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The Relationships of Egg Quality Traits and Age in Small Sized Japanese Quails (*Coturnix coturnix japonica*) in Nigeria Region

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Abstract

The effects of layers' age in lay on egg quality traits and there relationships among the traits in small sized Japanese quails (*Coturnix coturnix japonica*) were investigated. One hundred female quails reared in an improvised deep litter cage constructed to give adequate space and ventilation for normal growth and laying of the birds were used for the production of the eggs used in this study. For the entire duration of the experiment (40weeks), a total of 480 eggs were examined. Egg weight increased from 9.26±0.31g at the 6th week when the birds started to lay to 10.18±0.31g at 46th week of age when the experiment was terminated with similar ($p>0.05$) values from 10-46 weeks of age. Egg shell weight increased significantly with age, peaked at week 26 and decreased thereafter. Albumen weight increased with the age of birds from 5.32±0.23 g in week 6 to the peak at week 42 (5.88±0.20g). Yolk weight increased progressively as the birds aged ranging from 2.76±0.07 g in week 6 to 2.98±0.60 g in week 34 from where it plateaus till week 46. The egg shape index was not significantly ($p>0.05$) influenced by age, whereas the albumin index decreased while yolk index decreased from week 6 to week 22, increased from week 26 to the highest value of 51.90±0.29 in week 30 and declined to 44.15±0.29 in week 46. The Haugh unit peaked at the 10th week of age and declined significantly ($p<0.05$) to 83.09±0.51 at the 46th week of age. Egg weight was significantly correlated ($p<0.05$) with yolk weight (r=58), albumin weight (r=0.90) and egg shell weight (r=0.58). The albumin index, albumin weight, Haugh units and egg shell weight decreased with increasing age but the egg shape index was not affected. These characteristics of quails' eggs should encourage the programs for diversification of sources of eggs that are needed if future economical challenges are to be taken up.

Keywords

Albumin Weight, Egg Weight, Shell Weight, Yolk Weight

1. Introduction

An egg is the organic vessel containing the zygote, resulting from fertilization of the ovum, in which an animal embryo develops until it can survive on its own, at which point the egg hatches. Eggs provide all the nutrients required by the developing embryo and the hatched chicks in the first few hours of their life for normal growth. All female animals produce eggs and birds, particularly, apart from having relatively large-sized egg, lay the eggs externally. These eggs, because of their size and nutritional status, are secondarily used as food for man, in fast food industry and in pharmaceutical and cosmetic sectors [1].

Over the years man has depended on the domestic fowl for eggs to the disadvantage of other avian species such as quails which could serve as complementary choices. The net effect of this is high cost of eggs which are not within the purchasing powers of a great percentage of the populace with its attendant nutritional and economic consequences.

Bird's eggs are composed of the edible parts (albumen and yolk) and the non edible part (egg shell). Egg albumen and yolk weights are phenotypic traits that can influence egg quality and reproductive fitness of poultry [2,3,4]. Information on these traits is essential because eggs are probably the food item most frequently involved in the outbreaks of food borne infections caused by *Salmonella species* [5,6]. Common factors that affect the penetration of *Salmonella species* into an egg are the quality of the shell, yolk and albumen [7].

The proportion of each of the constituent parts of eggs from chickens [8] and Guinea fowl [9,10] had been reported. Intra-specific differences in egg composition due to dissimilarity in sizes of eggs and their allometric relationship with weights of the eggs have been widely reported in birds for American Coots, Alcidae (Aves: *Charadriiformes,* emu (*Dromaius novaehollandiae*) eggs and European Starling eggs [11, 12, 13, 14, 15, 16, 17].

Several authors have reported that egg weight increases with the hen's age [18, 19, 20], reaching a plateau by the end of the laying cycle due to physical and physiological changes that occur in the birds [21]. Also, the age of hens influences the proportion of the internal (yolk and albumen) and external (egg shell) components of eggs [19, 22, 20] by increasing the albumin and yolk average weights and the proportion of yolk in the edible part of the egg [23]. The fact that environment is an essential element in the determination of phenotypic traits (P=G+E) coupled with the fact that non of the authors who had worked on this subject matter did in Ekiti State axis of Nigeria, this study is therefore undertook to determine the egg weight and egg component parts of small sized Japanese quails and measure the relationships between egg weight (EW), yolk weight (YW), albumin weight (AW) and egg shell weight (ESW) in this environment.

