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Original article

Estimation of genetic parameters of egg production and reproductive traits in Japanese quails

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A B S T R A C T

The present study was conducted to estimate genetic parameters of egg production and reproductive traits in Japanese quail. The response to selection for egg production after two generations of selection was also estimated. A total of five hundred and twenty six Japanese quails, made up of three hundred and ninety seven females and one hundred and twenty seven males were used to conduct the study. Egg number (EGN), Egg weight at 12 weeks of age (EWT12), Age at sexual maturity (ASM) and Body weight at 6 weeks of age (BWT6) averaged 46.04, 8.73gm, 39.73days and 163.28gm in generation 1 and the corresponding values for generation 2 are 45.36, 9.06gm, 39.86days and 163.70gm. Percent fertility (Fert %) and percent hatchability (Hatch%) were recorded as, 80.43% and 77.99% for the first generation and the corresponding values for the second generation were 82.05% and 67.14%. Heritability estimates of production traits ranged from low to high (0.05 - 0.96). Egg number (EGN) had a negative correlation with Age at sexual maturity (ASM) (-1.21) but positively correlated with Body weight (BWT) (0.14). Response to selection for egg number was 3.91. Egg number increased, highly significantly ($P<0.01$) from 36.55 at generation zero to 45.36 at the second generation of selection. In conclusion, selection in generation 0 based on egg number to 12 weeks of age improved the egg number and BWT6 in generation 2.

1. Introduction

Current trends indicate that 80% of the world's populations are living in the under-developed countries and a significant number of these have large food deficits. An increased production of animal protein would make an important contribution towards filling this deficit (FAO 1992).

Poultry production is a fast means of meeting the ever-increasing demand for protein supply, especially in Africa, where intake of protein is relatively low. This is because poultry production has a rapid turnover rate. In other words, several tons of meat and eggs can be produced in a relatively short interval of time. This prompted breeders to put more interest in the breeding of quail, the laying performance of which is relatively high. Over six months laying period, the total egg production in quails was ten times higher than female's body weight, whereas in chicken such a relation is reached only by the production gathered from 12 months (Richtrova, 1999).

The production of Japanese Quails has gained tremendous interest among Nigerian populace especially because of the medicinal value of the egg. Japanese quails are also known for their low caloric values in addition to having quality protein of high biological value (Haruna et al., 1997). Studies using Japanese Quails in breeding experiments have demonstrated that this species offers scientist several advantages in exploring breeding systems and certain applied problems of poultry breeding. Improvement through selection requires estimates of genetic parameters. This study was therefore designed to estimate the genetic parameters of egg production and reproductive traits in Japanese quail.

2. Materials and methods

2.1. Experimental site

The research was conducted at the Poultry Unit of the Animal Science Department, Ahmadu Bello University, Samaru – Zaria. Zaria is geographically located between latitude 11012'N and longitude 7033'E, at an altitude of 610m above sea level. (Google Earth, 2011)

2. 2. Source of birds and production of foundation stock

250 birds were bought from National Veterinary Research Institute Jos at two weeks of age. The birds were raised together until four weeks of age before they were sexed. They were made up of 130 males and 120 females. The females were then put in individual cages and tagged according to cage number. 40 sires were randomly selected to meet the mating ratio of 1:3. These formed the base population.

2.3. Mating procedure

The dams were placed in individual cages with one sire mated to three dams by introducing the sire into the cages, with the sire spending one night in each cage. The sires were placed such that half-sib or full sib mating was completely avoided.

2.4. Nutrition

The birds were fed with starter diets of 2741 Kcal/Kg ME and 26% CP, for the first five weeks of age and then breeder diets of 2990Kcal/Kg ME and 23% CP. (Dafwang, 2006). Water and feed were given ad libitum.

2.5. Egg collection and hatching

Fertile eggs were marked according to sire number over a seven-day period. The eggs were incubated for a period of 16 days, 14 days in the setter and 2 days in the hatcher. The setter and hatcher were equipped with separate boxes which were marked according to sire number in order to pedigree hatch the chicks for the first generation. The hatched chicks were brooded in separate boxes marked according to sire number, and then wing banded after 21 days.

