Animal Science Papers and Reports vol. 40 (2022) no. 1, 89-98
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The effects of breeder age and laying period on hatchability and some external egg quality characteristics in breeder geese*

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(Accepted January 27, 2022)

This study was carried out to determine the effects of breeder age, laying period on hatchability and some external egg characteristics in geese. 3240 eggs from one, two, three- year -old breeder flocks of geese were examined in two different periods (the second part of March + the first part of April and the second part of May + the first part of June). In the first period fertility rates were 84.63, 87.40, and 88.33%; hatching from set eggs were 62.40, 68.51, and 70.00%; hatching from fertilized eggs were 73.74, 78.37, and 79.28% in one, two, three- year -old breeder flocks of geese, respectively. In the second laying period, fertility rates were 82.40, 84.44, and 85.00%; hatching from set eggs were 69.63, 67.77, and 65.92%; hatching from fertile eggs were 84.62, 80.34, and 77.54% in one, two, three- year -old breeder flocks of geese, respectively. In terms of the laying period, the fertility rates were 86.79 and 83.95%, hatching from set eggs were 66.97 and 67.77%; hatching from fertilized eggs were77.13 and 80.83%; the embryonic mortality rates were 16.04 and 12.16%, respectively. The differences in egg weight (P <0.001) and shape index (P <0.01) between geese in different breeder ages were found to be statistically significant. The highest egg weight was 176.41 g in 3-year-old breeder geese, while the highest shape index was seen in the 1-year-old breeder geese with 65.78%. According to these findings, whereas laying period only affects shape index, breeder age affects both egg weight and shape index. In addition, hatchability characteristics were relatively higher in two, three- year-old breeders than one- year-old and the first period of the laying season.

*This research was part of the Ph.D. thesis of the first author. It was supported by The Scientific and Technological Research Council of Turkey (119O925), and the authors are grateful for this support.
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KEY WORDS: breeder age / egg quality / fertility / goose / hatchability / laying season

Geese are one of the poultry species belonging to the *Anatidae* family and the *Anser* genus. Their domestication took place in Egypt about 3000 years ago. According to the Food and Agriculture Organisation of the United Nations (FAO), there are 204 different breeds and varieties of geese. Geese are raised around the world because of their high adaptability to different climates. Despite this wide adaptation, commercial goose breeding is common only in a few countries in Asia and Europe [FAO, 2021].

Many factors such as breed, age, feeding, lighting, ventilation, shelter, and climatic conditions affect egg and fertility in poultry. Egg laying in geese can last from January-February until June-July, and 15-60 eggs can be laid per bird depending on the genotype. However, due to the low hatching rate (below 80%) and high embryonic mortality rate, only a small number of goslings is obtained. Geese, which have an average lifespan of 20 years, can only be used in breeding for 3 to 6 seasons, unlike chickens, turkeys, and even ducks [Bielinski and Rosinski 1988, Tserveni-Goussi and Fortomaris 2011].

Hatching is affected by several factors such as; breed, male-female ratio, temperature, light, nutrition, shelter conditions, breeder age and general health conditions. Factors affecting the hatching characteristics can be divided in three main categories. The first category is the breeders used (breed, breeder age, and nutrition), second is the egg factor (fertility, egg quality, and storage), and third are is incubation/ hatching factors (temperature, humidity, carbon dioxide concentration, ventilation, egg turning and hygiene) [Narushin and Romanov 2002, Brillard 2003, Bogenfurst 2004, King'ori 2011].

Embryonic development of young individual, including poultry, apart from the genetic potential (basis) also depends on a variety of non-genetic factors. Physical (external) and structural (internal) egg characteristics are some of the most important of these factors. In this context that egg weight and egg shape index have effect on incubation results and subsequently on the weight of hatched offspring [Sreten 2018]. The average weight of goose eggs has a wide variation between approximately 123 and 185 g. These differences may result from genetic factors such as breed and age, as well as environmental factors such as care, feeding, breeding system and region differences.

Fertility rate of the eggs of native breeds in Poland is between 61-72%, the average hatchability of goose eggs was 69.51% in the white Roman breed, 83.37% in Kashmir geese, and 61% in general in Kars local geese [Rosinski 2002, Onk and Kırmızıbayrak 2019]. Wolc *et al.* [2008] reported the fertility rate was 75.2% and 75.6%, hatchability rate was 68.2 and 62.4% in W11 and W33 lines of White Koluda geese.

