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EFFECT OF THE AGE OF GANDERS ON REPRODUCTIVE BEHAVIOR AND FERTILITY IN A COMPETITIVE MATING STRUCTURE*

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Abstract

This paper presents the study on determination of gander-goose mating activity in relation to age and the position of gander in social hierarchic rank. Moreover, levels of fertility (F) and testosterone (T) in different gander age groups were analyzed. The study was carried out on one-year-old geese (*N* = 64) and one- or two-year-old ganders (*N* = 16; 1♂: 4♀). Observations of mating activity (MA) were conducted during the 3-h period of the daylight (10 h), 2–3 times per week (102 h/group/34 days). The recording was done with a digital recorder connected to cameras. Agonistic behavioral interactions between ganders were noted to determine a social hierarchic rank. The MA was described by frequency of courtship displays, copulation attempts, successful copulation (SCop), and interaction disrupted (DMI) with agonistic behavior. Fertility was evaluated after the artificial incubation (1×/week) in a commercial hatchery. The frequency of SCop, DMI, and T concentration were higher (P<0.05) for two- than one-year-old ganders. Moreover, F was higher by 11.2% for group of geese kept with two-year-old ganders. There was an effect of the gander's rank in social hierarchy on the frequency of MA. For dominant ganders, frequency of courtship displays (1.0/times/3 h) and copulation attempts (0.8/times/3 h) were lower (P<0.05), but SCop (1.5/times/3 h) was higher (P<0.05) than for subordinate ones. Thus, in domestic goose flocks reproductive success was associated with age of ganders used in competitive mating system. This is probably a multifactor effect of interaction between sexual/social experience, T-dependent mating motivation, and efficiency of MA. It is recommended to keep one-year-old geese with older ganders (after sexual reactivation) for optimal fertility results with sex ratio adjusted to gander-gander antagonistic interaction dynamic.

Key words: domestic geese, reproduction, age, sexual behavior, hierarchic rank

In flocks of birds with competitive social mating structure, the reproduction success depends on several factors connected with sexual and social behavior interrela-

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tionship between potential mates (Rosiński, 1986; Bilcik and Estevez, 2005; Bilcik et al., 2005; Gumułka and Rozenboim, 2015) including age (McGary et al., 2003 a; Chung et al., 2011), and/or breeding season (Angelier et al., 2006; Gumułka and Rozenboim, 2013). In this context, research on geese seems to be particularly interesting as domestic birds share typical traits for wild living species in which monogamous pair bond is common (Akesson and Raveling, 1982; Hirschenhauser et al., 2000; Poisbleau et al., 2006) but are commercially bred in large flocks with promiscuous mate choice management (Puchajda-Skowrońska, 2012). To date, only one study (Rosiński, 1986) presented mating behavior interactions in group of domestic geese kept in multi-male and multi-female social structure. Domestic geese as seasonal breeders are kept for several years. For the first reproduction season, poor results related to the number of eggs laid (Brun et al., 2003), semen parameters (Łukaszewicz, 2002), and hatchability (Bednarczyk and Rosiński, 1999). In commercial production, different age groups are recommended for regular hatching eggs supply. In a previous study (Gumułka and Rozenboim, 2013), the effect of age of females on mating activity (MA) parameters and fertility was noted, but the research was carried out in harem mating structure. It seems that in competitive conditions, the age of ganders connected with social and sexual experience may play a major role in effective breeding. Moreover, gander-gander antagonistic interactions may interfere with copulative efficiency as was noted in roosters (Cheng and Burns, 1988).

