Genetic Parameters of Egg Characteristics in Japanese Quail

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(Received 13 July 1988/Accepted 16 September 1988)

Heritability, phenotypic and genetic correlations of egg characteristics of Japanese quail were investigated to obtain basal information on breeding, strain identification and genetic monitoring. For this study, 3230 eggs produced from 323 female were used. Measurement were taken on egg weight, yolk weight, albumen weight, shell weight, egg shape index, albumen height, specific gravity, shell thickness, shell strength and yolk color. Heritability estimates of egg characteristics were high and ranged from 0.62 to 0.84. Diverse phenotypic and genetic correlations were observed among egg characteristics. These results indicate that individual selection should be the most efficient method of improving egg characteristics and that consideration should be given to the interrelationship of characteristics to accomplish genetic improvement. The possibility exists these assays of egg characteristics can be used for strain identification and genetic monitoring without killing an individual of quail.

The Japanese quail studied here have been widely used since 1959 as poultry models for genetic, embryological, physiological, endocrinological, toxicological and teratological studies in various parts of the world. The biological characteristics of Japanese quail have been extensively studied by many investigators and gradually have been better analyzed. However, detailed information on the genetic parameters of biological characteristics is limited to growth. Reliable estimate of genetic parameters, such as heritability, and phenotypic and genetic correlations of other characteristics are needed not only for genetic improvement but also for genetic monitoring.

This study was carried out to estimate heritability and phenotypic and genetic correlations of egg characteristics in Japanese quail maintained in our laboratory.

Materials and Methods

The Japanese quail used in this experiment were obtained from a randombred control pop-

ulation maintained at the Laboratory of Animal Breeding in the Faculty of Agriculture, Okayama University. Fifteen males and 45 females were taken at random from a randombred population to produce offspring. Each male was mated to three females. Three hundred twentythree female progeny were produced from three hatches. They were fed *ad libitum* a diet consisting of 24% protein and were kept under 14 hours of light per day. Ten eggs obtained from each female at 10 weeks were used to examine egg characteristics. Measurements were taken on egg weight, yolk weight, albumen weight, shell weight, egg shape index, albumen height, specific gravity, shell thickness, shell strength and yolk color. Albumen weight was calculated by subtracting the yolk weight and shell weight from egg weight. Shell weight with shell membrane was measured after washing and drying overnight at 40°C. Egg shape index was calculated as the ratio of egg width to egg length. Albumen height was measured with an albumen height indicator (Fujihira Co. Ltd). Specific gravity was

determined by flotation in saline solution. Shell thickness with shell membrane was measured with a thickness gauge (Fujihira Co. Ltd.). Shell strength was determined by measuring the force necessary to crush the egg. Yolk color was determined with a 15-grade color chart (Roche Co.). Analyses of variance and covariance for estimating heritability and obtaining phenotypic and genetic correlations were carried out as described by King and Henderson [7] and Hazel [4].

Results and Discussion

Means, standard deviations and coefficients of variation for egg characteristics are shown in Table 1. Values of egg characteristics were found to be within the range shown by others [2, 3, 9-14, 16]. However, higher values are reported in Yannakopoulos and Tserveni-Gousi [18] than in our data. There is little

information concerning shell strength in Japanese quail. For chicken eggs, it has been reported by Frank *et al* [1] to be 3.26 Kg/cm². The shell strength of quail eggs obtained in this study was found to be very low compared with that of chicken eggs. This discrepancy is attributable to true species difference.

Heritability estimates and standard errors for egg characteristics are presented in Table 2. The heritability estimates based on sire and dam components were found to be high values, above 0.51. Heritability estimates for egg weight, yolk weight, albumen weight and shell weight were close to the estimates for Japanese quail reported by Kawahara and Kusaka [6], Mitsumoto and Shotake [11] and Stino *et al* [13]. Our results indicate that these egg characteristics are highly heritable and are controlled by additive genes.