2.6. Selection procedure

Selection of females was based on each hen's production plus the average of its full and half sibs, while males were selected based on the performance of their female sibs. The selection procedure was repeated to produce the second generation. Selection index constructed was based on the type developed by Henderson (1963).

In notational form, the indexes can be written thus:-

I♀= (P – $\bar{x}$) + b1 (D – $\bar{x}$) + b2 (S – $\bar{x}$)

I♂= b3 (D1– $\bar{x}$) + b4 (S1 – $\bar{x}$)

Where $\bar{x}$ = population mean for the trait

P = a female breeding candidate's own performance

D and D1 = average phenotypic values for the trait of full sisters of a female and male breeding candidate, respectively.

S and S1 = average phenotypic values for the traits of half sisters of a female and male breeding candidate, respectively.

b1, b2= regression coefficients of the trait on the index for females.

b3 and b4 = regression coefficients of the trait on the index for males.

$$b_1 = \frac{2n\left(1-h^2\right)}{4+(n-2)h^2}$$

$$b_2 = \frac{4nd\left(1-h^2\right)\left(2h^2\right)}{\left[4+(n-2)h^2\right]\left[4+n(d+1)-2h^2\right]}$$

$$b_3 = \frac{\left(nh^2\right)}{4+(n-2)h^2}$$

and

$$b_4 = \frac{2nd\left(1-h^2\right)\left(2h^2\right)}{\left[4+(n-2)h^2\right]\left[4+n(d+1)-2h^2\right]}$$

Where

d = the number of dams

n = the number of offspring per dam

h2 = the heritability estimate

2.7. Measurements

2.7.1. Body weight

Individual body weights were recorded biweekly from hatch until 6 weeks of age to the nearest 0.1 gm. Body weights at two, four and six weeks of age were recorded (BW2, BW4 and BW6).

2.7.2. Growth rate

Individual absolute body weight gain during the different studied growth periods from two to four and from four to six weeks of age were obtained according to (Brody, 1945) as follows:

$$G.R = \frac{W_2 - W_1}{\frac{1}{2}(W_2 + W_1)} \times 100$$

Where,
G.R = Growth Rate
W1 = the weight at the beginning of the period.
W2 = the weight at the end of the period

2.7.3. Egg production traits

Age at sexual maturity for females was individually recorded in days (ASM), total egg production (numbers and weights) were recorded from the onset of lay till 12 weeks of production. However daily egg mass was estimated as the average egg number multiplied by the average egg weight per week (DEM).

2.7.4. Reproductive traits

Individual fertility and hatchability of each female were recorded accordingly. The hatched eggs were recorded and the residual eggs in the hatcher were broken to determine the fertile eggs. Percent fertility and percent hatchability were calculated as follows.

$$\text{Percent Fertility} = \frac{\text{Total number of fertile eggs}}{\text{Total number of egg set}} \times 100$$

$$\text{Percent Hatchability} = \frac{\text{Total number of chicks hatched}}{\text{Total number of fertile eggs}} \times 100$$

2.8. Statistical analysis

2.8.1. Genetic parameter estimates

Genetic parameters were estimated using the sire model. The variance component was partitioned into those due to sire or environment. The statistical model used was:

yij = μ + ai + eij

Where yij = the record of the jth progeny of ith sire.

μ = the common mean

ai = the effect of the ith sire

eij = the uncontrolled environmental and genetic deviations attributable to the individuals. All error terms were random, normal and independent with expectation equal to zero.

2.8.2. Heritability

Heritability of egg production, serum alkaline phosphatase activity and economic traits were estimated using the formula

$$h^2 = \frac{4\sigma_s^2}{\sigma_T^2}$$

h^2 = heritability estimate

σ_S^2 = Variance due to sire

σ_T^2 = Total variance

2.8.3. Estimation of correlations

The coefficients of genetic correlation between different traits studied were computed from the sire component of variance as follows:

$$rg = \frac{4\operatorname{cov}_{s(xy)}}{\sqrt{4\sigma^2_{s(x)} . 4\sigma^2_{s(y)}}}$$

$$\text{S.E of rg} = \frac{1-\sigma^2_g}{\sqrt{2}} \sqrt{\frac{SEh^2_{(x)} x S.Eh^2_{(y)}}{h^2_{(x)} h^2_{(y)}}}$$

