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Research paper

The influence of flock age and egg size on egg shape index, hatchability and growth of japanese quail chicks

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The study assessed the effects of age and egg size on egg shape, egg weight loss, hatchability and growth of Japanese quail. A total of 198 eggs from a breeder flock at 40, 43 and 46 weeks of age were categorised as light, medium and large. Egg shape index was analysed using Histogram with Fit and Groups. Data were subjected to two-way Analysis of Variance using General Linear Model procedure of Minitab (version 18) at 5% Least Significant Difference. Egg weight loss was not different in the younger birds but changed significantly at 46th week on the 6th and 12th days of incubation. Egg weight loss significantly changed between the light and medium-sized eggs. Fertility was significantly affected by egg size. Age and egg size did not change hatchability but significantly affected hatching weight. Chick growth varied significantly at day 14 in eggs collected at week 40. Chick growth significantly increased across the days as egg size increased. The least shape index (77.3%) was recorded in the heavy and medium eggs at 40 and 46 weeks of age. Fertility, hatchability, chick growth and mortality can be affected by age of quails and size of quail eggs.

Key words: *Japanese quail, flock age, egg size, hatchability, egg shape*

INTRODUCTION

In comparison to other poultry species, quails are extremely prolific and fast growing – requiring less space, feed and capital to start their production; they have better resistance to diseases and can be raised under a varied range of farm and climatic conditions (Aryee et al., 2020). Breeding of quails has become important because their products (meat and egg) are highly accepted globally for their medicinal properties (Aryee et al., 2020) and food values. Hatchery operation is one of the major facets of the poultry value chain but its sustenance is largely dependent on the quality of eggs and their ability to hatch – as these affect the efficiency of production, growth and supply of day-old and mature birds. External egg quality traits such as egg weight and shell thickness affect the internal quality parameters of eggs such as the albumen and yolk that are major determinants of an egg's ability to hatch apart from egg fertility, pre-incubation and incubation conditions. Narushin and Romanov (2002) discovered that egg quality traits are highly influenced by several factors including egg weight (the total fraction of eggshell, albumen and yolk) (Aryee et al., 2020) that is most significant to poultry breeders, farmers (Genchev, 2012b) processors and consumers regarding choices for breed development, production and consumption purposes. Alsobayel and Albadry (2011) found that egg hatchability was influenced by egg shape index as this affects the ability of an egg to fit well onto setter trays (Icken et al., 2006; Cavero and Schmutz, 2009; Blanco et al., 2014) in incubators. In addition, egg quality had been reported to affect hatchability and weight of day-old chicks (Farooq et al., 2001a) with hatchability, chick weight and later growth performance relating to egg weight/ egg size (King'ori et al., 2003; Rashid et al., 2005; Alkan et al., 2008). The influence of these external egg traits (egg weight/ egg size and egg shape index) on hatchability of the domestic chicken egg and growth of their chicks have been studied in other parts of the world. The quail sector is now gaining popularity worldwide but little or no attention has been given to the Japanese quail. Quails could be commercialised worldwide within the context of non-traditional farming (Mondry, 2016) if their eggs can be hatched more efficiently to ensure incessant supply of their day-old- chicks to farmers particularly in regions where quail production is new. This research aimed to determine the effetcs of age and egg size on egg shape, egg weight loss, hatchability and growth of Japanese quail chicks.

MATERIALS AND METHODS

Study Area

The experimental eggs were obtained from the Quail Section of the Animal Research Institute of the Council for Scientific and Industrial Research (CSIR), Accra, Ghana located in the Adentan Municipal Assembly on latitude 5′ 43′ ′ north and longitude 0′ 09′ ′ west (Ghana Statistical Service, 2014). Pre-incubation storage, incubation and hatching were done at the Hatchery Unit of the same institute.

Experimental Materials and Sampling Techniques

A total of 198 fertile eggs were randomly selected from a breeding flock of the Japanese quail that were at three different ages. Only 66 eggs were collected from the flock at each age and purposefully grouped into three egg weight/ egg size groups with 22 eggs in each weight category. The flock was kept in a slated floor cage enclosed in an opened-sided shed. A broiler-layer diet and water were provided to the birds ad libitum. No vaccination and medications were administered but glucose was given on arrival from the hatchery.

