Genetic analysis of body weights of Japanese quails (*Coturnix japonica*) in a semi-arid area of Nigeria

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Abstract

Production and management of Japanese quail is relatively new in Nigeria but the birds have been attracting national attention in the recent times. This study on Japanese quail was conducted to estimate genetic parameters of egg production traits of Japanese quails in a semi-arid area of Nigeria. In a study that lasted for 40 weeks, 40 sires and 120 dams that produced 1267 progenies (743 females and 524) in three batches were used. The mixed model least squares and maximum likelihood programme of Harvey was used to estimate heritability, genetic, phenotypic and environmental correlations for body weights of Japanese quails from 0 – 40 weeks of age. Heritability estimates from sire, dam and, sire plus dam variance components from 0 to 36 weeks were low to moderate ranging from 0.071 to 0.569. Genetic correlations between body weights at the different ages were positive but varied widely from low (0.02) to high (0.977). However, the genetic relationships between body weights from hatch to 8 weeks were high (0.921 to 0.992). This may suggest that selection for final body weight may be based on early weight records. The phenotypic and environmental correlations were generally high, positive and ranged from 0.572 to 0.995 and 0.776 to 0.999, respectively. Though, the magnitude of genetic and phenotypic correlations of body weights decreased with increase in age of Japanese quails. Thus, rapid progress in selection for improvement of body weight of the Japanese quail may be

Keywords: Heritability, genetic, phenotypic, environmental, correlations

Introduction

The Japanese quail is relatively unknown in Nigeria, and was introduced in 1984 for multiplication and commercial farming which started in the early 1990s, and has since been on the increase (NVRI, 1996). Quail is a collective name for several genera of midsized birds in the pheasant family *Phasianidae*, native to Asia and Europe and has been farmed since ancient times especially in the Far East (NRC, 1994). Many of the domesticated strains seem to have originated in China and migrating Chinese carried them throughout Asia. Today, the Japanese quails are widely distributed in Asia and Europe. Diversification into production of livestock with short generation interval has been proposed as a veritable tool in ameliorating

the shortage of protein among the populace in developing countries (NVRI, 1996). In poultry breeding, quails are as important as chickens for both meat and eggs leading to commercial quail breeding becoming widespread (Altinel *et al.*, 1996). Quail farming is generating considerable interest in many parts of the world as it provides low energy/high protein meat of immense biological value and offers an excellent opportunity for poultry farmers to enter a new and profitable poultry business. In addition to its lean meat, the egg is lower in cholesterol as compared to chicken (Musa *et al.*, 2008). They are, particularly, important for egg production in Japan and South East Asia and meat production in Europe (Minvielle, 1998). Japanese quails are the smallest avian species farmed for

meat and egg production and have the potential to serve as an excellent and cheap source of animal protein for Nigerians. They are considered a good and economical source of animal protein because of their small body size, early sexual maturity, high rate of production (290 - 300 eggs/year), short generation time, low maintenance cost and high resistance to common poultry diseases (Hassan *et al.*, 2003). Heritability is variable and refers to a particular population under a set of environmental conditions. Therefore, variations between heritability estimates for a particular trait should be considered the norm rather than exception (Falconer, 1996). Though estimates of genetic parameters of Japanese quail abound, there is a dearth of such information in the semi-arid area of Nigeria. Thus, the aim of this study was to estimate heritability, genetic, phenotypic and environmental correlations for body weights at different ages of the Japanese quail in Nigeria.

Materials and methods

The study was carried out at the Poultry Unit of the University of Maiduguri Livestock Teaching and Research Farm, Maiduguri, Borno State, Nigeria. Maiduguri, the Borno State capital is situated on latitude 11°5' N, longitude 13°09' E and at an altitude of 354 m above sea level. The area falls within the Sahelian region of West Africa, which is noted for great climatic and seasonal variations. It has very short period (3 – 4 months) of rainfall of 645.9 mm/annum with a long dry season of about 8 – 9 months. The ambient temperature could be as low as 20°C during the dry cold season and as high as 44°C during the dry hot season. Relative humidity is 45% in August which usually lowers to about 5% in December and January. Day length varies from 11 to 12

hours.