The aim of the study was to determine the effects of breeding age, laying period and some external egg quality characteristics on hatchability characteristics in geese.

Material and methods

This study was carried out at a livestock company, which has Eskildsen Schwer hybrid breeder geese in Elazıg, Turkey. All experimental procedures were approved by Firat University, Animal Experiments Local Ethics Committee (2018/115).All breeder geese were reared in closed barns with straw mat and stocking density was 1 bird/m^2 in all groups. Corn and soybean meal based mixture feed and freshwater were provided on *ad libitum* basis. Feed ingredients are presented in Table 1. Eggs were obtained from the breeding flocks of 250 geese, which were male-female ratio as one male for every four females. The characteristics of all 3240 eggs (540 eggs for each breeder age in each laying periods) were examined to determine the hatchability from one, two, three- year -old breeder flocks in the second of March + the first part of April (first period) and the second part of May + the first part of June (second period) in 2020. The eggs collected daily were turned 3-8 times in a day at 13-16°C and 70-75% humidity conditions and stored for 3-7 days. The eggs weight was measured with electronic scale accurate to 0.01 g (Radwag 2000.R1, Poland). Then, the shape of eggs (length/breadth) was measured with a vernier caliper accurate to 0.1 mm (Mesem, Turkey). All eggs, of which storage period was completed, were carried out

Table 1. Ingredients and nutrient composition of breeder diets (%)*

Ingredients (%)	
Corn	65.82
Wheat bran	3.50
Soybean meal, 44% hp	22.15
Vegetable oil	1.63
Dicalcium phosphate	1.03
Limestone	5.05
Dl-methionine	0.10
Salt	0.30
Sodium bicarbonate	0.10
Vitamin-mineral mix**	0.30
Total	100.00
Nutritional composition	
Dry matter (%)	89.90
ME (kcal/kg)	2900.00
Crude protein (%)	16.00
Crude cellulose (%)	3.38
Crude ash (%)	9.03
Calcium (%)	2.25
Phosphorus (%)	0.30
Sodium (%)	0.18
Lysine (%)	0.79

*Calculated.
**Vitamin A – 10000 IU, Vitamin D3 – 4000 IU, Iron – 30 mg, Iodine – 1.5 mg, Cobalt – 0.5 mg, Copper – 5 mg, Manganese – 80 mg, Zinc – 80 mg, Selenium – 0.3.

in automatic Yunfeng brand YFDF 17280 model development and YFDC-8640 model hatcher machine (China). During the development period, the incubation temperature was 37.7°C, and the humidity was 55-60%. On the 8th day of incubation, the eggs were checked with light, after the infertile eggs were separated they were broken, and examined, and the embryonic mortality rate was determined. Beginning from the ninth day the eggs were sprayed once a day and after the 20th day twice a day with 30-35° C with water. After spraying with water, a cooling time of 10 minutes was applied in the first few days, and this time was gradually increased to 35 minutes. On the 28th day of incubation, the eggs were transferred to hatcher machine with a temperature of 36.5°C and relative humidity of 75-80%. The values related to the hatching characteristics and shape index were calculated using the formulas below [Onk 2009].

Fertility rate	=	(number of fertile eggs / total number of eggs) x 100;
Hatching from set eggs	=	(number of live goslings / total number of eggs) x 100;
Hatching from fertilized eggs	=	(number of live goslings / number of fertile eggs) x 100;
Embryonic death rate (%)	=	(number of embryos dying between day 1 and 27 / total number of eggs) x 100;
Dead-in-shell rate (%)	=	(number of embryos dying between 28-31 days / total number of eggs) x 100;
Egg shape index (%)	=	(egg width / egg length) x 100

Statistical analysis

The research was a factorial experimental design in randomized plots of two incubation periods (First and Second periods) x three years (one, two, three- year -old breeder flocks of geese). Analysis of variance was applied using the General Linear Model procedure to compare the groups in the relevant data. Tukey HSD test was chosen as post-hoc for determining the differences between the groups The following model was assumed in the analysis of all traits:

$$Y_{ijk} = \mu + a_i + b_j + (a+b)_{ij} + e_j$$

where;

Y_{ijk} - the observation of measurement (egg weight, egg shape index, fertility rate, hatching from set eggs, hatching from fertilized eggs, embryonic, mortality, dead-in-shell rate);

μ - the overall mean;

a_i - the effect of breeder age (i: 1, 2, 3);

b_j - the effect of laying period (j: first and second period);

$(a + b)_{ij}$ - the interaction of the breeder age with laying period;

e_{ijk} - the random error.

