



Genetic Relationship Between External and Internal Egg Quality Traits of Japanese Quails

A. O. Abdulraheem¹, J. O. Aremu², A. Mohammed³, H. Allamin¹, H. Abdulazez¹, M. M. Shettima³, J. Aliyu¹ and A. O. Raji¹

¹Department of Animal Science, Faculty of Agriculture, University of Maiduguri, Maiduguri, Borno State, Nigeria

²Department of Animal Production, Kwara State University, Malete, 1530, Kwara State, Nigeria

³Department of Animal Science, Faculty of Agriculture, Borno State University, Borno State, Nigeria.

*yekeeno@yahoo.com 08064001509

Abstract

This work investigated genetic relationships between external and internal egg quality characteristic of Japanese quails reared at Livestock Teaching and Research Farm, Department of Animal Science, University of Maiduguri. Borno state. A total of 440 eggs produced by 110 quail hens, were used for egg quality traits analysis. Quails were grouped into young-laying (10 weeks old) and old-laying (20 weeks old). Variance and covariance components and genetic correlations were estimated using Restricted Maximum Likelihood (REML) procedures. The genetic correlations for egg quality traits of young- and old-laying were low to high (0.05 to 0.97, -0.01 to -0.74; 0.01 to 0.98, -0.02 to -0.83). The highest positive estimate (0.97) was recorded for yolk height and shell weight and least 0.05 between egg shape index and albumen length. Negative co-efficient was highest (-0.74) between albumen weight and shell ratio in young-laying group, indicating that shell ratio would have antagonistic effect on improvement of albumen weight. For old-laying quails, positive correlation was highest (0.98) for egg and albumen weight, implying that, heavy eggs would have large albumen. Highest negative correlation (-0.83) observed between shell and albumen ratio indicates that eggs with large albumen laid by old quail would possess delicate shell quality. Egg weight of young-laying group had positive correlations with all internal qualities except Haugh unit (-0.11) and albumen index (-0.40); and except Haugh unit (-0.09) and yolk index (-0.20) in old-laying. These findings suggest that egg weight can be used to improve internal egg qualities in laying quails.

Key words: Japanese quail, egg quality, young-laying, old-laying

Introduction

Quail belongs to the family *Phasianidae*, a family that also comprises pheasant. These birds were earlier identified as migratory in continents such as Africa, Asia and Europe (Adio *et al.*, 2019). Among the inbred subspecies is the Japanese quail, *Coturnix coturnix japonica* (Shin, 2004). They were so called perhaps for the reason that the birds were first discovered in Japan (Nasrollah, 2008). Quails are as important as domestic fowls in the production of meat and eggs. Quails lay up to 300 eggs in a year though the performance is tied to the quality of feed and

management provided (Abdulraheem *et al.*, 2024).

The primary goal of any breeding scheme in farm animal is improvement of economic traits in farm animal species (Odubote, 1996). The tool applied by breeder to accomplish this endeavour is the use of genetic parameters. Among its other key importance in animal production are ability to give a prediction of present and future performance of an animal as well as transmitting ability of its potentials to its offspring with reliability (Abdulraheem *et al.*, 2022). This largely rests on the magnitude of genetic variances and genetic parameter estimates. It is the scale of genetic

parameters that would demonstrate the degree of improvement that could be made when selection is conducted (Aliyu *et al.*, 2024). In other words, these are based on accurate estimates of variance components and genetic parameters such as heritability, repeatability and correlations.

Farm animals express numerous characters which could either be qualitative or quantitative (economic traits). Egg is recognized as an economical animal protein source. Its characteristics are determined by its external and internal qualities which are mostly inter-correlated (Abdulraheem *et al.*, 2021). In other words, they are associated in one manner or the other. The importance of estimating correlation analysis is to measure the extent of association or relationship between one trait and the other (Ikpeme *et al.*, 2016). Traits related to both external and internal qualities of eggs have significant effects on hatchability and development of chicks (Skewes *et al.*, 1988). They also influence subsequent growth and reproductive performance of the birds (Altinel *et al.*, 1996). Although, the internal and external quality traits of eggs of domestic fowls as well as correlations between these traits have been exhaustively studied, estimates of genetic and phenotypic correlations for egg quality traits in other Galliformes such as quail are sparse as attentions are focused on chicken eggs especially in the northeastern part of Nigeria. This work therefore was to investigate the genetic relationships between external and internal egg quality traits of young and old-laying Japanese quails reared in Maiduguri, Borno state, Nigeria.