One hundred and sixty birds were housed in cages at a male to female ratio of 1:3 for genetic parameter estimations. Eggs were collected from individual hens, stored in quail crates before setting in the incubator. At hatch, the chicks were marked individually before batch brooding. A total of 1,267 chicks (743 females and 524 males) from three batches were transferred into cages at three weeks to ease identification and management and, body weights at different ages (0 – 40 weeks). Heritability, genetic, phenotypic and environmental correlations of body weight traits were estimated using the mixed model least-squares and maximum likelihood computer programme described (Harvey, 1990). The full sib model (Becker, 1992) was used to fit the data.

$Y_{ijk} = \mu + S_i + D_j + e_{ijk}$

Y_{ijk} = Observation on the k th progeny of the j th dam mated to the i th sire.

μ = Overall mean (constant)

S_i = Random effect of the i th sire ($i=1,2,\dots,40$)

D_j = Random effect of the j th dam ($j=1,2,\dots,120$)

e_{ijk} = Random residual error.

The Harvey programme computes estimates of genetic, phenotypic and environmental correlations as well as heritability estimates from sire, dam and sire plus dam variance components.

Heritability of parameters recorded was estimated from sire, dam and, sire plus dam variance components according to Becker (1992) as follows:

Sire variance component:

$$h_S^2 = \frac{4\sigma_S^2}{\sigma_S^2 + \sigma_D^2 + \sigma_E^2}$$

Dam variance component

$$h_D^2 = \frac{4\sigma_D^2}{\sigma_S^2 + \sigma_D^2 + \sigma_E^2}$$

Sire plus dam variance components:

$$h_{S+D}^2 = \frac{2(\sigma_S^2 + \sigma_D^2)}{\sigma_S^2 + \sigma_D^2 + \sigma_E^2}$$

Where: h^2 = heritability
 σ_S^2 = Sire variance component
 σ_D^2 = Dam variance component
 σ_E^2 = Error variance component

Phenotypic correlations

$$\Gamma_P = \frac{\sigma_{P_{xy}}}{\sigma_{P_{xx}} \cdot \sigma_{P_{yy}}} \text{ Where } \Gamma_P = \text{Phenotypic correlation}$$

Environmental correlations

$$\Gamma_E = \frac{\sigma_{E_{xy}} - 2\sigma_{E_{xx}}\sigma_{E_{yy}}}{\sigma_{E_{xx}} - 2\sigma_{E_{xx}}\sigma_{E_{yy}} \cdot \sigma_{E_{yy}} - 2\sigma_{E_{xx}}\sigma_{E_{yy}}}$$

Where Γ_E = Environmental correlation

Results and discussion

Heritability estimates of body weight at different ages are presented in Table 1. Heritability estimates from sire, dam and, sire plus dam components from 0 to 36 weeks were low to moderate ranging from 0.071 to 0.569. However, heritability for body weights, from 2 to 8 weeks from dam components was inestimable. The highest heritability estimate was 0.569 at 24 weeks

of age and the least 0.071 was at one week. There was a general increase in heritability estimates with age especially at the earlier ages across the three methods of estimation. The estimates at older ages were generally low. Heritability estimates from sire component of variance were higher than those from dam and sire plus dam components with the latter being intermediate. Estimates from sire component are the most reliable because it contains variance due to additive gene effects (Cameron, 1997). Generally, there was an increasing trend in heritability estimates from the sire variance component from 0 to 3 weeks. This could be due to reducing environmental effect as the birds grew older. Between 4 and 12 weeks of age, heritability estimates were moderate and did not vary considerably; indicating that these traits were affected more by the genetic makeup of the birds than the environment.