Experimental Design

Complete Randomized Design with a 3 x 3 factorial arrangement involving three ages (40, 43 and 46 weeks) and three egg weights/ egg sizes was used. Egg size was categorised as: light (eggs that weighed <11.0g), medium (eggs that weighed 11.0 to 12.0g) and heavy (eggs that weighed over 12.0g) according to El-Samahy et al. (2017).

Data Collection Procedure and Instruments

The eggs were collected from the birds on the same day of each experimental week between 8:30 and 9:00am Greenwish Meridian Time (GMT), cleaned with a dry cloth and carried to the hatchery in sterilized plastic quail crates for an average of 15 minutes. On arrival, the eggs were sorted to remove cracked ones. Prior to setting, the uncracked eggs were weighed for their initial weight with a 5bit LCD display 500.0 G (100.00 G/ 200.00 G) Digital Pocket Scale (Srad Technology Limited, China) at an accuracy of 0.1g and categorized into the three egg sizes. Eggs in each group were identified individually by numbering using a permanent marker. Egg length and egg width were then measured with a digital veneer calliper at an accuracy of 0.01mm. The eggs were then put into an automatic turning Bluestar Incubator (Hyderabad Incubators PVT. LTD, India) with the broad ends up on setter trays for incubation at 37.5 – 37.7^{o} Celsius and 80 – 85% humidity for the first 15 days. Egg weight was measured with the digital pocket scale on the 6th and 12th days to determine weight loss at the respective days. The eggs were transferred into a Bluestar Hatcher (Hyderabad Incubators PVT. LTD, India) on the 15th day of incubation for hatching on hatching trays at a temperature of 36.5 – 36.6^{o} Celsius and humidity of 87.8%. Completely hatched quail chicks in each group were immediately counted and weighed individually for their initial body weight at hatch using the digital scale and a small zero scaled plastic basket to restrain them. The unhatched eggs were opened to detect number of unfertilized eggs and dead in shell (El-Samahy et al., 2017). The quail chicks were transferred to a pre- prepared brooder house for brooding in separate chick boxes that were identified by egg sizes.

Brooding was done in an enclosed cement block house with small windows for ventilation up to day 21 at an average temperature of 32.6 – 37.4^{o} Celsius and Humidity of 69.0% that were measured using a Thermopro TP-50 Digital Hygrometer Indoor Thermometer (Shenzhen Ecare Electronics Company Limited, China). Light, feed and clean water were provided throughout the brooding phase without restrictions but no vaccination and medications was administered except glucose on arrival from the hatchery. The weekly body weight of individual chicks was measured with the Yieryi Portable Electronic Hanging Scale and a zero scaled plastic bucket that was used to restrain the birds. Mortality was recorded at the end of the experiment.

The above physical data collected were used to calculate the derived quantities as follows:

1. Egg weight loss (g) = Initial weight – final weight (El-Samahy et al., 2017).
2. Percentage fertility = $\frac{\text{Number of fertile eggs}}{\text{Total number of eggs set}}$ x 100 (El-Samahy et al., 2017).
3. Percentage hatchability on fertile eggs = $\frac{\text{Number of hatced chicks}}{\text{Total number of fertile eggs}}$ x 100 (Alkan et al., 2008).
4. Percentage hatchability on incubated eggs = $\frac{\text{Number of hatced chicks}}{\text{Total number of incubated eggs}}$ x 100 (Ramaphala and Mbajiorgu, 2013).
5. Percentage dead in shell = $\frac{\text{Number of dead embryos in shell}}{\text{Total number of fertile eggs}}$ x 100
6. Egg shape index (ESI) = $\frac{\text{Egg width}}{\text{Egg length}}$ x 100[16]. (Sinha et al., 2017).

Percentage chick mortality =

$$\frac{\text{Number of dead chicks at end of experiment}}{\text{Total number of chicks hatched}} \times 100$$

Data Analysis

Data collected were subjected to the two-way Analysis of Variance with age of quails and egg size as fixed factors. The General Linear Model procedure of Minitab (version 18) was used. Differences in means were separated with the Tukey Comparison Method at 5% level of significance. Data on egg shape index was analysed using Histogram with Fit and Groups embeded with the help of the above statistical software. The model used was:

$Y_{ij} = \mu + A_i + S_j + (AS)_{ij} + \varepsilon_{ij}$

Where: Y_{ij} = the dependent variable, μ = the general or population mean, A_i = ith observation of age, S_j = jth observation of egg size, $(AS)_{ij}$ = interaction between age and egg size and ε_{ij} = the random error associated with the dependent variable.

