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Analysis of the Laying Rhythm and Reproductive Traits of Geese

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The aim of the performed investigations was to analyse the laying rhythm and reproductive traits of Kołuda® white geese from the W11 reproduction strain and to determine the heritability of these traits as well as correlations between the laying rhythm traits and reproductive traits. The total number of geese participating in the experiment included 383 one-year old layers from the control flock (the first year of reproductive utilisation). The following traits characterizing the laying rhythm were assessed individually for each layer: the number of 2 and 3-egg clutches or more, length (in days) of 2- or more egg clutches as well as the length of intervals between the laid eggs during the entire laying period. The following reproductive traits were also assessed individually for each bird: age at sexual maturity, initial number of eggs (eggs laid during the period from January, 1st to April, 30th), number of eggs during the whole laying period, laying intensity (the total number of eggs x 100 / length of the laying period in days) as well as the length of the reproductive period. It was found that Kołuda® white geese laid most of their eggs (on average 70.2 %) singly and not in clutches. With regard to egg clutches, it was found that 2-egg clutches constituted 85.3 % of eggs laid in clutches. Moderate or high variability of traits associated with the laying rhythm and reproduction were demonstrated. The observed moderate heritability of the laying rhythm traits indicate that they may be utilised in the selection programs for geese. On the other hand, the reported high, positive genetic correlation coefficients between the number of egg clutches and the initial and total egg number as well as laying intensity confirm the existence of interactions between these traits. This fact may be helpful in breeding programs for determining the optimal selection systems for geese.

Key words: Geese, laying rhythm, reproductive traits, heritability.

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The laying rhythm of domestic fowl comprises clutches of eggs laid every day separated by intervals between these clutches (GUMUŁKA & KAPKOWSKA 1996). The laying intensity is closely correlated with the rhythm of egg laying. If the egg clutches are longer and the intervals between them are shorter, then the hen is a better layer. The laying rhythm has been well characterized in chickens (ROBINSON *et al*. 1990; ROBINSON *et al*. 1991; LILLPERS & WILHELMSON 1993a, b). This species lays eggs every day, almost at the same time for a period of many weeks and ovulation occurs already after about 16 minutes from the time of laying. On the other hand, the laying rhythm in chickens can vary greatly. Studies revealed the occurrence of, among others, regular clutches and intervals, regular clutches and irregular intervals, irregular clutches and intervals. It was also found that hens which are good layers are characterized by large clutches with intervals between them of only one day (MIANDMIETS *et al*. 1993). On the other hand, a decline in the laying of broiler breeders connected with age is caused by the decrease in the number of eggs in the clutches and lengthening of intervals between clutches (KAPKOWSKA *et al*. 1993). Similar experiments were conducted on turkeys and ducks (SIMMONS 1983; PYRZAK & SIOPES 1989). It is well known that in the case of geese, ovulation occurs only 2.5-3.5 hours after egg laying (SZADO *et al*. 1995).

Therefore these birds, unlike chickens, lay eggs typically every second day (ROMANOV 1999).

Relatively few articles deal with the laying rhythm in geese (SZADO *et al*. 1995; KENT & MURPHY 2003; ROSIŃSKI *et al*. 2006). On the other hand, evaluation of genetic indices and correlations in this species of domestic fowl is connected, primarily, with reproductive traits (SOCHOCKA & WĘŻYK 1974; SMALEC & MAZANOWSKI 1982; ROSIŃSKI *et al*. 1997; ROSIŃSKI 2000).

Knowledge of the laying rhythm is interesting from the scientific point of view. The heritability of traits connected with laying rhythm as well as its association with reproductive traits may be useful in breeding work. Research can also indicate new selection traits whose application could improve the laying of these birds.

