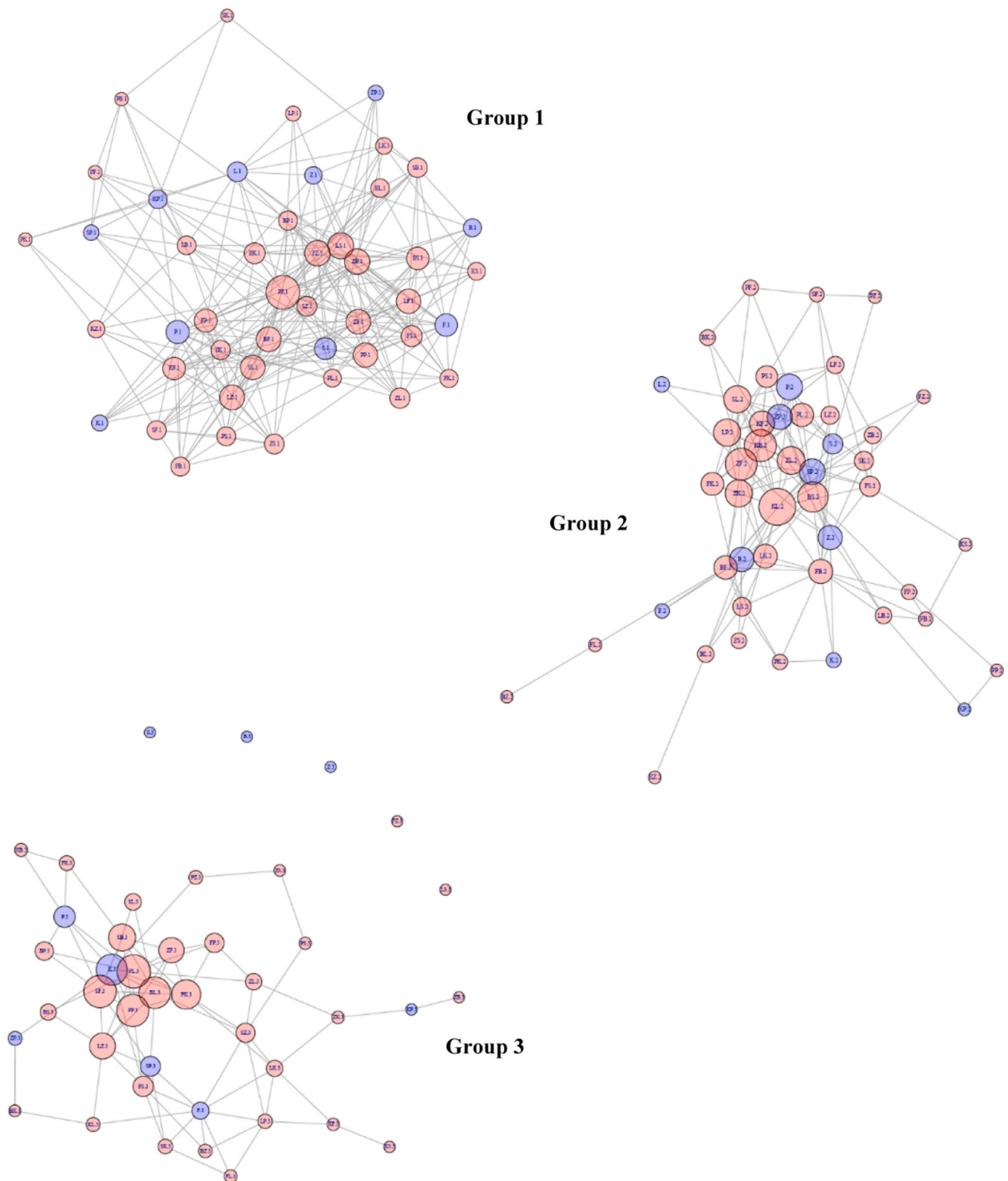


**Fig. 4.** Distance from furniture items of simulated and observed individuals. The distribution of distances of individuals from the position of the closest feeder (A), drinker (B), gravel (C) and nests (D). The distributions were plotted as densities; the grey line corresponded to the simulated individuals, the red one to the observed females, and the blue one to observed males. The interval delineated by the dashed vertical lines contains 95% of the distribution of the simulated values.

