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Correlations between egg weight, early embryonic development, and some hatching characteristics of Japanese quail (*Coturnix japonica*)

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Abstract: The correlations between selected egg, embryo development, and chick traits were analyzed in three lines of Japanese quail subjected to intrafamily selection for 28th day body weight (group S) and in three lines of random control birds (group K). The significant correlation coefficients between egg weight and most of the traits observed after the first two days of incubation as well as chick weight and shank length were estimated. Most of the correlations obtained were significant in both groups. No statistically significant differences between groups were confirmed, but there was a lines effect within the groups in most cases and a strong nest effect in every analyzed trait observed.

Key words: Japanese quail chicks, selection, embryo development, hatching characteristics, body weight

1. Introduction

Embryo development, traits of chicks (hatching weight and chick quality), and hatchability are associated with the hatching egg weight (1–5). Differences observed in these traits also depend on the line's genetic background (6). Regardless of the line and direction of conducted selection, it may affect egg production, egg parameters, embryonic development, and chick parameters of different avian species (7–11). Previous reports showed that strong relationships between egg weight and 1-day-old chick weight were observed in quails (12) and broiler chickens (13). Chickens with the highest body weight hatched from heaviest eggs (4,5). Although selection for body weight has a positive effect on egg weight increase, it may contribute to reduction in different reproduction traits, such as egg production, fertility, and hatchability (11,14,15).

Japanese quail is a poultry species commercially bred for meat (in countries of West Europe, such as Spain and France) and eggs (in Japan and other East Asian countries) and also used for experimental purposes (16). Japanese quail can be used in selection experiments as an avian model especially because of their high reproductive potential, fast growth rate, food conversion ability, and early sex maturity, and also the generation interval period is short (16,17). Regardless of the purpose of reproduction, issues related to the rate of embryonic development can be of great importance, especially when a breeder expects chicks to hatch simultaneously, be more uniform, and have the same activity and feed intake.

The aim of this experiment was to determine the relationships between egg weight and some traits of embryo development during the first two days of the incubation period and in chicks in repetition lines of Japanese quails selected for 28th day body weight and control birds.

2. Materials and methods

The experimental material consisted of eggs, embryos, and 1-day-old chicks of Japanese quail (*Coturnix japonica*) originated from the 10th generation of the 6 lines maintained in the Department of Genetics and Animal Breeding of the Warsaw University of Life Sciences. All lines were derived from a common gene pool (18). In three lines (S1, S2, S3) intrafamily selection for 28th day body weight was conducted, while the three others (K1, K2, K3) were managed as random control lines.

In each generation 16 males and 16 females of each line were chosen as parents (1 male and 1 female from full sib family). They were mated in monogamic pairs according to a scheme that minimalized the inbred level of hypothetical offspring. Following these rules, 12 pairs of birds in each of 6 lines were selected for this experiment. Birds used for mating were 8 months old, with a maximum difference of 2 weeks. The scheme of the experiment with number of nests (monogamic parental pairs) per group and lines as

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well as mean body weight of parental pairs at the 28th day of age is presented in Table 1.

The experimental flock was maintained in accordance with the keeping system adopted in our department. Birds were kept in batteries with water and feed ad libitum. The diet contained 2600 kcal/kg metabolizable energy and 21.5% crude protein. The lighting program included 14 h of light and 10 h of dark a day.

All eggs were collected every 1–2 h during the day, weighed using an electronic scale (Medicat Ltd., d = 0.01 g), and stored at 16 ± 1 °C to avoid uncontrolled embryo development during storage, which lasted not longer than 24 h. Although in previous studies the impact of egg storage temperature on embryonic development was not statistically confirmed (19), there were some suggestions for such proceedings (20).

Incubation was carried out in incubator with automatic egg turning every hour, at 37.8–37.9 °C temperature and 60% relative humidity.

Chicks were hatched after the 17 days of incubation period in three hatches. Body weight (electronic scale, Medicat Ltd., d = 0.01 g) and shank length (caliper, d = 0.01 mm) were measured. Embryo development was analyzed in two periods: after 24 h and 48 h of incubation. Observations of embryos were conducted using a 25× magnifying binocular microscope (PZO MSt 131). The following traits were evaluated: diameter and surface area of blastoderm after 24 h, presence of pairs of somites after 24 h, stage in both terms, diameter and vascular surface area after 48 h, and number of pairs of somites after 48 h. An original morphological evaluation point system was applied to estimate stage as a level of embryo development in both terms (21). This system was based on the Japanese quail development classification by Zacchei (22) and the chicken embryo development staging by Hamburger and Hamilton (23).

Statistical analyses were carried out using SPSS 17.0 PL (24). The phenotypic correlation coefficients between egg weight and early embryonic development traits as well as chicks traits were estimated for each group (S and K) separately and together. The model of analysis of variance included the effect of group (K, S), line within each group, and nest (female) within each line and group. For egg weight the analysis included the effect of day of egg collection, and for embryonic development and chick traits it included egg weight as a covariate trait.