In jungle fowl (Zuk et al., 1995; Johnsen et al., 2001), domestic chicken (McGary et al., 2002; McGary et al., 2003 b) and wild turkey (Buchholz, 1995), the physical condition of males is more important in females' choice of mate than intensity of courtship. Females preferentially copulate with dominant males (Cheng and Burns, 1988) and may eject the sperm of the subordinate as a part of post-copulatory mate selection mechanism (so-called sperm selection or "sperm choice"), in order to optimize the reproductive output (Pizzari and Birkhead, 2000). In a flock of jungle fowl, dominant (high-ranking) males sire most of the offspring (Jones and Mench, 1991). Then again, in domestic chicken, Bilcik and Estevez (2005) found the lack of association between reproduction success and mating activity, morphological traits and semen quality. It remains unclear whether and what nature of social relation occurs in a flock of geese. Denk et al. (2005) suggested that in waterfowl males, penis-like copulatory organ may allow for more behavioral control on females because sperm ejection might be less possible. The presence of potential sexual rivals (level of competition) and social status provides the information on the risk and intensity of sperm competition, enabling males to allocate sperm strategically (Garamszegi et al., 2005). According to Rosiński (1986), there was a positive correlation between mating activity of domestic ganders and position in hierarchic rank but without effect on fertility.

In wild, seasonally breeding birds, there are peaks of peripheral testosterone (T) concentration in pre-breeding period associated with the establishment of territory and competition for mate and during the egg-laying period when the male guards receptive females (Wingfield et al., 1990). During the breeding season, elevated concentration of T supports the competition and sexual activity over a prolonged period of time (Wingfield, 1994). In domestic geese, a significant increase in mating activity

(MA) after sexual reactivation is related to the highest T concentration (Gumułka and Rozenboim, 2013), but there is no interrelationship between T and mating ritual sequences (Gumułka and Rozenboim, 2015). However, individual differences in the threshold of T needed for seasonal activation of courtship (Fusani, 2008) and T-dependent phenotypic expression of secondary sexual traits may indicate male quality for females.

The objective of this study was to (1) investigate the effects of ganders' age on fertility and MA parameters in a flock of domestic geese managed in the conditions of competitive mating social structure and (2) characterize gander–goose sexual behavior in relation to the position of ganders in social hierarchic rank.

Material and methods

Experimental birds and management

The study was carried out on 80 Zatorska geese (ZD-1). The geese were managed at the Agricultural University Center for Research and Education in Kraków. Zatorska goose is a local Polish breed kept as a part of poultry genetic resources. One- and two-year-old males ($N = 16$) and one-year-old females ($N = 64$) were studied in the competitive mating system. At the onset of experiment, one-year-old birds (males and females) started the first reproduction season while two-year-old males were at the second season (after seasonal reactivation of the sexual activity). The sexual maturity of females was determined as the number of days from hatching to the first oviposition. The birds were kept on deep litter in a commercial light-proof building. Two pens (440 × 480 cm; stocking density*:* 0.5 bird/m^2) with nests for individual laying control were used. The pens were connected with runs situated outside the building.

In November, the birds were prepared for reproduction. Ganders were chosen from Zatorska goose flock and combined with geese. Moreover, artificial light regime was applied and nutritive value of commercial mixture was changed (for additional information see Gumułka and Rozenboim (2013) – with modifications adapted to the environmental conditions, the physical condition of the birds, and hatchery requirements in a given season). In general, the management practices complied with the rules recommended for the reproduction period in breeding flocks of geese (Elminowska-Wenda and Rosiński, 1993; Puchajda-Skowrońska, 2012). A photoperiod similar to the natural day length conditions was used until December (9L/8L: 15D/16D). Photostimulation was applied in January (+15 min/week). A short daylight (SD–10 L: 14 D) was used during the reproduction period. From January, the commercial layer-breeder mixture (16.0% CP/kg and 11.0 MJ ME_N/kg) along with the addition of grains such as oats or wheat were used in feeding.

Experimental design

All the procedures were approved by the First Local Ethical Committee on Animal Testing of the Jagiellonian University in Kraków, Poland (PL). The experiment

was conducted during the period from the end of November until the first half of April (second half of the egg production period). In November, geese (n = 32/group) and ganders (n = 8/ group) were each randomly divided into two groups; group 1: one-year-old ganders/one-year-old geese and group 2: two-year-old ganders/one-year-old geese). Ganders were chosen on the basis of the body conformation and similarity in body weight. Physical correctness of the development of copulatory organ was checked. At the onset of January, behavioral observation of the social hierarchic ranks for ganders was evaluated. During 10–14 weeks from January to April, MA observation, blood sample collection, and fertility determination were carried out.