mate most frequently in the afternoon while the Hungarian geese prefer mating in the morning. So it can be stated that the preference for mating time of ganders is dependent on the breed but the literature mentions mostly the morning and afternoon. Therefore, our observation regarding the number and time of mating/gander/day provides approximate data since there was no observation in the evening and at night. There was no difference in the frequency of the other examined behaviours by the time of the day. Regarding the international literature on the time of the day, only the findings of Kahlert et al. (1996) were available who established that in the moulting greylag geese, the frequency of foraging is the highest at night due to the more intensive presence of predators during the day. However, he made observations also at night and we did not have data for the dark periods. Furthermore, in our case birds were confined without any risk of predator attack. The frequency of other behaviours examined in this study has not been described previously.

#### 4.2. Spatial distribution

Comparing the space use of real and simulated birds (Fig. 3) indicates that real birds used a restricted part of the pens but their movement patterns still strongly overlap with the simulated birds. Therefore, it is difficult to draw a firm conclusion on the territoriality of domestic goose. This result is supported by the observation that the territorial behaviour of wild goose is more explicit (Weiß et al., 2011) compared to the domestic one, due to the mitigating effect of domestication on aggression (Molnár et al., 2002). Observed birds seemed to be closer to the feeders and gravel than the simulated ones (Fig. 4) which can be explained by the fact that the feeder and gravel occupied more central positions, while drinkers were on the edges of the pen. The central position of individuals might reveal a greater fitness (e.g. because of more efficient defence against predators in the wild) and dominance (Christman and Lewis, 2005) compared to peripheral ones (Pasquaretta et al.,