Material and Methods

Data for investigations were derived from the breeding documentation of the National Geese Research and Breeding Centre (KOB-HG), IZ ZZD Kołuda Wielka. The data were derived from books of individual laying control of the reproduction strain W11 of white Italian geese (commercial name: White Kołuda® geese) and referred to one reproductive season. The individual control was as follows: the presence of an egg in the *uterus* of each female was examined by the palpation method at the end of the day, i.e. photoperiod (16:00-17:00); females with eggs were put into closed nests; on the next morning (7:00-8:00) the eggs/geese were taken out of the nests and both female and successive egg numbers plus date were written down on the egg shells. All birds were kept in identical environmental-nutritive conditions (in accordance with the technology developed in KOB-HG), IZ ZZD Kołuda Wielka. Geese were kept in 10 flocks with sex ratio 1 gander : 5 females. During the reproductive period, birds were fed *ad libitum* complete diets which contained 14-15 % crude protein and 10.48-10.90 MJ EM/kg. Geese were housed in a building with access to runs. The applied photoperiod throughout the reproductive period was 10 hours of light (7:00-17:00) and 14 hours of darkness. The total number of geese participating in the experiment included 383 one-year old layers from the control flock (the first year of reproductive utilisation). Females were derived from 20 sires niejasne. The investigations analysed clutches of 2 and more eggs laid in succession as well as 1 day and longer intervals between these clutches. The following traits characterizing the laying rhythm were assessed individually for each layer: number of 2 and 3-egg clutches or more, length of 2-egg clutches or more as well as the length of intervals between the eggs during the entire laying period. Eggs laid every second day or at the interval longer than one day were treated as eggs laid singly. The following reproductive traits were also assessed individually for each bird: age at sexual maturity, number of eggs during the whole laying period, initial number of eggs (eggs laid during the period from January, 1st to April, 30th), laying intensity (the total number of eggs x 100 / length of the laying period in days) as well as the length of the reproductive period.

Heritability coefficients of the laying rhythm traits and reproductive traits were assessed by the method of hierarchical analysis of variance according to the following model (ŻUK 1979):

$$Y_{ijk} = s_i + d_{ij} + e_{ijk}$$

where: s_i - paternal effect, d_{ij} – maternal effect, e_{ijk} – random error.

Genetic correlation coefficients between the analysed laying rhythm traits and reproductive traits were calculated from the formula (ŻUK 1979):

$$r_{G\ X\ Y} = cov_s / \delta_{sx} \times \delta_{sy}$$

where: cov_s – covariance of two different traits (x, y) estimated from the paternal component.

Phenotype correlation coefficients between the examined traits were calculated according to the formula (ŻUK 1979):

$$r_P = cov_{xy} / \delta_x \times \delta_y$$

All the calculations were carried out with the assistance of the SELECT program (SZEWCZYK & BRĄGIEL 1981). The percentage of eggs laid singly and in clutches as well as the number of eggs laid in individual clutches and the percentage share of individual egg clutches were also calculated.

Results

The geese laid most of their eggs (on average 70.2 %) singly and not in clutches (Fig. 1). On the other hand, on average, 29.8 % of eggs were laid in 2-egg or more clutches with 2-egg clutches constituting 85.3 % of eggs laid in clutches (Fig. 2). The proportion of the 3-egg or more clutches constituted only 14.7 % of the clutch-laid eggs. Similarly, geese laid more eggs in 2-egg clutches in comparison with the remaining eggs (77.8 % against 22.2 %, Fig. 3). Table 1 presents the mean values and variability coefficients of the laying rhythm traits and reproductive traits. Considerable variability of the laying rhythm traits was ob-

Table 1

Characteristics of laying rhythm and reproductive traits in W11 strain of geese

Traits		
Laying rhythm		
No of clutches (2 and more eggs)	$\bar{x}$ CV	7.83 40.6
No of clutches (3 and more eggs)	$\bar{x}$ CV	1.15 92.2
Mean length of 2 and more egg clutches (days)	$\bar{x}$ CV	2.19 9.5
Mean length of interval between clutches (days)	$\bar{x}$ CV	1.71 29.9
Reproduction		
Age at sexual maturity (days)	$\bar{x}$ CV	295.1 2.4
Total number of eggs (pcs)	$\bar{x}$ CV	56.8 14.9
Initial number of eggs (pcs)	$\bar{x}$ CV	39.8 13.2
Laying intensity (%)	$\bar{x}$ CV	42.6 13.1
Length of the reproductive period (days)	$\bar{x}$ CV	134.1 11.5

