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Heritability of Exterior Egg Quality Traits in Japanese Quail

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Abstract

The objective of this study was to estimate the genetic and phenotypic parameters for Japanese quail external egg quality traits. In this study, 1567 eggs were collected out of 584 Japanese quails which were caged individually. Egg weight (EW), specific gravity (ESG), width (WE) and height (HE) of egg, shape index (ESI), shell thickness (ST), shell weight (SW), shell ratio (SR), egg surface area (ESA), and shell weight per unit surface area (SWUS) were measured. The restricted maximum likelihood procedure was applied to estimate heritability and genetic and phenotypic correlations for the examined traits. Heritability of EW, ESG, WE, HE, ESI, ST, SW, SR, ESA, and SWUS were 0.83, 0.31, 0.68, 0.72, 0.59, 0.53, 0.08, 0.31, 0.83, and 0.19, respectively. Shell weight, WE, and HE had high positive genetic correlations with EW and they were ranged from 0.52 to 0.94. However, SR and SWUS had high and negative genetic correlations with EW, they were -0.93 and -0.88, respectively. The genetic correlations between ESG and each of ST, SW, and SWUS were high and ranged from 0.56 to 0.82, whereas genetic correlations between ESG and the traits related with egg size were low and insignificant, ranging from -0.01 and 0.08. Therefore, selection based on ESG would be feasible to improve the ST and consequently high shell stiffness without antagonistic effect on egg size. Positive correlations between ESI and EW were higher in magnitude than the negative correlations between ESI and HE. This indicates that egg size is limited by the WE rather than HE. Shell ratio and SWUS were negatively correlated with EW, WE and HE, indicating larger eggs had proportionately less SW and consequently low SWUS. Hence, selection for increased EW will result in decreased shell quality.

Key words: genetic parameters, shell quality, specific gravity

INTRODUCTION

Japanese quail, the smallest farmed avian species [1], is getting more important for commercial egg and meat production. It has marked advantages such as fast growth, early sexual maturity, high rate of egg production, short generation interval and short incubation period. The average age at onset of laying for Japanese quail is 6-8 weeks [2] and with proper care, quail hens can lay up to 280-300 eggs in their first year.

Qualities of the breeding eggs have an overall significance for an economic breeding. Traits related with external quality of the eggs have effects on the hatchability and development of the chicks [3, 4, 5-6]. External qualities of the eggs are also directly related with the amount of broken eggs, leading to serious economic problems for the breeders and the dealers [7]. On the other hand, such traits of the eggs determine their value in the market by affecting the demand of consumers [8].

Egg composition of the domestic fowl shows high variations depend on the species, age of hens and breeding environment. Egg shell is one of the most important external characteristics of the eggs [9]. It was reported that EW had a positive correlation with ST and SW [10]. The percentage of shell is related to total egg weight, with larger eggs frequently having proportionately less shell. Other researchers also reported that ST had an effect on the shell stiffness [11, 12]. Egg specific gravity represents an easy method to test ST and has been used widely [13, 14]. At least some of the inability to resist fracture damage can be attributed to deficiencies in shell structure and shape [15]. It is also well known that eggs of normal shape hatch more successfully than those shaped abnormally [9].

The external quality traits and the phenotypic correlations among them were studied in a number of researches for Japanese quail eggs. However, reports on the genetic correlations among quality traits using restricted maximum likelihood (REML) procedure were relatively less (for reviews, see [9, 16]). Hence, the objective of current study was to estimate the genetic and phenotypic parameters for external egg quality traits for Japanese quail using REML procedure.

MATERIAL AND METHODS

The study was conduced at the Quail Breeding Unit of Gaziosmanpasa University, Tokat. Eggs were collected from the quails (12 weeks of age) pedigreed through eight successive generations. Totally 1567 eggs from 584 female quails were collected in three sequential days. Chicks were raised in quail battery brooders until five weeks of age. Then, the females were caged individually in 25X25X30 stainless steel wire mesh cages. Lighting schedule of 24 hours lighting for the first three weeks, and then 16:8 light:dark cycle was applied. Birds were allowed to access *ad libitum* to feed and water. They were fed with 24% crude protein (CP) and 3200 kcal ME/kg starter diet for 21 days, 19% CP and 3000 kcal ME/kg grower diet between

21 and 35 days of age and thereafter 17% CP and 2750 kcal ME/kg breeder diet.