Social hierarchic rank and sexual behavior

Agonistic behavioral interactions between ganders (gander-gander interaction) were noted to determine a social hierarchic rank (dominance and subordination). The number of occurrences of aggressive approach including active attack (fighting, pecking, and displacements), initiated attack, and creating a threat was observed. Moreover, activity associated with escape, avoiding of attacker, and submissive behavior were noted. In all interactions both receiver and attacker were identified. Based on at least eight interactions per pair, ganders were ranked on a scale of 1 to 3 (highest, middle, and lowest ranked). According to Kim and Zuk (2000), a score of 1 meant being the dominant and 3 the most subordinate. All antagonistic interactions between ganders especially presented during the intake of food and water were included. In both groups dominance relationships were established (January) before the start of the mating activity observation. All the records took place between 8:00 AM and 12:00 PM, 3 times per week (3 ×/ week), at the onset of January. Social hierarchic rank was considered as remaining stable throughout the study period.

Observations on sexual behavior were conducted in the morning (9:00 AM–12:00 PM) during the 3-h period of the daylight (10 h), 2–3 times per week. There were 102 h of records for each group collected during 34 days. The management/breeding treatments, i.e., feeding, watering, and egg collection were not carried out during the recording period. A digital recorder (4 NSYS, Vigilant series, FDS-410 G) connected to cameras (Nixar, day/night, resolution: 540 lines) was used. The resolution of image was 720 × 576 pixels, and the speed was 6.25 frames/s. The MA, as the number of courtship displays, copulation attempts, and successful copulation, was analyzed as described previously (Gumułka and Rozenboim, 2013). Moreover, the total MA (courtship displays + copulation attempts + successful copulation) and the number of gander-goose mating interaction disrupted by other ganders were evaluated (DMI). DMI was classified as aggressive attacks by dominant and/or subordinate males that destroyed mating ceremony on different level of display. Ganders for which MA frequency during the entire observation period was below 8 times/3 h were recognized as not sexually active (unmated individuals) and excluded from the study on the effect of social hierarchic rank.

For the identification, head or neck of ganders was marked with different colors. In each group, the individual received a unique color or combination of colors.

Fertility determination

For experimental geese, individual egg collection with first oviposition determination was performed. Eggs were collected twice daily. Hatching eggs (in accordance with OJ 2013 item. 1301; Regulation of the Minister of Agriculture and Rural Development dated September 27, 2013 on veterinary requirements applicable to poultry and hatching eggs) were stored for 7 days at 10–15°C and 75% of relative humidity (RH). Eggs were artificially incubated in the commercial poultry hatchery (Poultry Hatching Facility; Nowy Targ, Poland). The incubation was performed in Pas-Reform D36 setter chamber (Pas Reform Hatchery Technologies, Zeddam, the Netherlands) and Atlas 180 S hatcher chamber (Jartom, Gostyń, Poland) for goose eggs. The following were the incubation parameters in the setter: temperature and relative humidity (RH) were 37.4–37.8°C and 55–65%, respectively, with eggs turned after every hour. Cooling (from the eighth day of incubation: 1 × 15 min/day) and spraying (2 × day until the onset of hatching) were in accordance with the standard for goose egg incubation.

Fertility was estimated after candling of eggs (commercial conditions) on the eighth day of incubation. For eggs categorized as infertile, visual or macroscopic examination (stereoscopic microscope, × 30) of the germinal disc was performed to classify as infertile or with dead embryos. In results section fertility calculated on the bases of candling was presented.