Materials and Methods

The research was conducted at the Poultry Unit of University of Maiduguri Livestock Teaching and Research Farm, Maiduguri, Borno state. Maiduguri, the Borno state capital is located on Latitude 11° 5', and Longitude 13° 09' E (Encarta, 2007) and on altitude 354 m above sea level in the Northeastern Nigeria.

Based on the atmospheric condition of the area, the seasons are usually divided into three: dry hot (February to May), dry cold (October to January) and wet (June to September), and the vegetation zone is Sahelian type. The dry season lasts for eight to nine months with the hottest period occurring between March and June when the ambient temperatures are in the range of 35° – 40° C. The relative humidity ranges from 45 – 50% (Kellou, 2005) with a minimum in February and March when it drops to as low as 10%. The annual rainfall ranges from 150 – 600 mm (Alaku, 1983).

Experimental Birds and Management

Eighty Japanese quail chicks of wild-type strain (20 males and 60 females) of four weeks old were purchased from the National Veterinary Research Institute Farm in Vom, Plateau state, Nigeria which served as the base population. A total of 300 eggs were collected from the base population and set for hatching in a forced air incubator (1510 Sportsman Cabinet incubator GQF Manufacturing Company, USA). Eggs from the resulting progeny were used for the egg quality trait analysis.

Quail chicks were raised in quail brooder till four weeks of age. Sexing was done at three weeks of age as the females can be distinguished from the males by their characteristic light feathers with black speckling on the throat and upper breast (Randal and Bolla, 2008). Birds were randomly placed in cages in a mating ratio of 1:3 in a wire mesh cage measuring 40 x 30 x 30 cm. The birds were allowed free access to feed. The quail were given quail diet containing 25% CP and 3000 Kcal ME/Kg in the first six weeks period and later reduced to 24% CP and 2750 Kcal ME/kg. water was supplied *ad libitum* Constant sanitation of the pen including the feeder was carried out. Notwithstanding their hardy nature, antibiotics were given at regular intervals as

described by the manufacturer for preventive measure against poultry diseases. The research lasted for ten months.

Data collection

A total of 440 eggs were collected from 110 quail hens from the offspring of the base population at 80% hen day egg production. Eggs at weeks 10 and 20 of age and were used for quality traits analyses.

The egg weight was taken using a 0.01 g sensitive electronic scale. Egg height and width were measured using a vernier calipers. Thereafter, the internal components of egg were obtained by carefully breaking the egg around the narrow end and the components were received on a table with glass cover. The measurements of yolk height, yolk diameter, albumen length, width and height were taken using a vernier calipers. After these measurements, the yolk was carefully separated from the albumen by punching the albumen then the yolk weight was measured with the scale.

The egg shell (after removing the internal component) was carefully washed to remove the remnant of albumen and thereafter was air-dried for 24 hours. This was then weighed using the electronic scale (0.01 g sensitive). Samples taken from sharp, blunt and equatorial parts were measured using 0.01 mm sensitive micrometer screw gauge and the average was obtained from the values of the three parts.

For the computed traits, the following formulae were adopted according to Kul and Seker (2004):

$$\text{Surface area} = 3.9782 W^{0.75056}$$

Where W=egg weight (g);

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

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

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

Albumen index (%) = albumen height (mm)/ (albumen length (mm)+ albumen width(mm)/2 x 100)

Albumen ratio (%) = albumen weight (g) / egg weight (g) x 100

Yolk index (%) = yolk height (cm)/yolk diameter (cm) x 100

Yolk ratio (%) = (yolk weight (g) / egg weight (g)) x 100

Albumen weight (g) = egg weight – (yolk weight + shell weight)

Haugh unit (%) = $100 \log (H + 7.57 - 1.7W^{0.37})$

Where H = albumen height (mm), W= egg weight (g)

Data analysis

Variance and covariance components and genetic parameters were estimated using Restricted Maximum Likelihood (REML) procedures software (Harvey, 1990).