2. Materials and Methods

This study was carried out in the Aviary Unit of Ekiti State University Teaching and Research Farm, Ado-Ekiti, Nigeria. One hundred 6 weeks old quail layers were placed in an improvised deep litter cage constructed to give adequate space and ventilation for the laying birds. The quails were fed layers diet containing 11.3MJ ME/kg and 19.8% of crude protein throughout the experimental period *ad libitum*. At 6 weeks of age, 10 eggs were collected and examined and at intervals of 4 weeks thereafter until the 46th week of age, 47 eggs were collected and examined making a total of 480eggs.

Egg length and width were measured by means of an electronic sliding caliper (precision 0.01mm), so that an egg shape index could be calculated [24]. Egg weights were measured using a digital scale (precision 0.01g). Measurements of the internal components were obtained by carefully making an opening around the sharp end of the egg, large enough to allow the passage of both the albumen and the yolk through it without mixing their contents together. The yolk was then carefully separated from the albumen and the weight determined on wet basis. Albumen weight was obtained by subtraction (Albumen weight = Total weight – Yolk weight –Egg shell weight) [25]. The albumen height was measured at its widest part at a position half way between the yolk and the outer margin and the yolk height determined using Tripod Micrometer.

$$\text{ESI} = \frac{width\ of\ egg}{length\ of\ egg} x100$$

$$\text{ESI} = \frac{width\ of\ egg}{length\ of\ egg}\ x\ 100$$

$$\text{AI} = \frac{albumin\ height}{(long\ diameter\ of\ albumin + short\ diaameter\ of\ albumin/2}\ x\ 100$$

$$\text{Albumin percent} = \frac{Albumin\ weight}{Egg\ weight}\ x\ 100$$

$$\text{YI} = \frac{Yolk\ height}{Yolk\ diameter}\ x\ 100$$

$$\text{Yolk percent} = \frac{\text{Yolk weight}}{\text{Egg weight}}$$

Haugh unit (HU) was calculated from albumin height and egg weight with the formula of [26]:
HU=100 x log (albumen height - 1.7 x egg weight$^{0.37}$ + 7.56)

All statistical analyses which included the descriptive statistics and Pearson Correlation were done using SPSS version 18, 25 statistical packages.

3. Results and Discussion

3.1. Egg Weight, Egg Shell Weight, Albumen Weight and Yolk Weight

The mean egg weights and the component parts at different ages are shown in Table 1. Egg weight increased from 9.26±0.31g at the beginning of lay (6th week) to 10.18±0.31g at the 46th week of age, but the values from 10th to 46th week of age did not differ ($p>0.05$). The similarity indicates the attainment of full weight of quail's egg on the 10th week which disagrees with previous reports that egg weight continuously increased with age of the quail [27, 28, 29, 30, 31, 32, 33]. The average weight of 9.78g is low compared to 12.20-12.36g reported by [34] in 4 close-bred laying flocks of Japanese quails with different body weight categories during 31 weeks and 12.52g obtained by [33] in Japanese quails, similar to 9.27-10.5g obtained for low five weeks body weight quails and randomly bred cross line of quails [34] but higher than 7.5-9.5g for light weight Japanese quail [35]. [36] observed that egg weight in Japanese quails is largely dependent on the type of birds, being 8-10g in the egg type (small size), 10-11g in the combined type (medium size) and 12-16g for the broiler type (heavy size). The weight of an egg depends upon the breed and strain of birds and varies greatly from one individual to another [37]. The quail's egg weight is equivalent to 1:5.6 of the weight of black Harco laying chickens; 1:3.99 of pearl variety of guinea fowl [38] and 1:6.5 of the weight of laying hens [39].

The egg shell weight increased as the birds aged ranging from 1.16±0.02g in week 6 to 1.33±0.03g in week 26. The eggs laid at ages 6 and 10 weeks were similar ($p>0.05$) but differed ($p<0.05$) from eggs produced in ages 14–46 weeks.

However, despite the similarities in egg shell weight among weeks 14, 26, 34, 38 and 46 and among weeks 14, 18, 22, 30, 34 and 42, the age of quail in lay had a significant ($p<0.05$) effect on the egg shell weight. It reached a peak in the 26th week of age and subsequently decreased until the end of the experiment. Previous researchers had reported an increase in egg shell weight with quails' age [28, 29, 30, 31]. [33] mentioned a peak weight at week 25, in accordance with the 26 registered in the present study with a subsequent decrease until the end of the laying period.

The albumen weight increased from 5.34±0.23g in week 6 to 5.88±0.20g in week 46. The weights differed ($p<0.05$) between the ages of 6weeks and other ages. Previous reports had indicated increase in albumin weight with the age of quails [33, 30].