Hormone assays, T

Blood samples were collected from the brachial veins of ganders every second week. All the samples were taken in the morning hours. The handling of ganders was performed by the staff working with birds. After the centrifugation (laboratory centrifuge MPW 251, MPW Med. Instruments, Warsaw, Poland; 1500 × *g*/10 min), plasma samples were stored at −20 °C until assayed. Total plasma T concentration was measured in a single assay by radioimmunoassay (RIA) procedure using a commercially available kit (KIP1709) from Lencomm Trade International (Warsaw, Poland). The sensitivity of the assay was 0.07 μg/ml, and the intra-assay coefficient of variation (CV) was 6.5%.

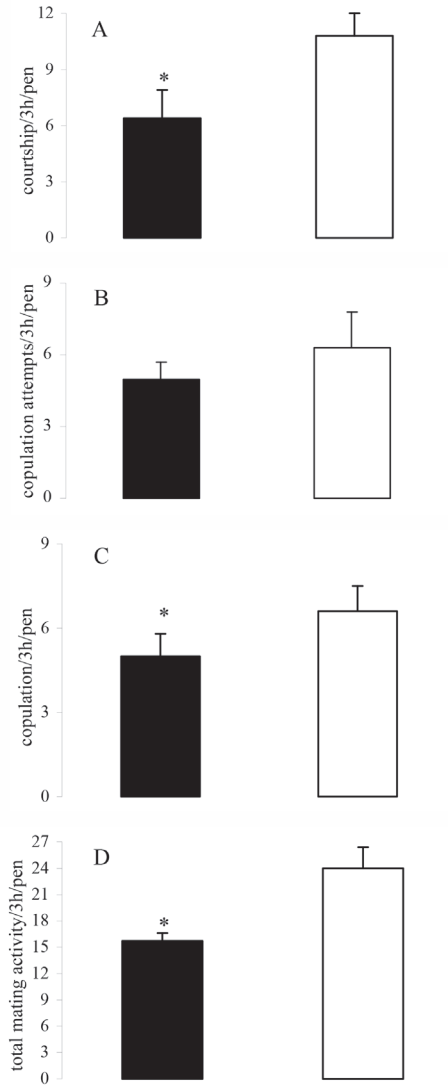
Statistical analysis

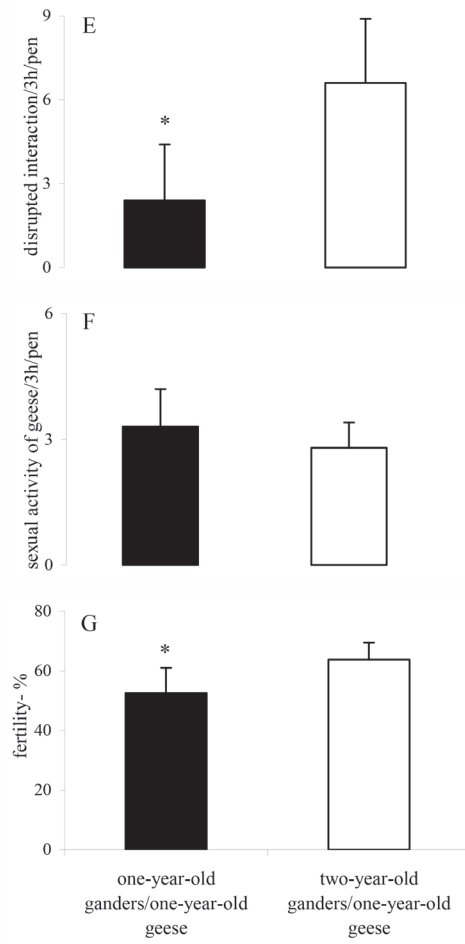
The data on the sexual behavior frequency obtained for all ganders in pen during 3 h recording period were analyzed for the age effect. Mating activity data for each sexually active gander (mated individuals) noted during the week were assumed as the repeated measure. The data were evaluated for normality of variance and for homogeneity using the Shapiro–Wilk and Cochran's C tests. Data on plasma T concentrations and fertility were log-transformed. The differences between means for ganders' age group were evaluated using Student's *t*-test for independent samples. The results for the social hierarchy rank effect were examined by one-way analysis of variance (ANOVA). The Tukey-Kramer was used as post-hoc test for multiple comparisons for unequal group sizes (Statistic 10.0 PL software). The $P<0.05$ was considered significantly different.