Table 1: Heritability and standard errors of body weights of Japanese quail at different ages

Age (Weeks)	Heritability (h^2_s)	Heritability (h^2_D)	Heritability (h^2_{S+D})
0	0.255 ± 0.03	0.096 ± 0.298	0.176 ± 0.15
1	0.379 ± 0.03	0.071 ± 0.295	0.225 ± 0.16
2	0.399 ± 0.03	-	0.200 ± 0.16
3	0.413 ± 0.03	-	0.206 ± 0.16
4	0.448 ± 0.03	-	0.224 ± 0.16
5	0.429 ± 0.03	-	0.214 ± 0.16
6	0.425 ± 0.03	-	0.212 ± 0.16
7	0.425 ± 0.03	-	0.212 ± 0.16
8	0.422 ± 0.03	-	0.211 ± 0.16
12	0.441 ± 0.03	0.075 ± 0.295	0.258 ± 0.17
16	0.433 ± 0.02	0.174 ± 0.309	0.303 ± 0.18
20	0.318 ± 0.02	0.565 ± 0.354	0.441 ± 0.20
24	0.387 ± 0.03	0.569 ± 0.355	0.478 ± 0.20
28	0.253 ± 0.02	0.103 ± 0.299	0.128 ± 0.15
32	0.383 ± 0.03	0.185 ± 0.311	0.284 ± 0.17
36	0.120 ± 0.02	0.189 ± 0.311	0.155 ± 0.15

- inestimable

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Individual selection for body weight is therefore more appropriate during the middle ages in quails. The declining trend in heritability estimates from 16 to 36 weeks of age could be due to increasing environmental influence on the traits. Low heritability estimates indicate that environmental factors such as feed, management and temperature have more effect on these traits than the additive genetic makeup. Sezer *et al.* (2006) reported that heritability of weekly body weight ranged from 0.20 to 0.60. Similar wide range of heritability estimates has been reported for body weights of Japanese quail at different ages by various authors (Minvielle, 1998; Aboul Hassan, 2001; Abdel Mounsef, 2005; Abdel-Fattah, 2006). These studies used different methods to estimate heritability. Since heritability is variable and refers to a particular population under a set of environmental conditions, it is expected to differ. Therefore, variations between heritability estimates for a particular trait should be considered the norm rather than exception. Falconer (Falconer, 1996) reported that heritability for a particular trait can take different values according to the population, the environmental condition surrounding the animal and the calculation method.

The heritability estimates of liveweight at hatch (0.255, 0.096 and 0.176) obtained from sire, dam and, sire plus dam components of variance reported in this study were lower than corresponding values of 0.49, 1.27 and 0.88 and, 0.67, 0.62 and 0.65 reported by El-Fiky *et al.* (1994) and Abdel-Fattah (2006), respectively. However, they were higher than 0.12 reported by Sefton and Siegel (1974) but similar to 0.28, 0.22 and 0.28 reported by Aboul Hassan (2001); Saatci *et al.* (2003) and Abdel Mounsef (2005), respectively from sire variance component. The

heritability estimate (0.379) for body weight at one week of age obtained from sire component is similar to 0.35, 0.32 and 0.39 reported by Resende *et al.* (2005), Saatci *et al.* (2003) and Sezer (2007). The estimates, 0.399 and 0.20 of body weight at 2 weeks of age obtained from sire and, sire plus dam components are similar to those reported by Minvielle (1998), Aboul Hassan (2001) and Abdel Mounsef (2005). They are however higher than 0.14 and 0.20 reported by Abdel-Fattah (2006) and Saatci *et al.* (2003). Three week heritability estimate (0.413) from sire component is similar to 0.43 and 0.38 reported by Resende *et al.* (2005) and Sezer (2007) but higher than 0.21 reported by Saatci *et al.* (2003).

The estimates (0.448 and 0.224) of body weight at four weeks of age from sire and, sire plus dam components are similar to those reported by Minvielle (1998), Aboul Hassan (2001) and Abdel Mounsef (2005). They are however higher than 0.20 and 0.10 reported by Saatci *et al.* (2003) and Abdel-Fattah (2006). Week 5 estimate (0.429) from sire component is similar to 0.50 reported by Sezer (2007) but higher than 0.15 reported by Saatci *et al.* (2003).

The heritability estimate (0.425 and 0.212) at six weeks of age, from sire and, sire plus dam components are similar to those reported by Tawefeuk (1995) and Aboul Hassan (2001) but higher than 0.13 and 0.25 reported by Shebl *et al.* (1996) and Abdel Mounsef (2005). The heritability estimate (0.441) at 12 weeks of age obtained from sire component is lower than the 0.56 reported by Baumgartner (1994). Similarly, estimates (0.378 and 0.253) at 24 and 28 weeks from sire components were lower than the 0.693 reported by Kawahara and Saito (1976) using the same method of estimation. Generally, heritability estimates tend to be lower at older ages. In

this study, heritability estimates increased with age up to week four before declining for the sire component. Reported trend for heritability of body weight with age varied widely. While Saatci *et al.* (2003) reported a decrease with age, an increase was observed by Resende *et al.* (2005). On the other hand, Sefton and Siegel (1974) and Aggrey and Cheng (1994) did not notice any trend.