Soft-shelled, cracked and small eggs were not used in the study. The collected eggs were labelled to identify each female egg. Eggs were weighted with a 0.01 g sensitive electronic scale. Egg specific gravity was determined by water displacement method [7]. An electronic digital calliper sensitive to 0.01 mm was used for measuring the length and width of the eggs to calculate the shape index. Shells of broken eggs were washed with slightly flowing water to separate remaining albumen. Air-dried egg shells were weighted together with the shell membrane. Finally, egg shell samples taken from sharp, blunt and equatorial parts without membrane were measured with 0.001 mm sensitive electronic digital micrometers after that the average ST was obtained. These data were used to determine the external quality traits of eggs with the following formulas.

Specific gravity = weight in air / (weight in air-weight in water)

Shape index (%) = [width (cm) / height (cm)] x 100

Egg surface area (cm^2) = $3.9782*(EW)^{0.7056}$

EW = egg weight (g)

Shell weight per unit surface area (mg/cm^2) = shell weight (mg) / egg surface area (cm^2)

Shell ratio (%) = (shell weight / egg weight) x 100

(Co)variance components and genetic parameters were estimated using restricted maximum likelihood (REML) procedures (ASREML software; [17]). Rearing group (generation) was included as fixed effect in the model for each trait. Animals were fitted as random effect into the model in order to estimate the additive direct genetic effect. Genetic and phenotypic correlations between traits were estimated with bivariate analyses using the same fixed and random effects.

$$Y_{ij} = \mu + a_i + b_j + e_{ij}$$

Where Y_{ij} is the observation of external egg quality trait of i^{th} animal that is located in the j^{th} rearing group, μ is the population mean, a_i is the animal additive genetic effect, b_j is the effect of rearing group, e_{ij} is the residual error.

RESULTS AND DISCUSSION

Descriptive statistics were calculated for the examined external quality traits and these were presented in Table 1. The average values of traits for the eggs were within the range which was reported in previous researchers [8, 18, 19, 20]. Slight differences among the reports for traits related with egg quality could be expected because of the differences in genetic structure, age of the folk, content of diets and managements. The biological function of the egg shell is as a chamber for embryonic development. Hence, deficiencies in external quality traits of the incubated eggs have deleterious effects on hatching performance of them and future development of the hatchlings [3, 4, 5, 6]. On the other hand, low external egg quality will result in reduced number of saleable eggs obtained from per hen housed.

Heritability, genetic and phenotypic correlations among the examined traits were shown in Table 2. Heritability of external egg quality traits were ranged high to moderate, except for SW and SWUS. Generally, traits related with the shell (SW, ESG, SR and SWUS) had lower heritability than the traits related with egg size (EW, WE, HE, ESI and ESA). Low heritability estimates for SW (0.08±0.029) and SWUS (0.19±0.036) indicates that environmental factors such as feed, management and temperature have more effect on these traits than the additive genetic backup. Stino et al. [21] reported that heritability values obtained by regression were high (>0.5) for ESI, SW and ESG. Sato et al. [22] also reported high heritability for egg characteristics, ranging from 0.62 to 0.84.

Egg shape index and EW are important characters from the point of mechanical handling of eggs. WE and HE has positive genetic and phenotypic correlations with EW, but EW had negative correlations with ESI. Similar results have been also reported in chickens by Choprakarn et al. [23]. Negative phenotypic correlation between the EW and ESI (-0.22) were also reported for Japanese quail by Kul and Seker [20]. Positive correlations between ESI and EW and negative correlations between ESI and HE are expected, because of the calculation method of the ESI. Nevertheless, these values were higher in magnitude for HE than for WE. These results indicate that egg size is limited by the WE rather than HE, which also explain the evolutionary consequence of egg shape.

Heavier eggs are expected to have high shell weight, which is also revealed in this study by estimating positive phenotypic and genetic correlation between EW and SW. Proportion of shell weight to total egg weight and SWUS are more reflective values to evaluate shell quality than the absolute SW [24, 25]. Both shell ratio and SWUS were negatively correlated with EW, WE and HE, indicating larger eggs had proportionately less SW

Table 1. Descriptive statistics for external quality characteristics of Japanese quail egg

Characteristics	N	Mean	SE	Min	Max	CV (%)
EW (g)	584	11.06	0.038	8.57	14.05	8.33
ESG	583	1.066	0.0003	1.038	1.078	0.63
WE (mm)	584	25.26	0.031	22.8	27.82	2.92
HE(mm)	584	31.97	0.051	28.25	35.88	3.86
ESI (%)	584	79.12	0.107	70.38	86.57	3.28
ST (mm)	584	175.50	0.710	116.00	237.00	9.77
SW (g)	581	0.96	0.004	0.76	1.41	8.91
SR (%)	581	8.78	0.044	5.96	12.45	12.15
ESA (cm^2)	584	21.67	0.053	18.11	25.67	5.88
SWUS (mg/cm^2)	581	44.65	0.19	32.11	63.17	10.61

N = Number of females; SE = standard error; Min and Max = minimum and maximum values; CV (%) = coefficient of variation.

and consequently low SWUS. Hence, selection for increased EW will result in decreased shell quality. Richards and Staley [26] reported that shape index had a significant effect on the variation of crushing strength. In this study, moderate genetic correlations between ESI and SR (0.18±0.083) and SWUS (0.19±0.090) were detected which indicated the possibility of improvement in shell quality with rounder eggs.