Estimating phenotypic correlation from sire component of variance

$$r_p = \frac{\operatorname{cov}_{w(xy)} + \operatorname{cov}_{s(xy)}}{\sqrt{\sigma^2_{w(x)} + \sigma^2_{s(x)} . \sigma^2_{w(y)} + \sigma^2_{s(y)}}}$$

3. Results and discussions

Table 1 shows the least squares means (±standard error) and coefficient of variation for growth traits for generation 1 and 2. Body weight at 2, 4 and 6 weeks was averaged 39 gm, 96.66 gm and 163.29 gm respectively after two generation of selection. This is similar to what was reported by Aboul-Hassan (2000) who reported estimates of body weight at 2 weeks as 35.2 gm. Higher estimates were reported by Aboul-Hassan (2001) as 46.4 gm for the Brown strain of Japanese quail and 40.2 gm for the White strain for body weight at two weeks of both sexes. On the contrary, Sharaf (1992) reported lower estimates for this trait which ranged between 27.07 and 28.54 gm.

For 4 weeks body weight, Sharaf (1992) reported estimates ranging between 94.46 gm and 100.45 gm. For 6 weeks body weight, El–Fiky (1991) reported an estimate of 128.1gm and 140.8 gm for males and females, respectively. Sharaf (1992) reported an estimate for this trait which ranged between 165.32 and 179.16 gm.

Body weight at 2, 4, and 6 weeks of age generally increased at the end of the first and second generation after selection, when compared to the base generation. However body weight for generation 1 was slightly higher than that of generation 2.

Table 2 shows the least square means of egg quality parameters of Japanese quails for generation 0, 1 and 2. The average EWT6, EWT8, EWT12, EGN, and DEM were found to be 8.72gm, 9.04gm, 8.95gm, 46.04, and 8.61gm/day respectively. These values are similar to what is found in literature. Abdul-Hasan (2004) reported EWT and DEM as 10.56gm and 9.18gm/day respectively.

Table 3 shows the heritability estimates with standard error of heritability for generation 1 and 2. Heritability estimate obtained for EGN (1.21), and ASM (1.63) were outside the parameter estimate. This could be due to low population size. This is similar to what was reported by Wilhelmson (1979) and El-Fiky et al. (1994) who both reported heritability estimates of 1.35 and 1.42 for ASM in Japanese quail. However, El-Fiky (1995) reported heritability of 0.75 for 70 days egg production, while other researchers reported lower heritablilty for EGN (Aboul Hassan, 2001, 0.13; Tawefeuk, 2001, 0.3; and Sitman et al.1966, 0.2). The heritability estimate for EWT12 (0.56) differs from the findings of Abdel-Mounsef (2005), Saatci et al (2006) and Abou Hassan (2001) who reported heritability of 0.12, 0.25, and 0.10 respectively. Estimates for other egg production traits were low.

Table 4 shows the estimates of genetic and phenotypic correlation for egg quality traits. The genotypic correlation estimates between EGN and SHT6 was negative (-1.36). However, the genotypic correlation estimates between EGN and other egg quality traits (HGU6, HGU12, YIN6, YLI12, and SHT12) ranged between – 1.35 and 1.09. The same trend was reported by Abdel-Mounsef (2005), who reported estimates which ranged between -1.03 and 1.18.

Phenotypic correlations between enzyme activity and egg quality traits ranged from low to moderate, and differs in magnitude and direction (-0.27 – 0.15). Phenotypic correlations between egg quality traits were low to moderate and varied in magnitude and direction (-0.95 – 0.57). Correlation between EWT and HGU6, SHT6 were low in magnitude. The phenotypic correlations were high and negative between EGN and ASM (-0.67) but relatively moderate between EWT12 and SHT12 (0.15). Other correlations obtained were low. The phenotypic correlation between BWT6and EWT12 was positive and lowin magnitude.Similar trend was reported by El- Fiky et al. (1994) and Abdel-Mounsef (2005).