Yolk weight increased with the birds' age from 2.76±0.07g in week 6 to 2.98±0.60g in week 34 and thereafter plateau till week 46. The yolk weight was significantly ($P<0.05$) influenced by age being lowest at the beginning of the laying period and subsequent increase with age. This result agrees with the report of [30] that yolk weight in Japanese quail increased with quail's age.

The proportions of yolk, albumen and egg shell weights to the whole egg weight were 29.55%, 57.46% and 12.47%, respectively, as against 30.43%, 56.93% and 12.65% reported by [33] for the respective traits. [38] obtained 32.46%, 56.91% and 10.66% as the respective proportions of yolk, albumin and shell in guinea fowl and 26.79%, 63.26% and 10.03% as the respective proportions of the traits in black Harco laying chickens. [40] obtained 27.66%, 57.25% and 11.74% respectively for yolk, albumin and shell in laying hens. With regard to nutritional quality, higher yolk percentage must be considered as favorable [41] and in fast food, pharmaceutical and cosmetic sectors [42], as it is linked to a higher dry matter content of the egg and a higher content in essential fatty acids. [43] reported that because albumen contains many functionally important proteins: 54% ovalbumin, 12% ovotransferrin, 11% ovomucoid, 3.5% ovomucin and 3.5% lysozyme they are useful in industrial applications. The contents of yolk and albumen obtained in this study being comparable with the proportions of yolk and albumen of guinea fowl and domestic hens make them as useful as the other eggs for human and industrial uses. The slight disparities in the proportions of these constituent parts agree with the report of [44] that the weights of shell, albumen and yolk in eggs vary between strains and species of hens.

Table 1. *Mean values of egg weight and egg component parts ± SEM.*

Ageinwks	Eggweight(g)	Shellweight(g)	Albumenweight(g)	Yolkweight(g)
6	$9.26^{b}\pm0.31$	$1.16^{c}\pm0.02$	$5.34^{e}\pm0.23$	$2.76^{d}\pm0.07$
10	$9.40^{ab}\pm0.52$	$1.18^{c}\pm0.07$	$5.49^{d}\pm0.42$	$2.73^{d}\pm0.14$
14	$9.62^{ab}\pm0.26$	$1.30^{ab}\pm0.03$	$5.46^{d}\pm0.19$	$2.81^{c}\pm0.06$
18	$9.66^{ab}\pm0.23$	$1.23^{b}\pm0.03$	$5.55^{c}\pm0.19$	$2.88^{b}\pm0.58$
22	$9.70^{ab}\pm0.26$	$1.24^{b}\pm0.03$	$5.59^{c}\pm0.20$	$2.87^{b}\pm0.06$
26	$9.73^{ab}\pm0.25$	$1.33^{a}\pm0.03$	$5.54^{c}\pm0.20$	$2.86^{b}\pm0.06$
30	$9.76^{ab}\pm0.25$	$1.29^{b}\pm0.03$	$5.56^{c}\pm0.19$	$2.91^{b}\pm0.05$
34	$9.99^{ab}\pm0.20$	$1.30^{ab}\pm0.03$	$5.71^{b}\pm0.15$	$2.98^{a}\pm0.60$
38	$10.06^{ab}\pm0.32$	$1.31^{a}\pm0.04$	$5.77^{b}\pm0.24$	$2.98^{a}\pm0.07$
42	$10.17^{a}\pm0.30$	$1.26^{b}\pm0.04$	$5.90^{a}\pm0.20$	$3.01^{a}\pm0.07$
46	$10.18^{a}\pm0.31$	$1.32^{a}\pm0.04$	$5.88^{a}\pm0.20$	$2.98^{a}\pm0.07$
Overallmean	9.78	1.27	5.62	2.89

Means with different superscripts along the same column are significantly different ($p<0.05$)

3.2. Egg Shape Index, Albumen Index, Yolk Index and Haugh Unit

Table 2 shows the average egg shape index, albumen index, yolk index and Haugh unit at different ages. The egg shape index was not significantly ($p>0.05$) influenced by age. [29, 33] had obtained similar results whereas [45, 31] had described a decrease in egg shape index with increasing age of Japanese quails. The average value of 75.71% in egg shape index is slightly lower than 77.85% obtained by [33].

The albumen index fluctuated but showed similar ($p>0.05$) values at 6-14 weeks and decreased to values which did not differ. This show that albumen index decreased with increase in ages of the birds. A decrease in albumen index with age was reported by [46] whereas [27, 31] had observed that the albumen index increased with quail's age.