Genetic correlations

Genetic correlations of the external and internal egg quality traits were estimated from variance and covariance components using the following formulae of Becker (1985):

$$r_{g(s)} = \frac{\text{COV}_s}{\sqrt{\sigma^2_{s(x)}} \sqrt{\sigma^2_{s(y)}}}$$

Where r_g = genetic correlation

cov = covariance component

σ_x = variance component of x trait

σ_y = variance component of y trait

Results and Discussion

Genetic correlations between external and internal egg quality characteristics

Genetic correlations between external and internal egg quality traits of young and old-laying Japanese quails are shown in Tables 1 and 2. The positive and negative correlations

(Table 1) fell within low and high range (0.05 to 0.97; -0.01 to -0.74). This low to high positive range is in line with the range (0.02 to 0.94) reported by Abdulraheem *et al.* (2024) but the authors observed a lesser negative range (-0.03 to -0.16) in Japanese quail. The highest positive estimate was recorded between yolk height and shell weight while the lowest was obtained for albumen length and egg shape index. On the other hand, negative co-efficient was highest between albumen weight and shell ratio while the least estimated value was found between yolk diameter and shell ration.

For the old-laying quails, positive correlation was highest (0.98) between egg and albumen weights, the lowest (0.01) of this was recorded for egg height and albumen index. This implies that, heavy eggs would have large albumen component. Highest (-0.83) negative correlation was observed between shell and albumen ratio. This indicates the age at which improvement of albumen component would experience highest antagonistic effect by percent shell. It is also an indication that eggs with large albumen would have poor shell proportion. Its lowest (-0.02) value was found for shell and albumen weight. The highest positive relationships between traits indicate that one trait would be the best to improve the other when the traits are subjected to selection while the least correlation suggests least improvement between the two traits when selection is made. On the other hand, the negative correlations mean that genes controlling the correlated traits act in opposite directions. In other words, this effect will be greatly felt where the negative relationship is highest.

There were negative genetic correlations between shell ratio and albumen qualities except for Haugh unit in young-laying birds. However, the trait (shell ratio) had positive correlations with yolk qualities apart from yolk weight and diameter in young-laying

hens while the correlation was only negative with yolk diameter in the old-laying birds. Similarly, shell weight had negative genetic correlations with albumen ratio. This means that egg selected for some albumen qualities may lack good shell quality. The result however also pointed out that if some yolk traits are included in such a selection, the shell quality would get better.

With exception of Haugh unit (-0.11) and albumen index (-0.40) with negative co-efficients, egg weight had positive correlations with all the internal qualities. In other words, Haugh unit correlated negatively with most external traits (except egg height, ESA and SWUS) in young-laying birds. This result is in line with the findings of Yahya *et al.* (2023) and Nano (2024) who observed positive correlations with internal egg qualities except Haugh unit and albumen width in chickens. On the other hand, egg weight expressed positive correlations with internal traits except yolk index and Haugh unit while Haugh unit had positive relationships with external traits except egg height (-0.33) in the old-laying group. These findings suggest that egg weight can be used to improve the internal quality traits in both the young and old-laying quails. By implication, with improved egg weight, both yolk and albumen qualities get improved (Kul and Seker, 2004). The negative correlation observed between Haugh unit and egg weight in the current study is in accordance with the finding of Abdulraheem *et al.* (2024) in Japanese quail.

The high and positive genetic correlations range of 0.67 to 0.97 reported by Zhang *et al.* (2005) between egg weight and albumen weight, yolk weight and shell weight in brown egg dwarf layers are similar to the results of this study on the same traits in the two laying groups. Similar findings were equally reported by Sezer (2007; 2008) in Japanese quail. This sub species corroboration reflects that the

genes influencing these traits in chickens and quails behave in a similar manner.

A few values were not estimable and these were between traits related to yolk and egg weight. According to El-Deen *et al.* (2008),

such inestimable estimates of correlations between traits may be due to sampling errors and some missing observations. The inestimable values in this work could be associated with sampling errors associated with egg weight and yolk traits.

Table 1: Genetic correlations between external and internal egg quality traits of young-laying (10 weeks of age) Japanese quail hens

External/ Internal	EW	EH	WE	SW	AVGST	SR	ESA	ESI	SWUS
AL	0.61	0.32	0.39	0.55	0.73	0.21	0.20	0.05	0.20
AH	0.38	0.68	-0.08	0.29	-0.07	-0.03	0.28	-0.43	0.29
WA	0.35	0.16	0.22	0.14	0.59	-0.01	0.14	0.07	0.14
AW	0.90	0.20	0.26	-0.14	0.30	-0.74	0.79	-0.27	0.78
YH	NA	0.67	-0.11	0.97	0.69	0.37	0.37	-0.48	0.37
YD	0.70	0.53	-0.02	0.54	-0.04	-0.01	0.46	-0.52	0.47
YW	0.87	0.85	0.12	0.40	-0.41	-0.06	0.38	-0.49	0.39
AR	0.23	-0.39	0.16	-0.41	0.38	-0.51	0.29	0.16	0.28
YI	NA	0.29	-0.10	0.52	0.92	0.41	-0.02	-0.07	-0.03
YR	0.11	0.50	-0.12	0.34	-0.45	0.37	-0.18	-0.22	-0.17
HU	-0.11	0.55	-0.14	0.26	-0.07	0.11	0.07	-0.32	0.09
AI	-0.40	0.42	-0.33	0.00	-0.56	-0.10	0.11	-0.44	0.13