Table 5 shows selection response for egg number and correlated response for some economic traits. There was a highly significant increase (P<0.01) in the egg number from 36.55 in generation zero to 45.36 at the second generation of selection. There was a slight decrease though in the EGN recorded, from 46.04 in generation 1, to 45.36 in generation 2. The same trend was reported by Aboul-Hassan (1997) and Aboul-Hassan (2001) when he selected Japanese quail for increased BWT6 and EGN produced for the first ten weeks of laying. As EGN increased generation wise, the C.V.% of this trait decreased from 24.72% at generation zero to 6.30% at the second generation, respectively. Other correlated responses were observed as a result of selection for egg number. Negative response (-1.84) was observed in ASM. This is so because the ASM reduced across the generation as EGN increased. Generally, positive response of varying magnitude was observed for EWT12 (0.05), BWT6 (0.72) and DEM (0.92). There was no significant increase (p>0.05) in EWT12 from generation 0, to generation 2. However DEM significantly increased from 162.09gm in generation 0 to 163gm in generation 2.

4. Conclusion

From the results obtained in this study, selection in generation 0 based on egg number to 12 weeks of age improved the egg number by 3.91, ASM by -1.84 days, EWT by 0.05gm, BWT6 by 0.72gm and DEM by 0.92gm after two generations of selection.

Table 1
Least squares means (± standard error) and coefficient of variation for growth traits of Japanese quails (Generation 1 and 2).

	Gen 1		Gen 2	
Traits*	**LSM ± SE**	**C.V (%)**	**LSM ± SE**	**C.V (%)**
BWT2	40.39 ± 0.20	6.27	40.06 ± 0.17	6.19
BWT4	97.17 ± 0.22	2.86	96.88 ± 0.19	2.93
BWT6	163.79± 0.44	3.43	163.00 ± 0.41	3.67
GR 4	80.96 ± 0.77	11.98	83.02± 0.41	7.15
GR 6	53.89 ± 0.82	19.22	50.83± 0.29	8.56

BWT2 =Body Weight at 2 weeks; BWT4= Body Weight at 4; BWT6= Body Weight at 6; GR4 = Growth rate at 4 weeks; GR6= Growth rate at 6 weeks.

EGW= Egg Weight; EGN= Egg Number; DEM= Daily egg mass. EGN=Egg number; EGW=Egg weight, SHT= Shell thickness; ALP20= Plasma alkaline phosphatase activity at 20 weeks; HGU= Haugh Unit; YIN= Yolk Index; ALH=Albumen height; ALD= Albumen width; EGD= Egg width; YLW=yolk weight

Table 2
Least square means (± standard error) of egg quality parameters of Japanese quail for generation 0, 1 and 2.

	Gen 0		Gen 1		Gen 2	
Traits	**LSM±SE**	**CV%**	**LSM±SE**	**CV%**	**LSM±SEM**	**CV%**
EGN	36.55±0.92b	24.72	46.04±0.29a	7.27	45.36±0.21a	6.29
EGW6	8.41±0.09b	10.80	9.16±0.07a	9.54	8.56±0.06b	10.07
EGW8	8.89±0.06b	6.37	9.15±0.04a	5.32	9.04±0.04a	5.97
EGW12	9.02±0.09	10.09	8.73±0.18	23.59	9.06±0.06	9.86
AGW	8.77±0.06b	6.68	9.02±0.07a	8.77	8.87±0.04a	6.22
EGH6	2.19±0.01	5.79	2.14±0.05	27.07	2.14±0.03	23.00
EGD6	1.89±0.05b	24.66	2.11±0.06a	35.70	2.04±0.05a	34.13
ALH6	0.11±0.00b	26.53	0.14±0.01a	93.50	0.13±0.01a	86.41
ALW6	4.04±0.06	15.14	4.02±0.05	14.47	3.98±0.04	16.49
YLH6	0.58±0.00b	10.37	2.16±0.51a	68.03	1.72±0.37a	89.06
YLW6	3.13±0.08	28.01	3.08±0.06	23.35	3.20±0.05	21.53
SHT6	22.22±0.51a	22.67	19.87±0.70b	39.67	20.59±0.53a	34.36
EGH12	2.69±0.01a	4.71	2.52±0.06b	28.60	2.57±0.04a	24.11
EGD12	2.037±0.05b	24.18	2.27±0.07a	37.44	2.20±0.05a	35.45
ALH12	0.11±0.00b	30.54	0.15±0.01a	99.36	0.14±0.01a	92.30
ALW12	4.55±0.06	14.24	4.50±0.05	14.77	4.47±0.05a	16.28
YLH12	0.63±0.00b	9.49	2.29±0.54a	64.79	1.82±0.39	84.69
YLW12	3.22±0.09	29.19	3.01±0.08	33.39	3.18±0.06	28.25
SHT12	23.25±0.52	22.09	23.88±0.15	7.48	23.78±0.19	10.64
DEM	6.43±0.17c	26.99	10.07±0.47a	52.89	8.75±0.06b	9.26
HGU6	57.58±1.84a	2.68	58.99±1.24b	1.98	59.95±1.03b	1.92
HGU12	58.98±1.75a	6.55	59.88±2.05b	5.37	59.11±1.45b	2.02
YIN6	1.53±0.00a	5.49	1.61±0.01a	6.86	0.61±0.01b	1.85
YIN12	0.12±0.01a	0.62	0.18±0.01a	0.15	0.20±0.01b	2.53