RESULTS AND DISCUSSION

There were no significant changes in the initial (pre-incubation) weight of the eggs collected from the birds at the respective ages but egg weight slightly decreased in the oldest group. Egg weight loss on the 6th and 12th days was not significantly different between eggs collected at 40 and 43 weeks of age but changed significantly at week 46 on both days (Table 1). Fertility was not significantly affected by age of the quails but there was a decreasing order in the trait with increasing age. The effect of age on hatchability and dead in shell was not significant but intermittent (Table 1).

The initial (pre-incubation) egg weight classified as light, medium and heavy were 9.9, 11.3 and 12.5g respectively. A significant difference was observed between the light and medium sized eggs weight loss during the 6th and 12th days of incubation but non-significant difference between the medium and heavy eggs (Table 2). Fertility was the highest in the medium-size eggs (100%) followed by the small-size eggs (93.9%) then least for the heavy-size eggs (90.9%). Hatchability and dead in shell were non-significantly and intermittently affected by egg size. But both were best in the middle class eggs (Table 2).

Effect of Age and Egg Size on Initial Egg Weight

Egg weight is one major egg quality trait considered in the hatchery business as it has the tendency to affect hatchability (Weaver and Bell, 2002; Ng'ambi et al., 2013; Hegab and Hanafy2019), chick weight and growth (Petek et al., 2003; Ulmer-Franco et al., 2010; Ng'ambi et al., 2013; Ayeni et al., 2018). Large and heavy eggs at all ages of quails are needed for higher hatchability, chick weight and growth to ensure regular supply and high prices of quail chicks.

The difference in egg weight observed in the current work is in agreement with the results of Padhi et al. (2013) who found that egg quality is affected by the age of birds. The similarity in egg weight in the 40th and 43rd weeks do not support the idea that as quails grow, their eggs increase in weight simultaneously (Omane et al., 2020). However, the drop in egg weight in the 46th week is in line with Padhi et al. (2013) who reported a decrease in egg weight of the domestic chicken from the age of 52 weeks (61.7g) to 64 weeks (60.4g) though they later recorded an increase in the trait at 72 weeks. Comparatively, the egg weight (11.2-11.3g) recorded in this experiment is more than the accepted average weight of 10g (Hubrecht and Kirkwood, 2010; Padhi et al., 2013) and close to the hatching eggs (10-12g) produced by the same breed

Table 1. Effect of Age on Initial Egg Weight, Egg Weight Loss, Fertility, Hatchability and Dead in Shell

	Age of Birds				
Hatching Traits	**Week 40**	**Week 43**	**Week 46**	**SEM**	**p-value**
Initial Egg Weight (g)	11.3[a]	11.3[a]	11.2[a]	0.0505	.342
Weight Loss at Day 6 (g)	0.6[b]	0.6[b]	1.0[a]	0.0753	.001
Weight Loss at Day 12 (g)	1.2[b]	1.2[b]	1.8[a]	0.147	.001
Fertility (%)	96.7[a]	95.5[a]	92.4[a]	1.38	.174
Hatchability on Incubated Eggs (%)	78.8[a]	81.8[a]	71.2[a]	7.10	.661
Hatchability on Fertile Eggs (%)	81.1[a]	85.9[a]	76.3[a]	7.27	.608
Dead in Shell (%)	18.9[a]	14.1[a]	23.7[a]	7.10	.661

Means that carry different superscripts are significantly different; %: percentage; g: gram; SEM: Standard Error of Means; p-value: probability value (0.05)

Table 2. Effect of Egg Size on Initial Egg Weight, Egg Weight Loss, Fertility, Hatchability and Dead in Shell

	Egg Size (g)				
Hatching Traits	**Light**	**Medium**	**Heavy**	**SEM**	**p-value**
Initial Egg Weight (g)	9.9[c]	11.3[b]	12.5[a]	0.0505	.001
Weight Loss at Day 6 (g)	0.4[b]	0.9[a]	0.9[a]	0.0753	.001
Weight Loss at Day 12 (g)	0.9[b]	1.4[ab]	1.8[a]	0.147	.001
Fertility (%)	93.9[ab]	100.0[a]	90.9[b]	1.38	.023
Hatchability on Incubated Eggs (%)	72.7[a]	87.9[a]	71.2[a]	7.10	.554
Hatchability on Fertile Eggs (%)	77.2[a]	87.9[a]	78.2[a]	7.27	.307
Dead in Shell (%)	22.8[a]	12.1[a]	21.8[a]	7.10	.554

Means that carry different superscripts are significantly different; **%:** percentage; **g:** gram; **SEM:** Standard Error of Means; **p-value:** probability value (0.05) kept for 8-10 months (Redoy et al., 2017) but below the 12-14g found in some heavier meat-type quail lines (Santos et al., 2011; Genchev, 2012b; Hrnčár et al., 2014; Lukanov et al., 2018; Taha et al., 2018).