Table 2

Coefficient of heritability of laying rhythm and reproductive traits in geese

Traits	h^2S	h^2D	h^2SD
Laying rhythm			
No of clutches (2 and more eggs)	0.61	0.02	0.30
No of clutches (3 and more eggs)	0.92	0.02	0.46
Mean length of 2 and more egg clutches (days)	0.01	0.26	0.13
Mean length of interval between clutches (days)	0.36	0.73	0.54
Percentage of single eggs	0.48	0.12	0.30
Percentage of eggs (2 egg clutches)	0.43	0.25	0.34
Percentage of eggs (2 and more egg clutches)	0.48	0.12	0.30
Percentage of eggs (3 and more egg clutches)	0.05	0.13	0.11
Percentage of clutches (2 eggs)	0.44	0.20	0.32
Percentage of clutches (2 and more eggs)	0.48	0.13	0.30
Percentage of clutches (3 and more eggs)	0.07	0.07	0.07
Reproduction			
Age of sexual maturity (days)	0.30	0.29	0.29
Total number of eggs (pcs)	0.50	0.01	0.25
Initial number of eggs (pcs)	0.32	0.15	0.23
Laying intensity (%)	0.52	0.30	0.67
Length of the reproductive period (days)	0.21	0.33	0.27

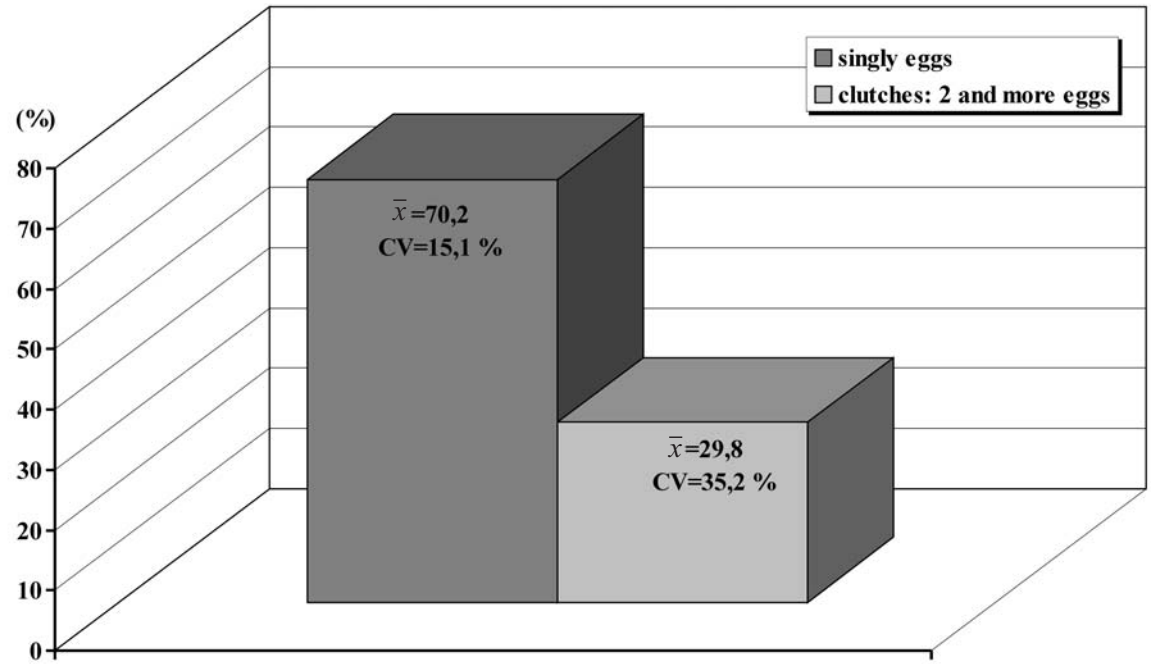

Fig. 1. Percentage of singly eggs and egg clutches in geese.