The program SPSS 21.0 [IBM] was used to analyze the data. It was taken into account that the difference between the groups was statistically significant when $P<0.05$. The data are presented as mean and standard error.

Results and discussion

Findings of hatching characteristics at different breeder ages and laying periods are presented in Table 2. There was statistically significant differences in the interaction between breeder age x egg-laying period for egg weight ($P<0.01$), no statistical difference was found for other studied parameters ($P>0.05$).

In terms of the breeder's age, significant differences were found in egg weight ($P<0.001$) and shape index ($P<0.01$). According to the laying period significant difference was found in egg weight ($P<0.001$). There was no statistically significant difference between the groups of different breeder ages and laying periods in the fertility rate, hatching from fertilized eggs, hatching from set eggs, embryonic, and dead-in-shell mortality rate ($P>0.05$). The fertility rate in geese with one, two, three- year -old breeders were 83.52, 85.93, and 86.66%; hatching from set eggs 66.02, 68.15, and 67.96%; hatching from fertilized eggs 79.18, 79.36, and 78.41%; embryonic mortality rate 13.06, 14.35, and 14.90%; the dead in shell rate 5.34, 3.99, and 4.39%; egg weights 147.71, 174,03, and 176.41 g; egg shape index 65.78, 64,84, and 65,16% were determined respectively.

In terms of the laying period, the fertility rate in the first and second periods were 86.79 and 83.95%, hatching from set eggs were 66.97 and 67.77%; hatching from fertilized eggs were 77.13 and 80.83%; embryonic mortality rates were 16.04 and 12.16%; dead-in-shell rate 4.43 and 4.89%; egg weights were 169.31 and 162.79 g; egg shape index 65.08, and 65, 44%, respectively.

Egg weight and shape index is one of the important external quality indicators of hatching eggs [Portillo-Salgado *et al.* 2021]. In terms of the interaction of breeder age and laying period, egg weight ($P<0,001$) increased in the second period only in 1-year-old breeder geese, while it decreased in 2 and 3-year-old breeder geese. Salamon and Kent [2013] reported that egg weight started to decrease after the first weeks of laying in 2 and 3-year-old breeder geese and then remained stable within a specific range.

In this study, differences in egg weight ($P<0.001$) and shape index ($P<0,01$) between groups with different breeder ages were found to be statistically significant. The highest egg weight was 176.41g in 3-year-old breeder flock of geese. It is seen that this result is due to the positive correlation between breeder age and egg weight and it is consistent with other studies. Because increasing egg weight with increasing layer age is connected to the increasing female body weight during egg production, as

the egg weight and female body weight are positively correlated and the heritability (h^2) is larger than 0.5 [Applegate *et al*. 1998, Adamski 2008]. The highest shape index was seen in the 1-year-old breeder geese with 65.78%. The similar results were reported by other authors [Pakulska *et al.* 2003, Biesiada-Drzazga*et al.* 2016]. As a result of the increase in the egg mass together with the increase in the breeders age, it is seen that the eggs take on an oblong shape. It is thought that the reason is due to the negative relationship between egg weight and shape index [Adamski 2016]. In this study, differences in egg weight ($P<0.001$) between groups with different laying period were found statistically significant. Egg weight in the first laying period (169.31 g) was higher than the second period (162.79 g). Salamon and Kent [2013] reported that egg weight started to decrease after the first weeks of laying in 2 and 3-year-old breeder geese and then remained stable within a specific range. The difference in the egg weight pattern over the laying season is attributed to the difference in the means of energy supply for egg production, as the utilization of endogenous reserves is of known importance for egg production in geese [Bromley and Jarvis 1993, Gauthier *et al.* 2003]. It has been reported that

Table 2. Hatchability (%) and some external egg quality characteristics according to breeder age and laying period