Results

Sexual maturity and egg production

Geese sexually matured (onset of egg production) at the age of 254.0±2.9 days (36 weeks of age). During the period from sexual maturity until the end of study, i.e., January–April (10 weeks), the number of eggs laid ranged from 4 to 28/goose and 4 to 29/goose for groups 1 and 2, respectively. The mean number of eggs was 14.1±2.9/goose. The total numbers of eggs collected for geese from groups 1 and 2 were 347 and 483, respectively. Egg weight was 129.6±3.6 g.





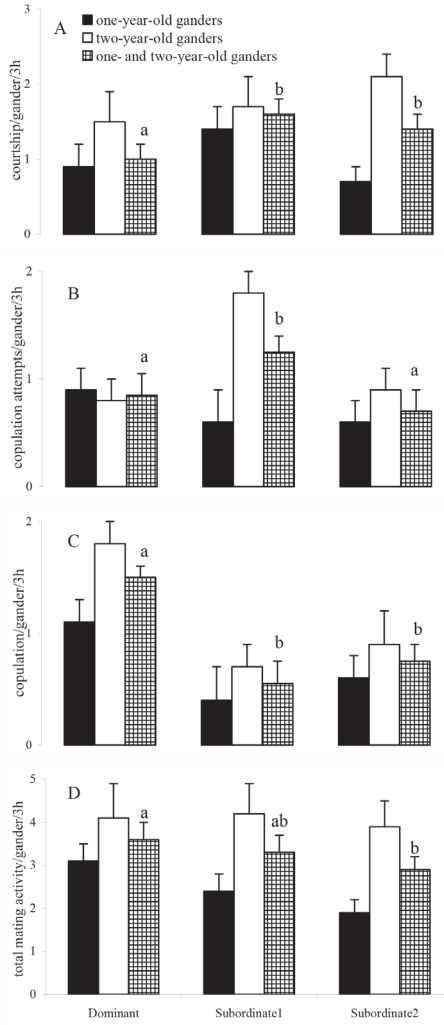
* different superscript means significant difference between groups (P<0.05).

Figure 1. Mating activity (MA) parameters (frequency; A–F) and fertility (G) (mean ± SEM) for one- (group 1) or two-year-old (group 2) ganders (A–F; *N* = 16) kept with one-year-old geese (F; *N* = 64). Sex ratio – 1 ♂ : 4 ♀. Total MA = courtship display + copulation attempts + successful copulation. Number of observations (January–April) : 102 h/group. Fertility (G) – artificial incubation; number of set eggs 327 and 448 for geese kept with one-year-old and two-year-old ganders, respectively

Effect of age of ganders: MA, fertility, and T concentration

The frequencies of courtship display (Figure 1 A) and copulation (Figure 1 C) for two-year-old ganders were higher compared to one-year-old ganders (P<0.05). As a result, for two-year-old ganders, 1.5 fold higher (P<0.05) frequency of total MA (Figure 1 D) was noted. The potential mean frequency of copulations was about 0.66 and 0.82/3 h for one- and two-year-old ganders, respectively. Moreover, there was an effect of the age of ganders on the frequency of agonistic behavioral interactions. The disrupted gander-geese interaction (DMI) was 2.7-fold higher (P<0.05) in group 2 than in group 1 birds (Figure 1 E). However, in both groups, there were

similar frequencies of goose–goose interaction (Figure 1 F). For group 2, the fertility was higher by 11.2% (63.8±8.4 *vs.* 52.6±5.7%) (P<0.05) compared with group 1 (Figure 1 G). During the experimental period (January to April), fertility for the rest of the birds in Zatorska geese flock was on the level of 60.9±2.1% (based on the information from commercial hatchery). The plasma T concentration for two-year-old ganders was 47.3% higher (P<0.05) (3.6±0.9 *vs.* 1.9±0.6 ng/ml) when compared to one-year-old ganders.