Abdallah et al. [25] reported that SR and SWUS were more sensitive estimates of shell quality than ESG in relation to incidence of cracked eggs. On the other hand, heritability of ESG is high, it has favourable genetic correlations with the other quality traits and it is easy to measure. Hence, ESG has been reported as the best shell quality traits to use in selection programs [13, 14, 27]. It has been concluded that differences in ESG was emerged from differences in the amount of shell presented [28]. The results of this study confirmed the previous findings. Additionally, positive genetic correlation between ESG and ST (0.82±0.041) suggests that selection based on ESG will be feasible to improve the ST and consequently high shell stiffness. Furthermore, this indirect selection could be more effective than the direct selection based on ST in improving the SR and SWUS. Genetic and phenotypic correlations between ESG and each of EW, ESI, WE and HE were not significant. Hence, it seems that selection based on ESG will not lead to antagonistic effects on egg mass or volume.

Table 2. Genetic and phenotypic parameters for external quality characteristics of Japanese quail eggs. Heritability on diagonal, genetic correlations above and phenotypic correlations below the diagonal with their standard errors

	EW	ESG	WE	HE	ESI	ST	SW	SR	ESA	SWUS
EW	**0.83±0.012**	-0.01±0.071	0.94±0.010	0.80±0.020	-0.14±0.055	0.27±0.056	0.52±0.001	-0.93±0.028	0.04±0.001	-0.88±0.049
ESG	-0.02±0.036	**0.31±0.036**	-0.02±0.078	-0.08±0.076	0.08±0.082	0.82±0.041	0.58±0.160	0.28±0.103	-0.01±0.071	0.56±0.119
WE	0.85±0.010	-0.04±0.035	**0.68±0.022**	0.59±0.039	0.16±0.059	0.20±0.062	0.42±0.134	-0.89±0.035	0.94±0.010	-0.86±0.054
HE	0.76±0.017	-0.07±0.035	0.50±0.029	**0.72±0.019**	-0.70±0.031	0.21±0.061	0.32±0.126	-0.86±0.044	0.80±0.020	-0.84±0.063
ESI	-0.13±0.038	0.04±0.035	0.28±0.035	-0.69±0.020	**0.59±0.027**	-0.09±0.067	-0.01±0.142	0.18±0.083	-0.14±0.055	0.19±0.100
ST	0.18±0.037	0.56±0.022	0.12±0.037	0.12±0.037	-0.04±0.037	**0.53±0.030**	0.74±0.114	0.05±0.087	0.27±0.056	0.18±0.102
SW	0.26±0.038	0.15±0.028	0.12±0.030	0.10±0.031	-0.01±0.031	0.18±0.029	**0.08±0.029**	-0.19±0.189	0.50±0.119	0.40±0.059
SR	-0.58±0.021	0.13±0.031	-0.50±0.024	-0.47±0.025	0.09±0.034	0.04±0.034	0.70±0.017	**0.31±0.037**	-0.94±0.027	0.20±0.012
ESA	0.07±0.002	-0.02±0.036	0.85±0.010	0.76±0.017	-0.13±0.038	0.18±0.037	0.15±0.031	-0.59±0.021	**0.83±0.012**	-0.88±0.049
SWUS	-0.45±0.025	0.14±0.030	-0.39±0.027	-0.37±0.027	0.08±0.033	0.12±0.032	0.82±0.012	0.68±0.023	-0.45±0.025	**0.19±0.036**

REFERENCES

[1]. Panda B, Singh RP. 1990. Development in processing quail. World's Poultry Science Journal 46:219-234.

[2]. Reddish JM, Nestor KE, Lilburn MS. 2003. Effect of selection for growth on onset of sexual maturity in randombred and growth-selected lines of Japanese quail. Poultry Science 82:187-191.

[3]. Shanaway MM. 1987. Hatching weight in relation to egg weight in domestic birds. World Poultry Science Journal. 43:107-119.