Effect of Age and Egg Size ont Egg Weight Loss

Decrease in egg weight might be due to loss of gases and water (Dudusola, 2009; Alsobayel and Albadry, 2011; Jin et al., 2011) or loss of moisture from the eggs by evaporation (Tabidi, 2011) during incubation. If a high volume of water is lost from eggs during incubation, embryonic growth could be compromised leading to low hatchability (Hegab and Hanafy, 2019). The significant loss in egg weight at 46th week indicated that water and gases needed for embryonic growth are lost during incubation of larger eggs. This is because larger eggs contain bigger embryos that produce more heat during incubation than smaller eggs from younger birds (French, 1997). The current results for egg size however do not concord to Iqbal et al. (2016) who reported higher egg weight loss in small eggs during incubation but ascribed their results to the higher volume/surface ratio (5.12) in the small eggs compared with large eggs (5.19); but agrees with Çağlayan et al. (2009) who indicated that weight loss in egg from rock partridge during incubation increased from 9.84 to 26.53% of egg weight.

Effect of Age and Egg Size on Fertility

Hen age affects egg fertility (Abudabos et al., 2017) though the effect may be non-significant as portrayed by the present findings. Decrease in fertility with increasing age had been reported by Insko et al. (1947) as cited in King'ori (2011) usually from the 8th month upward for quails (Mondry, 2016). Reduction in fertility as the quails aged might be a consequence of poor mating performance of the males as they grew (Woodward and Abplanalp, 1967; Narahari, et al., 1988) because younger females are known to be less sexually receptive than older females (Woodward and Abplanalp, 1967). On the other hand, the current study showed the lowest fertility rate in heavy eggs as egg size (egg weight) can significantly but intermittently affect the fertility in birds. This result agrees with a previous study conducted by Alkan et al. (2008) who showed higher fertility in smaller eggs (10.1-11.0g) than bigger eggs (12.1-13.0g); however, the differences were non-significant among small, medium and large eggs (Petek et al., 2005; Ramaphala and Mbajiorgu, 2013; Hegab and Hanafy, 2019). The current fertility values across age and egg size are some-what close to the findings of Ramaphala and Mbajiorgu (2013) who reported fertility rates (92.40, 90.90 and 90.90%) for small, medium and large eggs from Cobb 500 chickens but higher than the mean fertility rates (36-50%) reported by Alkan et al. (2008) who studied two egg groups. Aside the age which relates to the interior composition of eggs, egg weight could also cause declination in egg fertility. Sex factors such as: semen concentration, sperm metabolism, sperm motility and abnormal or dead sperm (male); behavioral, egg quality and sperm storage ability of females (Seigel, 1965; Brammel et al., 1996) might also influence egg fertility in the birds.