3. Results

Body weight observed in the parental generation at the 28th day of age (Table 1) differed between groups and repetition lines within groups ($P < 0.05$). Mean values of eggs deposited by 8-month-old quails, embryo development, and 1-day-old chicks traits observed in the control (K) and selected (S) groups are given in Table 2.

Egg weight differed statistically between groups ($P = 0.03$), lines within groups ($P = 0.016$), and nests within lines ($P < 0.001$). With regard to the embryonic development and chicks traits there were no statistically confirmed differences between groups ($P > 0.05$), but there was a lines effect within groups ($P < 0.05$) in most cases (except for chick traits) and a strong nest effect ($P < 0.001$) in every analyzed trait observed. In body weight of 1-day-old chicks the groups difference was close to significant ($P = 0.054$).

The phenotypic correlation coefficients between egg weight, stage of development, and other embryo traits in the two periods as well as correlations between egg weight and chicks traits in groups and lines of Japanese quail are presented in Table 3.

Estimated phenotypic correlation coefficients between the egg weight, stage of development, and selected traits

Table 1. Experimental scheme of lines and group nests of Japanese quail.

Group	Line	Number of nests	Mean body weight at 28th day (g) Mean ± SD		
			Males + Females	Males	Females
Group K	K1	12	119.41 ± 10.35	116.68 ± 9.94	122.13 ± 10.43
	K2	12	117.74 ± 10.58	113.82 ± 6.19	121.67 ± 12.74
	K3	12	113.63 ± 8.95	109.99 ± 7.49	117.28 ± 9.08
	Total	36	116.93 ± 10.14		
Group S	S1	12	150.49 ± 8.12	147.43 ± 6.96	153.55 ± 8.32
	S2	12	149.21 ± 10.66	147.75 ± 12.49	150.68 ± 8.78
	S3	12	143.88 ± 10.26	143.95 ± 9.49	143.80 ± 11.41
	Total	36	147.86 ± 10.03		

SD: Standard deviation.

Table 2. Egg weight, early embryo development, and some hatching characteristics in control (K) and selected (S) group of Japanese quail.

Trait	Group K		Group S	
	Mean ± SD	n	Mean ± SD	n
Egg weight (g)	10.91 ± 1.03	2803	11.97 ± 1.10	1992
Blastoderm diameter (mm)	10.24 ± 1.47	388	10.54 ± 1.88	250
Blastoderm surface area (mm^2)	83.82 ± 24.93	388	89.75 ± 33.08	250
Somites presence, 24 h (freq.)	0.38	375	0.40	230
Stage, 24 h (pts)	4.46 ± 0.87	372	4.45 ± 0.97	228
Vascular diameter (mm)	10.60 ± 1.46	398	10.83 ± 1.66	273
Vascular surface area (mm^2)	89.56 ± 24.63	398	93.72 ± 28.40	273
Pairs of somites no., 48 h	24.01 ± 2.51	396	24.06 ± 2.76	271
Stage, 48 h (pts)	12.86 ± 0.95	393	12.90 ± 0.95	268
Body weight (g)	7.17 ± 0.76	263	8.16 ± 0.95	146
Shank length (mm)	15.66 ± 0.72	263	16.19 ± 0.72	146

SD: Standard deviation.

Table 3. Phenotypic correlations (r) between egg weight and embryo characteristics in two incubation periods and chicks traits of Japanese quail.

Traits		Group K			Group S			Total		
		r	p	n	r	p	n	r	p	n
Embryos, 24 h	Egg weight									
	Blastoderm diameter	0.185	0.000	388	0.075	0.235	250	0.158	0.000	638
	Blastoderm surface area	0.193	0.000	388	0.093	0.143	250	0.174	0.000	638
	Somites presence, 24 h	0.061	0.238	375	0.125	0.058	230	0.095	0.019	605
	Stage, 24 h	0.042	0.416	372	0.112	0.091	228	0.061	0.133	600
	Stage after 24 h									
	Blastoderm diameter	0.623	0.000	362	0.723	0.000	222	0.664	0.000	584
	Blastoderm surface area	0.612	0.000	362	0.709	0.000	222	0.651	0.000	584
Embryos, 48 h	Egg weight									
	Vascular diameter	0.114	0.023	397	0.125	0.040	273	0.138	0.000	670
	Vascular surface area	0.102	0.042	397	0.113	0.063	273	0.130	0.001	670
	Pairs of somites no., 48 h	−0.007	0.892	396	0.115	0.059	271	0.050	0.196	667
	Stage, 48 h	−0.011	0.831	392	0.076	0.216	268	0.036	0.362	660
	Stage after 48 h									
	Vascular diameter	0.718	0.000	390	0.763	0.000	267	0.736	0.000	657
	Vascular surface area	0.694	0.000	390	0.743	0.000	267	0.713	0.000	657
Chicks	Egg weight									
	Body weight	0.882	0.000	422	0.877	0.000	261	0.907	0.000	683
	Shank length	0.500	0.000	422	0.475	0.000	261	0.566	0.000	683
	Body weight									
	Shank length	0.494	0.000	422	0.523	0.000	261	0.583	0.000	683

Mean ± standard deviation. P = probability.

observed in embryos after 24 and 48 h of incubation period (diameter and surface area of blastoderm after 24 h, presence of pairs of somites after 24 h, stage in both terms, diameter and vascular surface area after 48 h, and number of pairs of somites after 48 h) remained at low levels ($0.20 > r > -0.02$), and not all were statistically significant (number of pairs of somites and the stage in both terms).