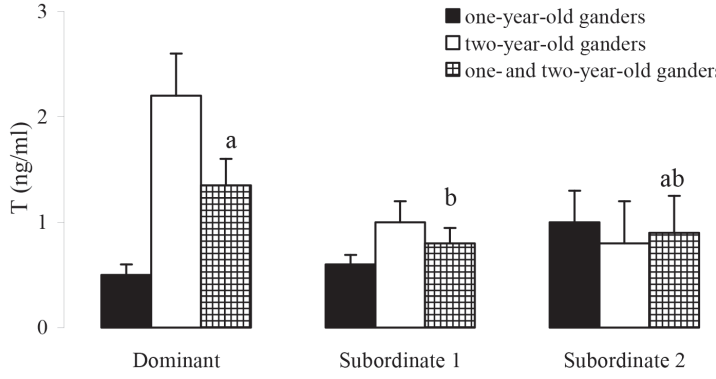
a–b – different superscript means significant difference between hierarchic rank (P<0.05) dominant *vs* subordinate 1 and 2.

Figure 2. Mating activity (MA) parameters (frequency; A–D) (mean ± SEM) for one- or two-year-old sexually active ganders (n = 13) in relation to social hierarchic rank. Observation period January–April. Number of observations: 102 h/gander/period. Sex ratio – 1 ♂ : 4 ♀. Total MA = courtship display + copulation attempts + successful copulation

Effect of position of ganders in social hierarchic rank: MA and T concentration

Ganders avoid direct confrontation understood as an aggressive approach including active attack (fighting and pecking) when determining the social hierarchy rank. The mean frequency of active attack for dominant ganders was 2.40±0.15/times/3 h. For this social hierarchy rank initiated attack (5.40±0.20/times/3 h) and creating a threat (4.00±0.10/times/3 h) by body posture were the most frequent. The subordinate 1 ganders had higher frequency of submissive behavior (7.80±0.15/times/1 h) than the dominant (1.00±0.10/times/3 h). For subordinate 2 only submissive behavior in relation to the dominant and subordinate 1 was noted.

For ganders from both groups 1 and 2, 81.2% were sexually active. About 20% of subordinate 2 ganders were characterized as passive in MA. There was an effect of the gander's rank in social hierarchy on the MA frequency. The dominant males had lower ($P<0.05$) frequency of courtship display (Figure 2 A) and copulation attempt (Figure 2 B) than both subordinate group and subordinate 1 ganders, respectively. For the subordinate 1 ganders in group 2, copulation attempts were about 2.2 fold higher compared to group 1. For ganders in this group, gander–gander display coalitions between subordinate 1 were observed. The mean frequency of copulations for dominant ganders was 1.50±0.11/times/3 h. For these social hierarchy rank the frequency of copulation was more than 2.0-fold higher ($P<0.05$) than for subordinate 1 (0.55±0.10/times/3 h) and subordinate 2 (0.75±0.22/times/3 h), while total MA for the dominant ganders (3.61±0.41/times/3 h) was higher ($P<0.05$) only in comparison to subordinate 2 (2.91±0.34/times/3 h). The plasma T concentration was higher by 40.8% ($P<0.05$) in dominant ganders compared to subordinate 1 ganders (Figure 3).



a–b – different superscript means significant difference between groups ($P<0.05$) dominant vs subordinate 1 and 2.