Age significantly ($p<0.05$) affected the yolk index (Table 2). The yolk index decreased from week 6 to week 26, increased to highest value in week 30 and 34 from where it declined to 44.15±0.29 in week 46. This result agrees with the findings by [31, 33] but contrast the reports of [27, 45] who found that the yolk index continuously increased with the age of quail.

The Haugh units decreased with age of birds. The Haugh unit had a peak (88.65±0.41%) at the 10th week of age which did not differ from 6th week. The Haugh unit, considered the best objective mathematical expression to measure egg quality [47] has been reported to decrease [30,31] with the age of quail birds which agree with the result obtained in this study but negates the findings by [29] who observed no changes in the Haugh unit in the course of the laying period. In United Kingdom, consumers' resistant to low Haugh unit had been reported and a minimum acceptable level of 70 HU is recommended on regular documented test [48]. The Haugh unit of quails' egg obtained in this study attests to its good quality.

Table 2. *Average values of egg shape index, albumen index, yolk index and Haugh unit scores at different ages (Mean ± SEM).*

Age in wks	Egg shape index	Albumenindex	Yolk index	Haugh unit
6	75.76±0.27	10.26^{a}±0.19	49.11^{bc}±0.34	88.07^{ab}±0.66
10	75.43±0.16	10.12^{a}±0.11	47.66^{cd}±0.22	88.65^{a}±0.41
14	76.56±0.42	10.17^{a}±0.29	46.81^{cde}±0.57	88.43^{ab}±1.14
18	75.33±0.18	8.26^{b}±0.21	46.82^{cde}±0.32	83.85^{cd}±0.61
22	75.17±0.22	8.33^{b}±0.18	46.82^{cde}±0.32	85.07^{bc}±0.60
26	75.16±0.24	7.64^{b}±0.20	48.05^{c}±0.34	83.04^{cd}±0.65
30	75.72±0.19	8.08^{b}±0.17	51.90^{a}±0.29	83.38^{cd}±0.53
34	76.03±0.18	7.32^{b}±0.17	50.81^{a}±0.26	81.68^{cd}±0.48
38	75.98±0.20	6.70^{b}±0.17	47.34^{cd}±0.27	80.69^{d}±0.50
42	75.61±0.19	6.67^{b}±0.17	45.25^{de}±0.28	80.76^{d}±0.51
46	76.02±0.20	7.63^{b}±0.18	44.15^{e}±0.29	83.09^{cd}±0.51
Overallmean	75.71	8.29	47.70	84.25

Means with different superscripts alongthe same column are significantly ($p<0.05$) different

4. Correlation

The correlation matrix of the relationships between egg weight and other egg components are shown in Table 3. Egg weight showed significant correlations ($p<0.05$) with yolk weight, albumen weight and egg shell weight. Also correlations between albumen weight and egg shell weight and yolk weight and egg shell weight were significant ($p<0.05$). The magnitude of the correlation coefficients is an indication of how closely linear the variables are. The correlation coefficients obtained in this study showed strong linear relationships among the egg traits implying that the traits are likely to be under the influence of the same gene action. The results of this study agree with the reports of [49, 50, 51, 33] who found very high correlations between egg weight and the weights of its component parts but conflicts with the report of [52] that the correlation between egg weight and egg component parts computed from the averages of investigated traits in 20 generations was low and not significant. The correlation value of $r = 0.90$ between the egg weight and albumen weight is higher than the value of $r = 0.70$ between egg weight and yolk weight suggesting a closer association between the earlier than the later [53].

Table 3. *Correlations between the averages of egg weight and egg component parts.*

Traits	Ew(g)	Yw(g)	Aw(g)	Esw(g)
Ew(g)	1	0.70***	0.90***	0.58***
Yw(g)		1	-0.36***	0.39***
Aw(g)			1	0.44***
Esw(g)				1

***<0.001 (highly significant)
Where Ew = Egg weight; Yw = Yolk weight; Aw = Albumen weight and Esw = Egg shell weight (g)

5. Conclusion

Monitoring of the quality traits of Japanese quails'eggs is important when considering health and food safety issues. In this study, the albumen index, albumen weight, albumen proportion, Haugh units and egg shell weight decreased with increasing age, but the egg shape index was not influenced by age. Egg weight was significantly correlated ($p<0.05$) with yolk weight (r=58), albumin weight (r=0.90) and egg shell weight ($r = 0.58$). The albumin index, albumin weight, Haugh units and egg shell weight decreased with increasing age but the egg shape index was not affected. These characteristics of quails' eggs should encourage the programs for diversification of sources of eggs that are urgently needed if future economical challenges are to be taken up.

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