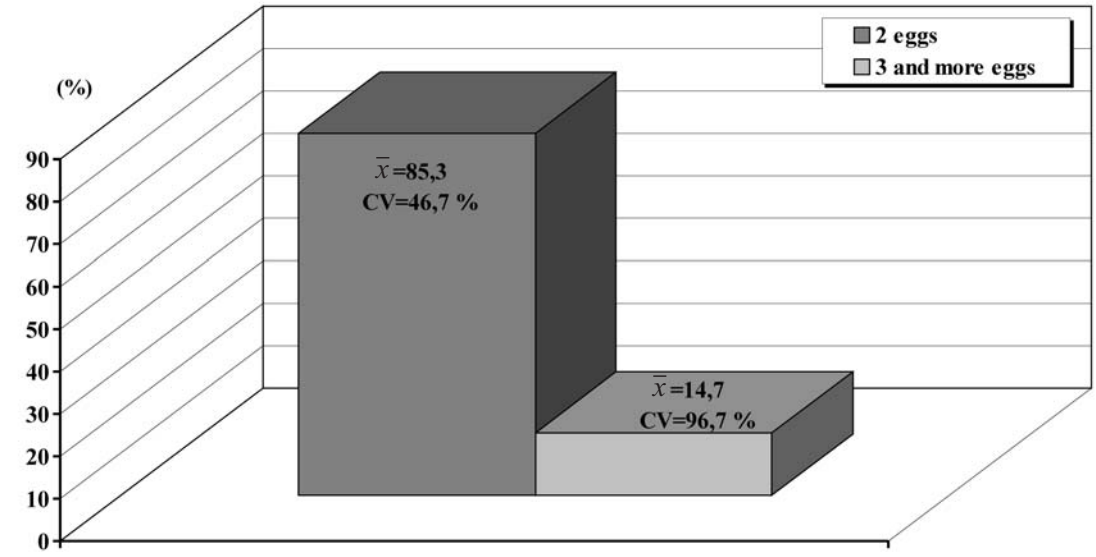

Fig. 2. Percentage of different egg clutches in geese.

served (CV = from 29.9 to 92.x2 %). The smallest variability was determined for the mean length of 2 or more egg clutches (CV = 9.5 %). The reproductive traits were characterized by moderate variability (Table 1). The smallest variability was determined for the age of sexual maturity (CV = 2.4 %).

The analysis of heritability coefficients (Table 2), taking into consideration joint variation of the paternal and maternal components (h^2_{S+D}), revealed moderate heritability of the majority of traits associated with the laying rhythm (h^2 = from 0.30 to 0.46). From among these traits, only the percent of 3- or more egg clutches, the percent of eggs laid in 3- or more egg clutches and the mean length of 2- or more egg clutches showed low heritability (h^2 = from 0.07 to 0.13). On the other hand, the mean interval between clutches showed high heritability. All reproductive traits were moderately heritable (h^2 = from 0.23 to 0.29), with the exception of the laying intensity which turned out to be a highly heritable trait (Table 2).