Figure 3. Concentration of plasma T (mean ± SEM) for one- and two-year-old sexually active ganders (n = 13) in relation to position in social hierarchic rank: dominant, subordinate 1 and 2 (Kim and Zuk, 2000). Blood collection – breeding period: January–April. Photoperiod: 10L: 14D

Discussion

Results obtained in the present study revealed that in domestic goose in competitive mating social structure: (a) reproduction success was associated with age of ganders as probably a multifactor effect of positive interaction between sexual experience, T-dependent mating motivation, and efficiency of mating activity; (b) higher fertility should be expected for females in the first reproduction cycle when mated with males in second or subsequent breeding season (up to 4 seasons in husbandry conditions in Poland); (c) intensity of MA corresponded with fertility and was more efficient as manifested by a successful copulation for ganders after the first reproduction cycle; (d) it is recommended to keep young geese in commercial husbandry with older ganders after the first reproduction cycle for optimal hatching results; (e) dynamics of gander-gander antagonistic interaction should be taken into account when creating optimal sex ratio in small flocks; (f) there is a social hierarchic rank connected with the dominance and subordination position and different mating strategy like subordinate with display coalition; (g) successful copulation for dominant ganders was relatively high with 1.5 times/3 h in the morning.

Gander-goose interactions in competitive mating: effect of age on MA and fertility

For a successful copulation to occur, there needs to be a positive response and interaction of mating partners during physical contact in consummatory phases of behavior (Duncan, 2009). Accordingly, chances for reproductive success may increase with the use of past experience in pre-copulatory phase and during the completion of the entire ritual sequences. In the present study, higher fertility was noted for the group of geese managed with ganders in second breeding season (sexually experienced) compared to young ones in the first season (not experienced). Moreover, the reproductive success was associated with higher frequency of successful copulation, total MA, and plasma T concentration. However, it should be noted that more than quarter of total MA for older ganders were disrupted by antagonistic gander-gander interactions mainly at the initial period of mating display (courtship). It may be an alternative pre-copulatory strategy of sexually experienced ganders for the protection of goose from polyandry. This is partially consistent with results of a previous study (Gumułka and Rozenboim, 2015) in which a positive correlation between fertility and successful copulation frequency for goose kept in harem mating was noted. In addition, gander-goose social interaction and mating experience were shown as important part of sexual seasonal reactivation and future MA frequency (Gumułka and Rozenboim, 2013). In the present study, observations were carried out on geese kept as a genetic resources protected flock. Moreover, randomly chosen females in first breeding season were used. Thus, variation in the number of laid eggs and lower fertility compared to White Kołuda® geese (W31) commercially kept in Poland and selected for reproductive traits (Puchajda-Skowrońska, 2012) was expected.

Thus, in practice, it is recommended to manage geese in first breeding season with older ganders after the sexual reactivation for optimal hatching eggs results. In meat-type chickens kept in husbandry (McGary et al., 2003 b; Chung et al., 2011)

and free-living birds (Angelier et al., 2006), age of mates was shown to play a role in breeding success. On the contrary, Hocking and Bernard (2000) found that both fertility and MA were not affected by age in hens. While according to Chung et al. (2011), only frequency of MA changes with age in flocks of domestic chicken. Moreover, research by Rosiński (1986) showed that in domestic goose, the frequency of MA was not linked to fertility. Therefore, higher reproductive results for ganders in second breeding season may be a malfunction effect of both frequency of copulation and semen quality parameters. The following researchers found that after artificial insemination (AI), sperm quality determined paternity under sperm competition conditions in: chickens – Birkhead et al. (1999); turkey – King et al. (2000); and mallard ducks – Denk et al. (2005). In commercial husbandry of domestic goose, semen quality was lower for ganders in first reproduction season (one year old) than after sexual reactivation (two to four years old) (Łukaszewicz, 2002). Moreover, for two-year-old Zatorska gander, standard semen parameters were shown to be similar to the population of goose not selected for reproduction traits (Gumułka and Rozenboim, 2014). Therefore, we may expect a lower probability of fertilization for young ganders than older ones, especially at the onset of breeding season connected with the onset of sexual maturity. Also, lower concentration of plasma T in young ganders may result from inter-individual variation in sexual maturity and mating behavior motivation. In domestic ganders, plasma T concentration was not directly linked to both semen production (Gumułka and Rozenboim, 2014) and fertility (Gumułka and Rozenboim, 2015).