Generally, the traits had moderate heritability indicating that body weight of Japanese quails could be increased by direct selection for high body weight. The relatively higher heritability estimated for week four (0.448) from sire component indicates that selection for live weight at that age might be more effective than earlier or later ages.

Genetic correlations among body weights of Japanese quail at different ages are presented in Table 2. Generally, genetic correlations between body weights at different ages were positive but varied widely from low to high (0.02 to 0.977). The magnitude of correlation coefficients decreased with increasing age. In addition, it was observed that the closer the ages, the higher the correlations, because weights at 0-16 weeks were poorly correlated with 28-40 weeks body weights, though they were strongly correlated with each other and 20 and 24 weeks weights. The correlations between successive ages were also high.

The genetic relationships between body weights from hatch to 8 weeks of age obtained in this study were high and ranged from 0.921 to 0.992. These values are higher than 0.50, 0.40 and 0.48 reported by Sefton and Siegel (1974) and, 0.46, 0.34 and 0.61 by Abdel-Fattah (2006) as genetic correlations between body weight at hatch and weeks 2, 4 and 6, respectively. The genetic correlations between body weights at weeks 1 and 2, 3, 4, 5, 6, 7 and 8 were 0.981, 0.984, 0.992, 0.979, 0.977,

0.973 and 0.970, respectively. These values were similar to the report by Tawefeuk (1995) who established that genetic correlations between body weights at these ages to be positive, high and ranged between 0.73 and 1.01 while Shebl *et al.* (1996) reported estimates between - 0.23 and 1.00 for body weights at hatch and 4 weeks of age. Resende *et al.* (2005) also reported high genetic correlations between, not only successive but also early and late weighing. They suggested that selection for final weight may be based on early weight records. This corroborates the findings of Aggrey and Cheng (1994) and Saatci *et al.* (2003) who also reported strong genetic correlations among weekly weights and suggested that selection for later weights could be based on weights recorded earlier. Low genetic correlations between weights at earlier ages and weeks 12 and 40 observed in this study might imply that much progress will not be made in selection for improvement in body weights at these ages when based on weights at early ages.

Phenotypic correlation among body weights at different ages in the Japanese quail are presented in Table 3. The correlations were generally high, positive and ranged from 0.572 to 0.995. The highest correlation value, (0.995) was between body weight at weeks 3 and 4, 3 and 5, 4 and 5, 4 and 7 and 4 and 8 while the lowest (0.572) was between hatch and week 40. Phenotypic correlations of body weights decreased with increase in age of Japanese quails. It was also observed that the narrower the interval between ages, the higher the correlations. Weight at 40 weeks had the lowest correlation with weeks 0, 1, 2, 3, 4, 5, 6, 7, 8, and 12, though they were strongly correlated with each other. The correlation between successive ages was also high, indicating that selection for improvement in body weight at one age will

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lead to improvement in weight at other ages. Similarly, Vali *et al.* (2005) reported high and positive correlations between body weights ranging from 0.547 to 0.890. The phenotypic correlation values reported in this study were similar to those of Mark (1984) and Saatci *et al.* (2003) but higher than those reported by Sefton and Siegel (1974) and Aboul-Seoud (2008). Sefton and Siegel (1974) reported phenotypic correlations between body weights at hatch and weeks 2, 4 and 6 as 0.23, 0.24 and 0.25. Mark (1984) reported that phenotypic correlations between two and four weeks body weight for 7 generations of Japanese quail ranged from 0.91 to 0.98. Saatci *et al.* (2003) also reported that the highest

phenotypic correlation (0.85) was between weeks 4 and 5 weights as is the case in this study.