EW=Egg weight, EH=egg height, WE=egg width, SW=shell weight, AVGST=average shell thickness, SR=shell ratio, ESA= egg surface area, ESI=egg shape index, SWUS= shell weigh per unit surface area, AL=Albumen length, AH=Albumen height, WA= Albumen width, AW= Albumen weight, YH=Yolk height, YD=Yolk diameter, YW=Yolk weight, AR=Albumen ratio, YI= Yolk index, YR=Yolk ratio, HU=Haught unit, AI=Albumen index, NA= not available

Table 2: Genetic correlations between external and internal egg quality traits of old-laying (20 weeks of age) Japanese quail

External/ Internal	EW	EH	WE	SW	AVGST	SR	ESA	ESI	SWUS
AL	0.63	-0.29	0.17	0.26	0.14	0.46	-0.24	0.63	-0.25
AH	0.13	-0.23	0.29	0.32	0.21	0.15	0.17	0.64	0.15
WA	0.31	-0.34	0.42	0.27	0.13	0.50	-0.25	0.94	-0.28
AW	0.98	0.76	0.37	-0.02	-0.14	-0.80	0.87	-0.59	0.86
YH	0.51	-0.06	0.54	0.49	0.10	0.21	0.29	0.60	0.26
YD	0.74	0.35	0.03	0.24	0.16	-0.16	0.42	-0.36	0.42
YW	NA	-0.13	-0.08	0.64	0.68	0.66	-0.09	0.06	-0.09
AR	0.28	0.52	0.25	-0.34	-0.43	-0.83	0.58	-0.39	0.58
YI	-0.20	-0.25	0.49	0.27	-0.30	0.24	0.04	0.77	0.02
YR	0.12	-0.53	-0.31	0.30	0.43	0.78	-0.57	0.36	-0.56
HU	-0.09	-0.33	0.25	0.26	0.19	0.21	0.03	0.73	0.02
AI	0.43	0.01	0.18	0.04	-0.03	-0.30	0.39	0.13	0.38

EW=Egg weight, EH=egg height, WE=egg width, SW=shell weight, AVGST=average shell thickness, SR=shell ratio, ESA= egg surface area, ESI=egg shape index, SWUS= shell weigh per unit surface area, AL=Albumen length, AH=Albumen height, WA= Albumen width, AW= Albumen weight, YH=Yolk height, YD=Yolk diameter, YW=Yolk weight, AR=Albumen ratio, YI= Yolk index, YR=Yolk ratio, HU=Haught unit, AI=Albumen index, NA= not available

Conclusions

Yolk height could be best improved by shell weight while improvement of albumen weight could be hindered by shell ratio at early

laying-age (10 weeks old) in Japanese quails. For old-laying quails, both egg and albumen weight could be used to improve each other. Negative correlation observed between shell and albumen ratio indicates that eggs with large albumen laid by aged quail would possess delicate shell quality. Positive correlations of egg weight with most internal qualities suggest that egg weight can be used to improve internal egg qualities in both laying groups of quails except albumen index or yolk index.