Group	Number of examined eggs	Fertility rate	Hatching from set eggs	Hatching from fertilized eggs	Embryonic mortality	Dead- in-shell rate	Egg weight (g)	Egg shape index (%)
Breeder age								
one	1080	83.52 (1.98)	66.02 (2.60)	79.18 (2.98)	13.06 (2.86)	5.34 (0.92)	147.71^{b} (0.94)	65.78^{b} (0.14)
two	1080	85.93 (1.64)	68.15 (1.98)	79.36 (2.23)	14.35 (2.09)	3.99 (1.14)	174.03^{a} (2.52)	64.84^{a} (0.19)
three	1080	86.66 (1.44)	67.96 (1.97)	78.41 (1.98)	14.90 (1.85)	4.39 (0.90)	176.41^{a} (2.65)	65.16^{a} (0.17)
Laying period								
first (March + April)	1620	86.79 (1.81)	66.97 (2.43)	77.13 (2.42)	16.04 (2.26)	4.43 (0.93)	169.31 (5.76)	65.08 (0.22)
second (May + June)	1620	83.95 (1.54)	67.77 (1.94)	80.83 (2.39)	12.16 (2.30)	4.89 (1.15)	162.79 (3.51)	65.44 (0.13)
Breeder age x laying period								
one x first	540	84.63 (2.12)	62.40 (2.93)	73.74 (3.10)	18.14 (2.92)	4.82 (0.69)	146.65 (1.80)	65.80 (0.15)
one x second	540	82.40 (1.94)	69.63 (0.57)	84.62 (2.02)	7.96 (2.05)	5.85 (0.94)	148.77 (0.33)	65.75 (0.22)
two x first	540	87.40 (1.75)	68.51 (1.88)	78.37 (1.52)	15.37 (1.40)	4.05 (1.06)	179.03^{c} (2.58)	64.48 (0.29)
two x second	540	84.44 (1.21)	67.77 (2.26)	80.34 (2.70)	13.33 (2.53)	3.93 (1.31)	169.03^{d} (0.32)	65.20 (0.27)
three x first	540	88.33 (1.21)	70.00 (1.49)	79.28 (1.89)	14.63 (2.05)	4.20 (1.01)	182.24^{e} (1.06)	64.96 (0.13)
three x second	540	85.00 (0.75)	65.92 (2.12)	77.54 (2.19)	15.18 (1.84)	4.57 (0.83)	170.57^{f} (0.27)	65.36 (0.17)
P-value								
breeder age		>0.05	>0.05	>0.05	>0.05	>0.05	<0.001	<0.01
laying period		>0.05	>0.05	>0.05	>0.05	>0.05	<0.001	>0.05
breeder age x laying period		>0.05	>0.05	>0.05	>0.05	>0.05	<0.01	>0.05

$^{ab...}$ Means within a column not sharing a common superscript are significantly different at $P<0.05$.

this decrease in egg weight causes a decrease in shell thickness and weight, yolk weight, Haugh unit, albumen height, and n-6 and n-3 polyunsaturated fatty acid ratios [Mazanowski*et al.* 2005, Razmaite*et al* 2014, Biesiada-Drzazga*et al* 2015].

Geese are poultry species that lay eggs in a specific season (January -February until June-July) and are known for low egg yield and hatchability. The most important reasons for low hatching yield are poor semen quality and high embryonic mortality [Tserveni-Goussi and Fortomaris, 2011]. In general, it is reported that the fertility rate in goose eggs is between 60-90% [Graves 1985, Feltwell 1992, Brake 1997, Biesiada-Drzazga *et al.* 2016]. In this study, fertility rates were found 83.51, 85.92, and 86.66% at different breeder ages (one-, two-, three-year-old breeders), respectively. Biesiada-Drzazga*et al.* [2016] found fertility rates as 79.4, 82.5, and 82.5% in one, two, three-year-old breeders. The rates obtained in this study were higher than Biesiada-Drzazga *et al.* [2016], while the relationship between ages was similar. The fertility rates in Turkish geese of different breeder ages (one-, two-, three-year-old) found by Onk [2009] 79.15, 75.73, and 72.61% and are lower than this study. The relationship between fertility rate and breeder age had the opposite tendency.