In this experiment, heritability estimates for egg shape index, albumen height, specific

Table 1. Means, standard deviations and coefficients of variation for egg characteristics in Japanese quail

Characteristics	Mean	Standard deviation	Coefficient of variation (%)
Egg weight (g)	9.22	0.68	7.3
Yolk weight (g)	2.85	0.27	9.6
Albumen weight (g)	5.63	0.44	7.8
Shell weight ¹⁾ (g)	0.74	0.07	9.2
Egg shape index (%)	79.05	2.56	3.2
Albumen height (mm)	3.78	0.40	10.7
Specific gravity	1.070	0.004	5.9
Shell thickness ¹⁾ (mm)	0.20	0.01	5.5
Shell strength (Kg/cm ²)	0.97	0.14	14.0
Yolk color	6.3	0.6	9.7

1) Including shell membrane

Table 2. Heritability estimates and standard errors for egg characteristics in Japanese quail

Characteristics	Heritability estimates			
	Sire component	Dam component	Sire ±	Dam
Egg weight	.28 ± .28 ²⁾	.96 ± .34	.62 ± .17	
Yolk weight	.55 ± .34	.82 ± .30	.68 ± .19	
Albumen weight	.40 ± .32	.93 ± .33	.66 ± .19	
Shell weight ¹⁾	.86 ± .44	.71 ± .27	.78 ± .23	
Egg shape index	1.17 ± .50	.36 ± .18	.77 ± .26	
Albumen height	.61 ± .38	.92 ± .32	.77 ± .21	
Specific gravity	1.11 ± .50	.57 ± .23	.84 ± .26	
Shell thickness ¹⁾	.96 ± .46	.62 ± .24	.79 ± .24	
Shell strength	.47 ± .30	.56 ± .25	.52 ± .16	
Yolk color	.53 ± .33	.68 ± .27	.61 ± .18	

1) Including shell membrane 2) Standard error

Table 3. Phenotypic and genetic correlations of egg characteristics in Japanese quail¹⁾

Characteristics	Egg weight	Yolk weight	Albumen weight	Shell weight	Shape index	Albumen height	Specific gravity	Shell thickness	Shell strength	Yolk color
Egg weight		.81*	.93*	.70*	-.07	.10	-.14*	.19**	.13*	.14**
Yolk weight	.73 ±.09 ³⁾		.56**	.44**	-.02	-.08	-.38**	.00	.02	.06
Albumen weight	.93 ±.03	.44 ±.16		.65**	-.08	.21**	-.05	.20**	.13*	.18**
Shell weight ²⁾	.70 ±.17	.19 ±.20	.73 ±.09		-.06	.06	.61**	.69**	.56**	.21**
Egg shape index	-.03 ±.21	.01 ±.22	.03 ±.21	.01 ±.22		.13*	-.03	.12*	.17**	-.01
Albumen height	-.04 ±.20	-.03 ±.19	.13 ±.20	-.01 ±.20	-.31 ±.19		.06	.10	.10	.19**
Specific gravity	-.06 ±.21	-.54 ±.15	.11 ±.20	.56 ±.15	.05 ±.23	.16 ±.21		.75**	.54**	.14*
Shell thickness ²⁾	.29 ±.19	-.17 ±.20	.41 ±.17	.81 ±.07	.28 ±.21	.35 ±.18	.77 ±.09		.59**	.18**
Shell strength	.35 ±.18	-.14 ±.21	.46 ±.15	.73 ±.10	.45 ±.18	.25 ±.20	.65 ±.13	.85 ±.06		.09
Yolk color	.36 ±.37	.08 ±.43	.37 ±.37	.53 ±.32	.03 ±.46	.15 ±.43	.41 ±.38	.55 ±.31	.42 ±.37	

1) Phenotypic correlation to right of diagonal : genetic correlation to left of diagonal

2) Including shell membrane 3) Standard error *P<0.05 **P<0.01

gravity and shell thickness showed high values (0.77 to 0.84). These results did not coincide with the estimates of 0.11 for egg shape index, 0.28 for specific gravity and 0.12 for shell thickness reported by Stino *et al* [13]. No reports concerning heritability of shell strength in Japanese quail were found in the literature, but for chickens, a value of 0.53 was reported by Torges [15]. The value obtained for shell strength, a high value, was close to that for chickens reported by Torges [15]. The heritability estimate for yolk color showed a high value (0.61) in comparison with that of 0.20 reported by Stino *et al* [13]. The heritability estimate reported by the same author [15] for yolk color was lower in chickens. We cannot suggest an explanation for this discrepancy.