References

- Abdulraheem, A.O., Raji, A.O. and Magaji, A.S. (2021). Principal component analysis of egg quality traits of Japanese quail reared in Borno state, Northeast Nigeria in *46th Annual Conference of Nigerian Society for Animal Production*, 808-812, held at Federal University Dutsi-ma, Katsina state 14th – 18th March, 2021.
- Abdulraheem, A.O., Magaji, A. S., Raji, A.O. and Jibrin, A. (2022). Heritability and repeatability estimates of egg quality traits in Japanese quails reared in Northeastern Nigeria. *Proceedings of the 47th Annual Conference of the Nigerian Society for Animal Production*:186-189, 13th -17th March, 2022, University of Jos and Federal College of Forestry, Jos, Plateau State.
- Abdulraheem, A.O., Raji, A.O., Aliyu, J. and Alade, N.K. (2024). Heritability estimates for body weight and morphological traits of Nigerian indigenous chickens in Borno state. *Proceedings of 29th Annual Conference of Animal Science Association of Nigeria*, 117-121, 8th -12th September, 2024, Lagos, Lagos state, Nigeria.
- Adio, S., Ijaiya, A.T., Egena, S.S.A., Afolabi, F. and Olalere, H.W. (2019). Carcass characteristics of Japanese quails fed diets containing graded levels of sundried cassava peel meal flavoured with molasses as a replacement for maize. *44th Annual Conference of Nigerian Society for Animal Production (NSAP)-Abuja* 2019.
- Alaku, S.O. (1983). The influence of season on birth weight, body weight at 3, 12 months in Wadama cattle in the Sahel region of Northeast, *Review of Animal Production*, 23-32.
- Aliyu, J., Abdulraheem, A.O., Raji, A.O. and Alade, N.K. (2024). Heritability estimates for egg production traits in six plumage-type indigenous chickens in some northeastern states of Nigeria. *Nigerian Journal of Genetics*, 38(1):89-101.
- Altinel, A. Gunep, H., Kirmizibayrak, K., Coreki, S. G. and Bilal, T. (1996). The studies of egg quality characteristics of Japanese quails. *Journal of Veterinary Medicine*, 22(1):203-213.
- Becker, W.A. (1985). *Manual of Quantitative Genetics* (4th ed). Academic Enterprises, Pullman, Washington, U.S.A.
- El-Deen, M.B., Shebi, N.K., Abd Allah, G.A. and Debis, A.B. (2008). Using selection index to improve some performance traits in Japanese quail females. *Egypt Poultry Science* 25:449-460.
- Encarta, (2007). Microsoft Students Encarta Dictionary. *Microsoft Corporation inc.*
- Harvey, W.R. (1990). *Mixed Model Least Square and Maximum Likelihood Computer Programme (LSMLMN) PC-2 VERSION*. Ohio state University, Columbus, pp 59(Mimeograph).
- Ikpeme, E. V., Kooffreh, M. E., Udensi, O. U., Ekerette, E. E., Ashishie, L. A. and Ozoje, M. O. (2016). Multivariate-based genetic diversity analysis of three genotypes of Nigerian local chickens (*Gallus domesticus*).

International Journal of Science and Research Methodology, 5(2):1-12.

Kellou, K.M. (2005). Development of multinational blocks for dry season supplementary feeding of sheep in a semi-arid environment. *M.Sc. Thesis: Department of Animal Science, University of Maiduguri, Nigeria* pp23-38.

Kul, S. and Seker, I. (2004). Phenotypic correlations between some external and internal egg quality traits in Japanese quail (*Coturnix coturnix japonica*). *International Journal of Poultry Science* 3(6):400-405.

Nano, (2024). Egg quality characteristics of two strains of chicken in Maiduguri. *Final year Project, Department of Animal Science, University of Maiduguri, Borno state, Nigeria*, pp 41.

Nasrollah, V. (2008). The Japanese quail: A Review. *International Journal of Poultry Science* 7(9):925- 931.

Odubote, I.K. (1996). Genetic parameters for litter size at birth and kidding interval in the West African Dwarf goats. *Small Ruminant Research*, 20:261-265.

Randall, M. and Bolla, G. (2008). *Raising Japanese Quail*. Ptimefact 602. 2nd edition. www.dpi.nsw.gov.au/primefacts.

Sezer, M. (2007). Heritability of exterior egg quality traits in Japanese quail. *Journal of Applied Biological Sciences* 1(2):37-40.

Sezer, M. (2008). Heritability of interior egg quality traits for Japanese quail. *International Journal of Natural and Engineering Sciences*, 2(2):77-79.

Shim, K.F. (2004). *Nutrition and Management of Japanese (Coturnix) Quail in the Tropics*. That Quail place; all about game birds, 22-28.

Skewes, P.A., Wilson, H.R. and Mather, F.B. (1988). Correlations among egg weight, chick weight and yolk sac weight in bob-white quail (*Coturnix virginianus*). *Florida Science*, 51:159-162.

Yahaya, B., Abdu, I., Adamu, J.L. and Khalid, S.A. (2023). Phenotypic correlation between egg quality traits of Nigerian unimproved (indigenous) and improved (Noiler) chicken genotypes. *Nigerian Journal of Animal Science*, 6(2):57-70.

Zhang, I.C., Ning, Z.H., Xu, G.Y., Hon., Z.C. and Yang, N. (2005). Heritability and genetic and phenotypic correlations of egg quality traits in brown-egg dwarf layers. *Poultry Science* 84(8):1209-1213.