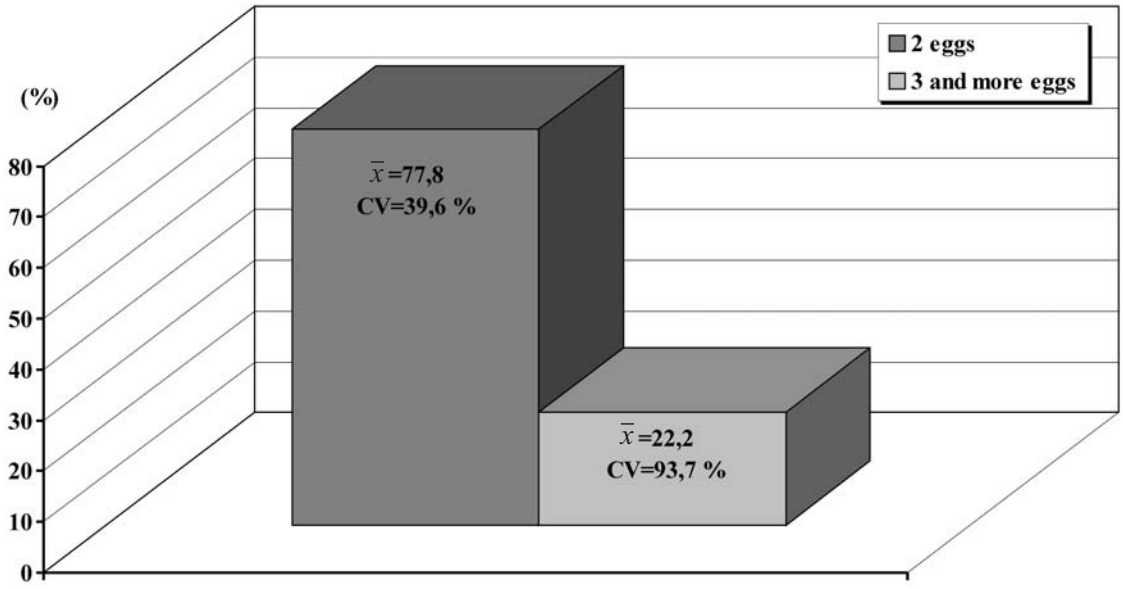

Fig. 3. Percentage of eggs laid in different clutches.

Table 3

Coefficients of genetic correlation between laying rhythm and reproductive traits in geese

Laying rhythm trait \ Reproduction trait	Age of sexual maturity	Total number of eggs	Initial number of eggs	Laying intensity	Length of the reproductive period
No of clutches (2 and more eggs)	0.251	0.664	0.721	0.683	0.063
No of clutches (3 and more eggs)	0.754	0.991	0.992	0.996	0.362
Mean length of 2 and more egg clutches (days)	-0.852	0.993	0.998	0.991	0.993
Mean length of interval between clutches (days)	-0.522	-0.816	-0.823	-0.932	0.047
Percentage of single eggs	0.123	-0.442	-0.531	-0.422	0.045
Percentage of eggs (2 egg clutches)	-0.061	0.282	0.253	0.371	-0.135
Percentage of eggs (2 and more egg clutches)	-0.124	0.442	0.531	0.491	-0.042
Percentage of eggs (3 and more egg clutches)	-0.191	0.992	0.994	0.962	0.352
Percentage of clutches (2 eggs)	-0.102	0.342	0.333	0.421	-0.101
Percentage of clutches (2 and more eggs)	-0.152	0.415	0.499	0.482	-0.071
Percentage of clutches (3 and more eggs)	-0.221	0.897	0.991	0.904	0.112

Genetic correlation coefficients (Table 3) show a very high, positive correlation between the number of 3- or more egg clutches, mean length of 2- or more egg clutches, percentage of eggs laid in 3- or more egg clutches and percentage of the 3- or more egg clutches and the initial and total number of eggs and laying intensity (r_G = from 0.897 to 0.998). A high, positive correlation was also demonstrated between the number of 2- or more egg clutches and the initial number of eggs; the number of 3- or more egg clutches and the age of sexual maturity as well as the mean length of 2- or more egg clutches and the length of the reproductive period. A highly negative genetic correlation was found between the mean length of 2- or more egg clutches and the age of sexual maturity as well as between the mean length of the interval between clutches and the total and initial number of eggs and the laying intensity (r_G = from -0.816 to -0.932).