Gander-goose interactions in competitive mating: effect of position of ganders in social hierarchic rank

It is now accepted that reproduction success is increased through intra-sexual competition for mating opportunities and the choice of most appropriate sexual partner. In accordance with the expectation in the present study, copulation frequency for dominant ganders was higher than that for subordinate ones. These findings are consistent with studies in jungle fowl (Jones and Mench, 1991; Johnsen et al., 2001; Parker and Ligon, 2002) and domestic chicken (Cheng and Burns, 1988). Also, Rosiński (1986) demonstrated in geese the relationship between dominant position of ganders and mating activity. In contrast to previous suggestions (Gumułka and Rozenboim, 2015) that intensity of copulation below one time per daylight is enough to achieve desirable fertility in husbandry conditions, dominant ganders copulate theoretically about five times more. However, it is even of lower frequency than presented in observation by Rosiński (1986). Surprisingly, Bilcik and Estevez (2005) found that the sexual activity in meat-type chickens kept in a harem was higher than in competitive social structure. It can be assumed that dominant ganders are likely to transfer relatively more semen volume into individual females' reproductive tract because of higher copulatory frequencies. Moreover, elimination of subordinates by disruption of courtship displays created more opportunities for mating. However, the transfer of semen may be less effective when female is attempting to escape immediately after social conflicts and some may even be aspermic (i.e., copulations with no semen transfer) as a part of post-copulatory strategy (Garcia-Gonzalez, 2004).

Moreover, dominant ganders may be in poor physical condition in second half of breeding cycle after a long period of defending a territory and protecting mate. Interestingly, Froman et al. (2002) found that subordinate males had higher sperm quality than dominant ones that may facilitate to eliminate losses in reproductive efficiency (King et al., 2000). However, copulations with subordinate, non-preferred ganders may lead to fitness reduction in goose, similar to what has been observed in mallard ducks (Bluhm and Gowaty, 2004). In the present experiment, some subordinate ganders created display coalitions that cooperate to attract females and there were also non-mating ones. Although subordinate ganders with coalitions show more copulation attempt, the reproductive strategy seems to be relatively inefficient because of the low frequency of the successful copulation. However, according to Webb et al. (2002), presence of unmated and low sexually active males may affect the mating pattern of the flock. Thus, the operational sex ratio is probably more gander-biased and increase in male-male competition frequency may negatively affect geese fitness.

Androgens are known as modulators of different aspects of behavior in male birds (Fusani, 2008). In the present study, a dominant position of ganders was connected with higher concentration of plasma T, which may promote aggressive (antagonistic gander–gander interaction) confrontation and courtship display. Indeed, this hypothesis is supported by a study in tropical breeding birds in which dominant males have higher concentration of plasma T relative to subordinate ones (Peters et al., 2001; Ryder et al., 2011; DuVal and Goymann, 2011). However, Garamszegi et al. (2005) drew attention to possible individual immunocompetence (Wingfield et al., 2001) and physical costs associated with elevated concentration of T during an extended period of the breeding season. In domestic birds, there was no (McGary-Brougher et al., 2005; Gumułka and Rozenboim, 2015) direct correlation between frequency of MA and plasma androgen concentrations. According to Fusani (2008), additional and more detailed analysis of mating sequence structure in birds may show modulatory role of androgens.

In conclusion, for goose flock with females in first reproduction cycle, the probability of achieving high fertility in commercial conditions is more likely when kept with ganders in the second breeding season than with the same age ganders. However, considering the frequency of total mating activity with rituals disrupted by antagonistic sexual interaction behavior for ganders in second breeding season is probably more energetically costly. Thus, it is recommended to adjust sex ratio in relatively small goose groups according to the age of potential mate. The efficiency of mating activity for individual ganders seems to be associated with social status mediated by plasma T concentrations. Quantitative relationship between the long-time reproduction success and frequency of mating activity for individuals in multi-male geese flock is problematic.

Conflict of interest

The authors declare that there is no conflict of interest related to this study.

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