Means with different superscripts across the row are significantly different ($P < 0.05$)

Table 3
Heritability estimates (±standard error) of growth, production and egg quality traits for generations 1 and 2.

	Gen 1	Gen 2
Traits	**Heritability ±SE**	**Heritability±SE**
EGN	1.20±0.42	0.05±0.15
ASM	0.29±0.28	1.63±0.44
EGW12	1.25±0.42	0.56±0.29
HGU6	0.64±0.35	0.22±0.20
YIN6	0.90±0.39	0.42±0.26
SHT6	1.55±0.44	0.33±0.23
HGU12	1.14±0.41	0.42±0.27
YIN12	0.96±0.39	0.16±0.18
SHT12	0.58±0.34	0.20±0.19
BWT6	0.39±0.25	0.20±0.20

BWT6= Body Weight at 6; GR4 = Growth rate at 4 week; GR6= Growth rate at 6 weeks. EGGNO=Egg number; EGW=Egg weight, SHT= Shell thickness; ALP6= Plasma alkaline phosphatase activity at 6 weeks; ALP12= Plasma alkaline phosphatase activity at 12 weeks; HGU= Haugh Unit; YIN= Yolk Index.

Table 4
Genetic (above the diagonal) and phenotypic (below the diagonal) correlation for alkaline phosphatase activity and egg quality traits (Generation 2).

Traits+	EGW12	HGU6	YIN6	SHT6	HGU12	YIN12	SHT12
EGW12		-0.65	0.30	-0.24	-0.77	0.49	1.22
HGU6	-0.29		0.72	-0.51	1.07	0.32	-1.32
YIN6	0.07	0.53		-0.89	0.35	0.58	-0.02
SHT6	-0.02	-0.45	-0.61		-0.38	-0.55	0.28
HGU12	-0.72	0.63	0.58	-0.42		-0.36	-1.12
YIN12	0.09	0.09	0.54	-0.22	0.17		-0.38
SHT12	0.15	-0.19	-0.09	0.38	-0.18	0.05	

ALP6= Plasma alkaline phosphatase activity at 6 weeks; ALP12= Plasma alkaline phosphatase activity at 12 weeks; EGW=Egg weight, SHT= Shell thickness; HGU= Haugh Unit; YIN= Yolk Index

Table 5
Selection response for egg number and correlated response for some economic traits.

Traits				Response		Cumulative Response (±SE)
	G0	G1	G2	G1	G2	
EGN	36.55	46.04	45.36	9.49	-0.68	3.91±0.35
ASM	43.97	39.73	39.86	-4.24	0.13	-1.84±0.17
EGW12	9.02	8.73	9.06	-0.29	0.33	0.05±0.08
SHT12	23.25	23.88	23.78	0.63	-0.1	-0.15±0.11
BWT6	162.09	163.30	163.02	1.21	-0.28	0.72±0.36
DEM	6.43	10.07	8.75	3.64	-1.34	0.92±0.21

EGGNO = Egg number, ASM= Age at sexual maturity, EGGWT12= Egg weight at 12 weeks of age, ST12= Shell thickness at 12 weeks of age, BW6 = Body weight at 6 weeks of age, DEM = Daily egg mass.

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