Comparing the heritability estimates based on the sire component with that based on the dam component, shown in Table 2, the sire component estimate showed higher values for shell weight, egg shape index, specific gravity and shell thickness, while the dam component estimate showed higher values for egg weight, yolk weight, albumen weight, albumen height and shell strength. These findings, except for yolk weight, coincide with the results of Stino *et al* [13] for Japanese quail and with findings reported for chickens in the references cited here. Generally, it is said that the differences

between sire and dam component estimates may be attributable to sex-linked effects or maternal effects and/or non-additive genetic effects. Our results suggest that sex-linked effects and/or non-additive genetic effects appear in shell weight, egg shape index, specific gravity and shell thickness, while maternal effects and/or non-additive genetic effects are manifested in egg weight, yolk weight, albumen weight, albumen height, shell strength and yolk color.

Phenotypic and genetic correlations among egg characteristics are given in Table 3. Phenotypic and genetic correlations among egg weight, yolk weight, albumen weight and shell weight were high values, exceeding 0.44, with one exception of genetic correlation between shell weight and yolk weight. Kawahara and Kusaka [6] found phenotypic and genetic correlations of 0.30 to 0.98 among these egg characteristics. Mitsumoto and Shotake [11] also observed phenotypic correlations of 0.54 to 0.92 among the traits related to weight. In the present experiment, highly positive correlations, above, were observed among shell weight, specific gravity, shell thickness and shell strength. In particular, highly significant phenotypic correlation (0.75) was found between specific gravity and shell thickness. This is consistent with the findings of Mahmoud

and Coleman [9], who noted that there is a close association between specific gravity and shell thickness. The results of this experiment indicate that specific gravity is a good measure of shell thickness in quail.

Yannakopoulos and Tserveni-Gousi [18] found a close relationship between shell strength and egg shape. The results of our study did not suggest that close relationship. On the other hand, significantly negative correlation was found between yolk weight and specific gravity. This may be associated with the percentage of fat (35.5, 30.7) in the egg yolk [8, 17]. In this experiment then, diverse phenotypic and genetic correlations were observed among egg characteristics. This reflects the marked complexity of phenotypic and genetic interrelationships of egg characteristics.

Jones *et al* [5] reported that egg size and shape, and shell color pattern were valuable as criteria for identifying quail females. In view of this report and the present results, it may be possible to identify quail strain (female) by discriminant analysis of the egg characteristics examined in this study.

From these results, it is considered that individual selection should be most efficient method for improving egg characteristics and that for genetic improvement consideration should be given to the interrelationships of characteristics. It is also suggested that utilizing these egg characteristics makes it possible to perform identification and genetic monitoring of quail strains without killing any of the quail.

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ニホンウズラにおける卵形質の遺伝的パラメータについて

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本研究は、選抜育種および系統の同定、遺伝的モニタリングに関する基礎資料を得る目的で、ニホンウズラの卵形質の遺伝率と表型相関、遺伝相関について検討した。本研究では、323羽の雌から生産された3230個の卵を使用した。卵形質の測定は、卵重、卵黄重、卵白重、卵殻重、卵形係数、卵白高、卵比重、卵殻厚、卵殻強度、卵黄色について行った。その結果、卵形質の遺伝率

の値は高く、0.52から0.84の範囲の値を示した。表型相関、遺伝相関は卵形質間で種々の値がみられた。これらの結果から、個体選抜が卵形質の改良にもっとも有効な方法であり、卵形質の遺伝的改良を行うにあたってはそれらの相互関係を考慮すべきであることが示された。また、卵形質を利用してウズラ系統の同定、遺伝的モニタリングを個体を殺さないで行えることが示唆された。