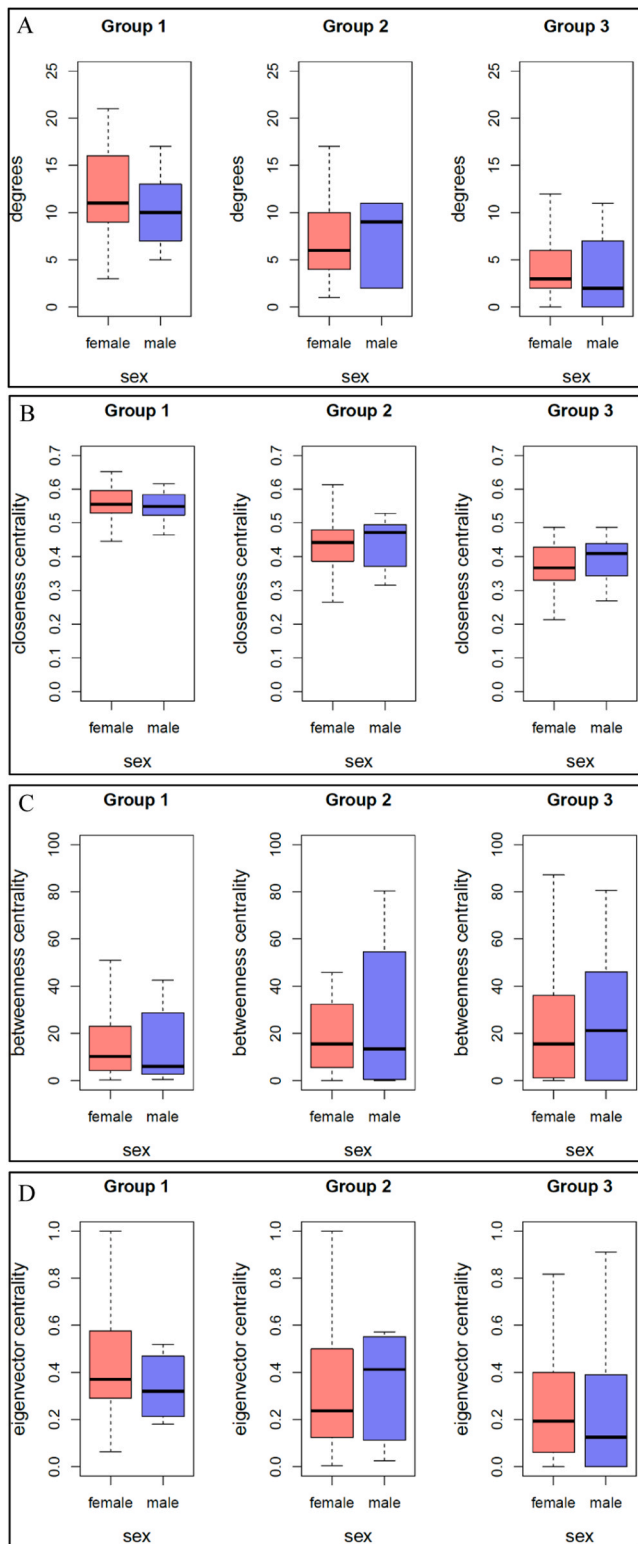


**Fig. 5.** The social networks of the studied goose groups. The individuals were denoted by circles (females, red; males, blue). Two individuals were connected if their average distance was lower than a threshold (for details, see text). The size of the circle was proportional to the betweenness value of the given individual.

2014). In our study, there was no difference between the position of males and females, which might indicate that dominance was not strongly expressed between the sexes. There was no obvious difference between the sexes in their positions from the furniture items.

#### 4.3. Social network analysis

We hypothesised that the closeness of small groups (50 individuals with a 1:4 sex ratio) to each other would influence the hierarchy within the groups. The hierarchy was expected to increase from Group 1 (next



**Fig. 6.** The network measures for females and males in the studied groups. A: degree centrality, B: closeness centrality, C: betweenness centrality and D: eigenvector centrality.

to another 50-bird group on only one side) to Group 3 (between a 50-bird group on one side and a large group ( $n = 850$ ) on the other) because of the stronger influence of individuals in the adjacent groups.

In line with our assumptions, there were remarkable differences between the social networks of the examined groups (Fig. 5). Social

bonds and interactions between individuals were present more frequently in Group 1 and Group 2 compared to Group 3 (Fig. 6). According to the betweenness and eigenvector centralities, birds in Group 1 and Group 2 were considered more connected than birds in Group 3. The presence of the large group next to Group 3 might have affected the social network of that group. This may explain why the members of Group 3 appeared to be less bonded to each other (Fig. 6). However, we do not know what the social network of groups would look like without any impact from other groups. It could be evaluated by a single group without close neighbours. Also, the small sample size used in this study indicates that more research is needed to replicate our findings to evaluate the effect of neighbouring groups on social networks in Grimaud geese. Literature working with the social network of domestic or wild geese does not seem to be available. However, it is suggested that the social network and the sociomatrix of a group might be related to the dominance structure of the group (Archie et al., 2006) and the fitness of the individuals (Wey et al., 2008, Silk et al., 2003).

## 5. Conclusions

Our study aimed to investigate the behaviour of domestic geese (Grimaud) by sex, at the onset, at the peak and at the end of the laying season, and also at different times of the day. The high frequency of comfort behaviours indicated that the space restriction (smaller area for the separated groups compared to the general large one), with the same stocking density, does not inhibit the expression of the natural behaviours and does not negatively impact the animal welfare. The relative frequency of social behaviours and feed intake showed a similar tendency from the housing until the peak of production supporting the comfort of birds. Also, the decrease in social encounters indicated that the laying season was closing to an end. Regarding the spatial distribution analysis, it could be concluded that the domestic geese, compared to the wild ones, did not keep their strong territory-holding ability. The sexes did not differ in this respect. Analysis of the groups' social networks showed variation in structure, which requires further research to be understood.

## CRediT authorship contribution statement

**Lili Dóra Brassó:** Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Formal analysis. **István Komlósi:** Supervision, Formal analysis, Conceptualization. **Zoltán Barta:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Methodology, Conceptualization.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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