Environmental correlation coefficients between body weights of Japanese quails at different ages are presented on Table 4. Environmental correlation coefficients were generally high and positive. They ranged from 0.776 to 0.999. Vali *et al.* (2005) reported that environmental correlations among body weights of Japanese quail ranged from 0.42 to 0.87. They concluded that high and positive environmental correlations among body weights at different ages indicated that body weight can be further improved by providing good (management) environment.

Table 2: Genetic correlations among body weights at different ages (weeks) of the Japanese quail

Age (Weeks)	0	1	2	3	4	5	6	7	8	12	24	28	32	36
1	0.958													
2	0.921	0.981												
3	0.948	0.984	0.957											
4	0.949	0.992	0.967	0.968										
5	0.935	0.979	0.955	0.956	0.965									
6	0.935	0.977	0.953	0.953	0.962	0.951								
7	0.932	0.973	0.946	0.948	0.958	0.946	0.943							
8	0.929	0.97	0.944	0.946	0.955	0.943	0.940	0.937						
12	0.314	0.065	0.080	0.078	0.039	0.050	0.049	0.049	0.059					
24	0.266	0.458	0.516	0.481	0.497	0.497	0.505	0.487	0.490	0.514				
28	0.060	0.260	0.295	0.301	0.316	0.305	0.308	0.295	0.292	0.296	0.956			
32	0.074	0.354	0.398	0.397	0.399	0.400	0.401	0.382	0.384	0.313	0.692	0.764		
36	0.451	0.080	0.030	0.040	0.020	0.030	0.010	0.020	0.017	0.100	0.744	0.602	0.817	
40	0.274	0.022	0.020	0.050	0.030	0.020	0.050	0.060	0.060	0.030	0.429	0.519	0.737	0.821

Table 3 : Phenotypic correlations among body weights at different ages (weeks) of the Japanese quail

Age (Weeks)	0	1	2	3	4	5	6	7	8	12	24	28	32	36
1	0.943													
2	0.936	0.989												
3	0.938	0.988	0.994											
4	0.940	0.990	0.995	0.995										
5	0.940	0.989	0.994	0.995	0.995									
6	0.938	0.988	0.994	0.994	0.995	0.994								
7	0.936	0.988	0.993	0.994	0.995	0.994	0.994							
8	0.937	0.988	0.993	0.994	0.995	0.994	0.993	0.993						
12	0.683	0.708	0.722	0.722	0.720	0.724	0.723	0.720	0.721					
24	0.703	0.737	0.757	0.749	0.754	0.754	0.754	0.751	0.751	0.719				
28	0.715	0.746	0.751	0.749	0.748	0.750	0.751	0.747	0.748	0.737	0.897			
32	0.723	0.772	0.771	0.766	0.767	0.769	0.770	0.765	0.767	0.664	0.825	0.894		
36	0.657	0.690	0.692	0.690	0.688	0.690	0.691	0.689	0.689	0.660	0.827	0.905	0.911	
40	0.572	0.592	0.595	0.592	0.590	0.593	0.594	0.591	0.591	0.552	0.766	0.817	0.864	0.882

Table 4: Environmental correlations among body weights at different ages (weeks) of the Japanese quails

Age (Weeks)	0	1	2	3	4	5	6	7	8	20	24	32
1	0.941											
2	0.940	0.992										
3	0.937	0.990	0.999									
4	0.940	0.989	0.999	0.999								
5	0.943	0.992	0.999	0.999	0.999							
6	0.940	0.992	0.999	0.999	0.999	0.999						
7	0.939	0.993	0.999	0.999	0.999	0.999	0.999					
8	0.940	0.993	0.999	0.999	0.999	0.999	0.999	0.999				
20	0.950	0.939	0.937	0.941	0.939	0.940	0.938	0.939	0.938			
24	0.955	0.923	0.925	0.930	0.930	0.929	0.926	0.929	0.928	0.947		
32	0.919	0.916	0.894	0.889	0.894	0.894	0.894	0.894	0.895	0.897	0.933	
40	0.871	0.840	0.822	0.820	0.829	0.827	0.825	0.825	0.825	0.907	0.999	0.925

Conclusion

The study showed that body weight of Japanese quails can generally increase by direct selection for high body weight, though selection for live weight might be more effective at four weeks of age than earlier or later ages. In addition, body weights at different ages can be further improved by providing good management as a result of high environmental correlations among them.

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