Exceptions were quite strong development stage correlations with diameter ($r > 0.62$) and surface area ($r > 0.61$) of blastoderm, and vascular surface area ($r > 0.69$) in both groups, as well as slightly negative (insignificant, $P > 0.8$) correlations between the egg weight and number of pairs of somites ($r = -0.007$) and stage after 48 h ($r = -0.011$) in group K (Table 3).

Phenotypic correlation coefficients estimated in groups separately and in total between the egg weight and chicks traits were moderate to strong ($0.91 > r > 0.47$).

4. Discussion

Results obtained in studies conducted on hens (25,26), ring-necked pheasants (27), and Japanese quails (28) also indicated low correlations or a lack of correlation, and even a slight negative correlation, between egg weight and the rate of early embryonic development.

In an experiment carried out after 7 generations of selection with a much lower number of observations, low values of the coefficient in the group S and K were also obtained (21). This refers to the correlations between egg weight and stage in both terms of incubation period, respectively 0.103 (S) and –0.050 (K) after 24 h and 0.326 ($P \leq 0.01$, S) and 0.032 (K) after 48 h. However, in comparison to these results, the tendency in groups was reversed.

In a study of three experimental lines of Japanese quails maintained in our department (28), mostly negative but also low and insignificant phenotypic correlation coefficients (from –0.21 to 0.03) were obtained between the egg weight and embryonic development in the first two days of incubation period: blastoderm diameter after 24 h, stage and pairs of somites in both terms, and vascular diameter after 48 h. Due to the small number of observations the data were analyzed for all lines together. Also in studies on W and J lines of Japanese quail, Korzyńska-Nowak (29) obtained similar results, where the correlations were positive and close to zero.

The studies of Starosta and Hyánková (30) and Hyánková and Starosta (31) on Japanese quails divergently selected for the shape of the growth curve showed that the low growth (LG) line was developmentally accelerated during the whole prenatal period and hatched earlier in comparison with the high growth (HG) line. The LG line was characterized by a fast postnatal growth rate immediately after hatching. The embryo growth difference was probably due to a greater size of LG line eggs. Hyánková et al. (32) confirmed the association of this divergent selection with correlated changes in the embryonic period. Early embryonic development in the LG line was accelerated in comparison with the HG line (stage and blastoderm diameter after 12 and 42 h of incubation, number of somites after 42 h of incubation).

In our experiment only the correlations of egg weight with number of pairs of somites and the stage after 48 h in the control group were negative. For other traits, significant or even highly significant coefficients were mostly obtained (Table 3).

When considering the relationships between the stage of development and other traits associated with embryonic development in the first two days of the incubation period in both groups (S and K), significantly high values ranging from 0.61 to 0.88 were obtained in this experiment. Nowaczewski et al. (27) reported highly significant correlations between some extra embryonic and embryo parameters reaching a value of over 0.8.

All estimated correlation coefficients obtained for hatched quails were extremely significant and high in both groups (Table 3). Especially high values of correlation were obtained for egg weight and chick body weight. This means that ca. 80% variation of chicks' body weight was determined by variation of egg weight.

In earlier studies conducted after 7 generations of selection (33), the correlations were slightly lower in both groups for egg weight and body weight (0.828 and 0.835 in K and S groups, respectively) and between egg weight and shank length (0.469 and 0.281, respectively). Similar results were obtained by Marks (34), in whose studies this coefficient for egg weight and body weight fluctuated from 0.8 to 0.9 in all lines. Othman et al. (35) noted that heavy egg weight (10–11 g) in Japanese quails gave the best hatching performances. Wilson (1) described several interrelationships apparent between egg weight, chick weight, chick growth, and other parameters. The best hatchability was observed in intermediate size eggs in comparison with very large or very small ones. Incubation time was positively correlated with egg size, while egg weight was not correlated with embryo weight during the first half of the incubation period. This correlation increased and reached its maximum at the time of hatching (0.5–0.95). In this report, chick weight was primarily determined by initial egg weight and was secondarily determined by weight loss during incubation, shell and residue weight, strain, incubation time and conditions, breeder age, and chick sex. In addition, the correlation between egg weight and posthatching chick weight decreased with increasing age of the chick (1).

In summary, the correlations between analyzed traits remained at low levels and in most cases were statistically significant. However, it is difficult to identify these results with conducted selection. The impact of the intraclass selection on early embryonic development and chick traits in quails was not statistically confirmed. However, sorting eggs by weight prior to incubation might be advantageous in some later production operations to improve chick, broiler, or pullet uniformity and further efficiency.

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