Table 4

Coefficients of phenotypic correlation between laying rhythm and reproductive traits in geese

Reproduction trait / Laying rhythm trait	Age of sexual maturity	Total number of eggs	Initial number of eggs	Laying intensity	Length of the reproductive period
No of clutches (2 and more eggs)	-0.132	0.543*	0.495*	0.411*	0.202*
No of clutches (3 and more eggs)	0.122	0.234*	0.216*	0.224*	0.041
Mean length of 2 and more egg clutches (days)	0.142	0.052	0.054	0.063	0.002
Mean length of interval between clutches (days)	-0.211*	-0.586*	-0.467*	-0.895*	0.262*
Percentage of single eggs	0.042	-0.184	-0.262*	-0.183	-0.014
Percentage of eggs (2 egg clutches)	-0.154	0.152	0.232*	0.139	0.027
Percentage of eggs (2 and more egg clutches)	-0.046	0.186	0.263*	0.184	0.163
Percentage of eggs (3 and more egg clutches)	0.145	0.085	0.105	0.116	-0.028
Percentage of clutches (2 eggs)	-0.135	0.158	0.236*	0.142	0.037
Percentage of clutches (2 and more eggs)	-0.072	0.163	0.241*	0.178	0.017
Percentage of clutches (3 and more eggs)	0.147	0.063	0.088	0.109	-0.037*

– significant at $P \leq 0.05$.

The evaluation of phenotype correlations (Table 4) confirmed a significant ($P \leq 0.05$), positive dependence between the number of 2-, 3- and more eggs clutches and the total and initial number of eggs as well as the laying intensity (r_P = from 0.216 to 0.543). The mean length of the interval between clutches was significantly, negatively correlated with all reproductive traits with the exception of the length of the reproductive season which showed a positive correlation. The percentage of eggs laid in 2-egg and 2- or more egg clutches and the percentage of these clutches were positively ($P \leq 0.05$) correlated with the initial number of eggs (r_P = from 0.232 to 0.263).

Discussion

The results show the highest proportion of 2-egg clutches in laying geese. Similar results were reported by ROSIŃSKI *et al*. (2006) in geese of the same breed ($\bar{x}$= 90 %). It is evident from experiments carried out by SZADO *et al*. (1995) that in comparison with white Italian geese, Zatorska geese were characterized by a distinctly greater proportion of 3- or more egg clutches ($\bar{x}$= 69.4 against 14.7 %). ROBINSON *et al*. (1990) and GUMUŁKA & KAPKOWSKA (1996) reported the occurrence of one very large clutch in which the number of eggs laid exceeded 50 in some hens, during the laying peak.. In the performed experiments, the largest clutches comprised only 6 eggs. On the other hand, SZADO *et al*. (1995) reported in Zatorskie geese one case of a 37-egg clutch. The same researchers reported the mean length of the interval between clutches of laid eggs similar to that found in these experiments (1.8 days). ROSIŃSKI *et al*. (2006) reported a slightly shorter length of the interval between clutches, namely 1.4 days, in white Italian geese of the W11 strain. In addition, these authors found considerable variability for the traits characterizing the laying rhythm similar to that found in our study.

The shorter (by 5.4 days) reproductive period reported by ROSIŃSKI *et al*. (2006) may be explained by the fact that geese from the discussed experiments reach sexual maturity later. The age of the first laid egg was 9 days later than that reported by SOCHOCKA & WĘŻYK (1974) and ROSIŃSKI *et al*. (2006). ROSIŃSKI (2000), after analysing time trends of this trait, claims that delays of the age of sexual maturity can be noticed in geese of the W11 strain. The mean number of eggs laid by one goose in the entire reproductive period amounted to 56.8 (Table 1). In comparison with our studies, ROSIŃSKI *et al*. (1997), PAKULSKA *et al*. (2004) and ROSIŃSKI *et al*. (2006) reported higher laying of the geese from the W11 strain during the entire season by 6.2, 2.9 and 11.2 eggs, respectively. Also SMALEC and MAZANOWSKI (1982) reported

higher laying intensity in white Italian geese than in our studies (by 6.4 percentage points). This may have been caused, according to ELMINOWSKA-WENDA *et al*. (1997), by the lighting program. The above-mentioned researchers found that shortening daylight hours from 12 to 8-10 of light per day decreased laying intensity and delayed the initiation of egg laying, as also confirmed by our studies. The observed mean variability of the reproductive traits in geese of the W11 strain was in agreement with the results reported by ROSIŃSKI *et al*. (2006).