[4]. Tserveni-Gousi AS. 1987. Relationship between parental age, egg weight and hatching weight of Japanese quail. British Poultry Science 28:749-752.

[5]. Skewes PA, Wilson HR, Mather FB. 1988. Correlations among egg weight, chick weight and yolk sac weight in Bobwhite quail (Calinus virginianus). Florida Science. 51:159-162.

[6]. Khurshid A, Farooq M, Durrani FR, Sarbiland K, Manzoor A. 2004. Hatching performance of Japanese quails. *Livestock Research for Rural Development, Vol. 16, Art. #2.* Retrieved March 19, 2006, from http://www.cipav.org.co/lrrd/lrrd16/1/khur161.htm.

[7]. Hamilton RMG. 1982. Methods and factors that effect the measurement of egg shell quality. Poultry Science 61:2022-2039.

[8]. Uluocak AN, Okan F, Efe E, Nacar H. 1995. Bildircin yumurtalarinda bazi dis ve ic kalite ozellikleri ve bunlarin yasa gore degisimi. Turkish Journal of Veterinary and Animal Science 19:181-185.

[9]. Narushin VG, Romanov MN. 2002. Egg physical characteristics and hatchability. World's Poultry Science Journal. 58:297-303.

[10]. Stadelman WJ. 1986. The preservation of quality in shell eggs. In: Egg science and technology (ed. Stadelman WJ, Cotteril OJ), Avi Puplishing Com Inc Westport, Connecticut, U.S.A.

[11]. Thompson BK, Hamilton RMG, Voisey PW. 1981. Relationships among various egg traits relating to shell strength among and within five avian species. Poultry Science 60:2388-2394.

[12]. Buss EG. 1982. Genetic differences in avian egg shell formation. Poultry Science 61:2048-2055.

[13]. Harms RH, Rossi AF, Sloan DR, Miles RD, Chrismas RB. 1990. A method to estimating shell weight and correcting specific gravity for egg weight in egg shell studies. Poultry Science 69:48-52.

[14]. Bennett CD. 1992. The influence of shell thickness on hatchability in commercial broiler breeder flock. Journal of Applied Poultry Research 1:61-65.

[15]. Hunton P. 1995. Understanding the architecture of the egg shell. World's Poultry Science Journal, 51:141-147.

[16]. Minvielle F, Oguz Y. 2002. Effects of genetic and breeding on egg quality of Japanese quail. World's Poultry Science Journal. 58:291-295.

[17]. Gilmour AR, Cullis BR, Welham SJ, Thompson R. 2000. ASREML. NSW Agriculture, Orange, Australia.

[18]. Yannakopoulas AL, Tserveni-Gousi AS. 1986. Quality characteristics of quail eggs. British Poultry Science 27:171-176.

[19]. Nazligul A, Turkyilmaz K, Bardakcioglu HE. 2001. A study on some production traits and egg quality characteristics of Japanese quail. Turkish Journal of Veterinary and Animal Science 25:1007-1013.

[20]. Kul S, Seker I. 2004. Phenotypic correlations between some external and internal egg quality traits in the Japanese quail (Coturnix coturnix japonica). International Journal of Poultry Science 3:400-405.

[21]. Stino FKR, Kicka MA, Kamaer GA, Altakreti BTO. 1982. Egg quality traits of the Japanese quail and their heritability in the subtropics. Archiv für Geflügelkunde. 3:104-108.

[22]. Sato K, Ida N, Ino T. 1989. Genetic parameters of egg characteristics in Japanese quail. Jikken Dobutsu. 38:55-59

[23]. Choprakarn K, Salangam I, Tanaka K. 1998. Laying performance, egg characteristics and egg compositions in thai indigenous hens. J. Natl. Res. Council. Thailand, 30:1-17

[24]. Tyler C. 1961. Shell strength: Its measurement and relationship to other factors. British Poultry Science 2:3-19.

[25]. Abdallah AG, Harms RH, El-Husseiny O. 1993. Various methods of measuring shell quality in relation to percentage of cracked eggs. Poultry Science 72:2038-2043.

[26]. Richards JF, Staley LM. 1967. The relationships between crushing strength, deformation and other physical measurements of the hen's egg. Poultry Science 46:430-437.

[27]. Grunder AA, Hamilton RMG, Fairfull RW, Thompson BK. 1989. Genetic parameters of egg shell quality traits and percentage of eggs remaining intact between oviposition and grading. Poultry Science 68:46-54.

[28]. Wells RG. 1968. Egg quality characteristics. In: Egg Quality: A Study of the Hens Egg. (ed. Carter TC) pp. 214-225. Oliver and Boyd, Edinburgh.