It has been reported that the hatchability of goose eggs varies on average between 50-90%, depending on factors such as breed, age, care, and feeding [Feltwell 1992, Ayakyay 2008, Onk 2009]. This study determined the hatching from set eggs of geese related to different breeder ages (one-, two-, three-year-old) as 66.02, 68.15, and 67.96%, respectively. Onk [2009] found that in Turkish domestic geese at different breeder ages (one-, two-, three-year-old) the hatching from set eggs were 63.02, 61.22, and 58.24%, respectively; Toboev *et al.* [2020] found 47.87, 63.36, and 51.99%. The values obtained in this study are higher than the values obtained by Onk [22] and Toboev*et al.* [2020]. The relationship between breeder age and hatchability is similar to Toboev [2020] and different from Onk [2009].

Hatching rate from fertilized eggs was 79.18, 79.36, and 78.41%, depending on breeder ages (one-, two-, three-year-old). These differences were not found to be statistically significant. Biesiada-Drzazga *et al.* [2016], found hatching from fertilized eggs 70.7, 76.6, and 78.7% in one-, two-, three-year-old breeder flocks of geese, respectively; Merritt *et al.* [1960] found that it was 64 and 85% in one, two-year-old breeder flocks of geese. While the results were similar to those of Biesiada-Drzazga*et al.*, it was considerably higher than the one-year-old breeder reported by Merritt *et al.* [1960] but lower than the two-year-olds.

Tserveni-Goussi and Fortomaris [2011] reported that similar to the findings of this study, geese generally performed better in terms of hatching characteristics in the second and third seasons even though they have been used in breeding for many years. Mcloughlin and Gous [1999] associated the low hatchability of young breeders with the low number of pores in the eggshells, as well as the inability of the embryo to achieve the optimal respiratory rate due to the thicker cuticle layer and higher viscosity of albumin.

In this study, fertility rates in geese at different laying periods (first and second periods) were found at 86.79 and 83.95%, respectively. The relationship between laying periods and fertility rate in the study of Biesiada-Drzazga *et al.* [2016] showed similarity with the findings in this study. In different laying periods (first and second), hatching from set eggs was 66.97, 67.77%, and hatching from fertilized eggs was 77.13 and 80.83%. Boz *et al.* [2019] found fertility rates in February, March, April and May were 76.33, 76.34, 65.69 and 69.80%, respectively; hatching from fertilize eggs were 77.32, 74.25, 61.23 and 60.87%; hatching from set eggs 59.32, 57.0, 40.24, 44.48%. In general, the hatching characteristics of the study were obtained by Boz et al. [2019] were lower than the results of this study.

Bednarczyk and Rosinski [1999] reported that the hatching from fertilize eggs of White Italian geese in the WD1 and WD3 lines was 82.6 and 79.8% in March; 84.2 and 80.00% in April; 81.3 and 76.4% in May and 72.00 and 68.3% for June. These findings are similar to the findings of this study. Seasonal temperature and differences in seasonal photoperiod duration are thought to play a role in these differences between periods.

In the study, although the differences between embryonic mortality rates in one, two, three-year-old breeder flock of geese were not statistically significant, they were found to be 13.06, 14.35, and 14.90%, respectively. It was similarity with findings of Onk [2009] which the embryonic mortality rates is 13.54, 13.91, and 13.19%. According to the different laying period, embryonic mortality rates were 16.04 in the first and 12.16% in the second. Boz *et al.* [2019] found embryonic mortality rate was 16.46, 15.12, 19.03, and 14.90% in February, March, April, and May, respectively. The findings of this study are similar to the findings of Boz *et al.* [2019].

By breeder age, dead-in-shell rates (one-, two-, three-year-old breeder of flocks) were 5.34, 3.99, and 4.39%; According to the hatching period, it was determined as 4.43 and 4.89% in the first and second periods, respectively. The differences detected in both breeder age and hatching period were not statistically significant. The dead-in-shell rate was reported by Ayakyay [2008] 4.6%; Tilki and İnal [2004] 0.0-6.9%; Boz *et al.* [2019] 0.28-3.64%.

It is thought that the differences between the findings of this study and other researchers related to fertility rates, hatching rates, embryonic mortality and dead-in-shell rates are due to differences in breed, male-female ratio and incubation method, nutrition, photoperiod, lighting, ventilation, shelter and climatic factors.

According to these findings, it can be concluded that breeder age affects both egg weight and shape index, laying period only affects shape index. Also, hatchability characteristics were relatively better in two-, three-year-old breeders and the first period of the laying season. It is considered that due to the disadvantages of goose species, such as seasonal production, low hatching rate and high embryonic mortality, it is essential to intensify studies on breeding and different genotypes.

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