There are only a few studies on the heritability of clutch traits, and the existing papers pertain only to the estimation of heritability for the oviposition interval within clutches (MCCLUNG *et al*. 1976; YOO *et al*. 1988; LILLPERS & WILHELMSON 1993b). The heritability of the interval within clutches in hens was 0.35 (MCCLUNG *et al*. 1976), while in the geese, this value was higher (h^2 = from 0.36 to 0.73). However, in our study the heritability of the majority of the studied traits of the laying rhythm demonstrated moderate values. Similarly, BEDNARCZYK *et al*. (2000) concluded that the heritability of clutch traits in a commercial line of laying hens: clutch size, clutch number and maximum clutch size showed moderate values; however, they were found to be several times greater, particularly in the case of clutch number and clutch size (h^2 = from 0.15 to 0.34), compared to those concerning the total egg number.

According to WĘŻYK *et al*. (1993), the heritability of sexual maturity in broiler breeders was, as in the case of our studies, a moderately heritable trait (h^2 = 0.42). Also in the case of geese, ROSIŃSKI and BIELIŃSKI (1989) found moderate or high heritability of sexual maturity (h^2 = from 0.42 to 0.68). The results of investigations on the heritability (h^2 = 0.25) of the total egg number laid by white Italian geese obtained in this study were similar to those reported for the same strain by SMALEC and MAZANOWSKI (1982). However, these researchers reported poor heritability of the laying intensity (h^2 = 0.09), while in the experiments described here, this trait was highly heritable (h^2 = 0.67). This may indicate the effectiveness of the selection process carried out for many years. WĘŻYK *et al*. (1975) reported moderate heritability of laying (h^2 = 0.34) in white Italian geese. On the other hand, WAWRO *et al*. (1993) maintain that turkeys are characterized by low heritability of the number of laid eggs (h^2 = 0.15).

The performed analysis of genetic and phenotypic correlation coefficients showed that the majority of traits characterizing laying rhythm were positively correlated with the reproductive traits. The only exception was the mean interval length between clutches which showed a high and significantly negative correlation (r_G and r_P) with the initial and total number of eggs and laying intensity. MCCLUNG *et al*. (1976) reported in hens moderate, negative and low positive genetic correlation between the length of the interval between clutches and the initial and total number of laid eggs which amounted to: -0.431 and 0.205, respectively. The same authors also found a high positive correlation between the age of sexual maturity and the length of the interval between clutches. Experiments carried out by ROSIŃSKI *et al*. (2006) indicate that geese which lay more eggs have a greater number of intervals between the laid eggs. This was confirmed by a high positive phenotypic correlation coefficient reported in two geese strains (W11 and W33) between the number of eggs and the number of intervals as well as between the number of eggs and the number of clutches (r_P = from 0.274 to 0.957). Similarly, BEDNARCZYK & KIEŁCZEWSKI (1998) reported high values of correlation coefficients in hens, especially genetic ones, between the number of eggs and the number of clutches. CYWA-BENKO (1989) claims that, in the case of laying hens, there is a negative correlation between the age of sexual maturity and the total number of laid eggs. This means that hens which begin laying earlier can lay more eggs during one production cycle. On the other hand, in geese, a moderate and high positive genetic correlation was demonstrated between the age of sexual maturity and the total number of eggs and the number of 2-, 3-egg or more clutches, i.e. traits which influence significantly the number of laid eggs. Similarly, ROBINSON *et al*. (1990) found a significant dependence between the number of eggs laid in the longest clutch and the total egg production in hens (r_p= 0.399).

The performed experiments showed that white Italian geese laid most of their eggs (on average 70.2 %) not in clutches but singly. From among clutches of laid eggs, the 2-egg clutches turned out to be the most common as they constituted 85.3 %. Moderate or high variability was found in traits associated with laying rhythm and reproduction. The observed moderate heritability of the laying rhythm traits points to the possibility of using these traits in selection programs for geese. The reported high, positive genetic correlation coefficients between the number of egg clutches and the initial and total egg number as well as laying intensity confirm the existence of interactions between these traits and this fact may be helpful in breeding programs to determine the optimal selection stresses in geese.

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