Effect of Age and Egg Size on Hatchability of Incubated and Fertile Eggs

Hatchability is directly proportional to egg weight (Narahari et al., 1998) and is an important trait for hatchery operators. Though hatchability increased from 40-43 weeks of age, it decreased non-significantly in the oldest age group as their initial egg weight dropped. Nevertheless, the non-significant differences in hatchability observed with age is good for a sustainable supply of day-old chicks throughout the egg production period and for the continuity of any hatchery industry. Ideally, as fertility increases, hatchability must also increase; therefore, the lower hatchability detected at 40 weeks of age against 43 weeks of age can be ascribed to poor quality (structural/ nutritional) or poor incubation of eggs collected at the former age. This result does not completely agree with Farooq et al. (2001b) who proposed that hatchability decreases with reduced fertility. The results showed that quail eggs laid at 46 weeks of age must be the least choice for hatchery operators while those from the middle aged quails (week 43) should be preferred for incubation. The present study showed that egg size did not affect the hatchability. Similar results were reported by Ramaphala and Mbajiorgu (2013) who found the hatchability of 100.00, 99.98 and 100.00% for small, medium and large-sized fertile eggs obtained from Cobb 500 chickens, respectively. This result is in accordance with the results of Ng'ambi et al. (2013) who recorded higher hatchability in heavy eggs obtained from the indigenous Venda chickens. Similar results were reported by Hegab and Hanafy (2019) who confirmed higher hatchability for large Japanese quails eggs compared to their smaller ones. Some previous studies do not entirely support the results of the present study which found higher hatchability in smaller eggs over heavier eggs (Ayeni et al., 2018). It is obvious from the current study that quail eggs that weigh less than 11g should be the least choice for hatchery operators while the medium-sized eggs (eggs that weigh from 11 to 12.0g) are also more suitable for incubation than the heavy-sized eggs (those more than 12g). This result agrees with findings in a previous study where medium-sized eggs ensured a successful incubation (Uddin et al., 1994) though their medium-size eggs (9.1-10.0g) are in the small group in this study. Hatchability of incubated eggs of <10.0, 10.1-11.0, 11.1-12.0, 12.1-13.0g and >13.1g were 43, 44, 40, 29 and 30% respectively; the highest hatchability of incubated eggs occurred in the egg weight group of 10.1-11.0g with the lowest in the egg weight group of 12.1-13.0g; indicating a decline in hatchability of incubated eggs as egg weight/ egg size increased (Alkan, et al., 2008) as shown in the present study. But the differences in hatchability of the fertile eggs could also be due to inadequate nutrition of embryo in the eggs or bad incubation.

Effect of Age and Egg Size on Dead in Shell

The hatchability of eggs is a key determinant of the income of hatchery operators. Therefore, total hatchability of incubated eggs is the hallmark at the hatchery but almost always impossible to achieve. This is because the reproductive efficiency of breeding birds decreases with age in relation to reduction in external (too large egg weight; poor shell) and

Table 3. Effect of Age on Growth and Mortality of Quail Chicks

Chick Weight (g)	Age of Birds Week 40	Week 43	Week 46	SEM	p-value
Hatching Weight	7.8^{a}	7.4^{ab}	7.0^{b}	0.0962	.013
Day 7	26.1^{a}	26.3^{a}	26.7^{a}	0.605	.824
Day 14	52.4^{b}	61.0^{a}	61.1^{a}	1.02	.006
Day 21	76.0^{a}	73.8^{a}	75.9^{a}	1.14	.390
Chick Mortality (%)	31.7^{a}	38.6^{a}	43.1^{a}	6.39	0.506

Means that carry different superscripts are significantly different; %: percentage; g: gram; SEM: Standard Error of Means; p-value: probability value (0.05)

Table 4. Effect of Egg Size on Growth and Mortality of Quail Chicks

Chick Weight (g)	Egg Size Light	Medium	Heavy	SEM	p-value
Hatching Weight	6.5^{c}	7.5^{b}	8.3^{a}	0.0962	.001
Day 7	21.2^{c}	25.1^{b}	32.8^{a}	0.605	.001
Day 14	54.6^{b}	57.4^{ab}	62.5^{a}	1.02	.013
Day 21	66.1^{c}	74.1^{b}	85.3^{a}	1.14	.001
Chick Mortality (%)	39.5^{a}	42.3^{a}	31.6^{a}	6.39	0.526

Means that carry different superscripts are significantly different; **%:** percentage; **g:** gram; **SEM:** Standard Error of Means; **p-value:** probability value (0.05)

internal (poor albumen) quality characteristics which can result to early or late embryo mortality or dead in shell (Vieira and Moran, 1998; Tona et al., 2002). In this experiment, high rate of dead in shell was observed in the eggs collected during the 46th week. However, quails at 43 weeks of age and medium-sized eggs must be prioritised when lower embryo mortality (dead in shell) is the objective of any hatchery business.

Hatching weight significantly decreased as the quails advanced in age. Also, chick weight/ growth was lowest on day 14 in eggs collected during the age of 40 weeks but not between the older age groups. Nevertheless, chick weight on days 7 and 21 was not significantly affected by age of the quails. Chick mortality was not significantly influenced by age but increased as the quails aged (Table 3).

Hatching weight of the quail chicks increased greatly as egg size increased. Growth (weight) of the quail chicks significantly increased across the days as egg size increased. Though chick mortality was not significantly affected by egg size, it was the lowest in the heavy-sized eggs followed by the light-sized eggs and the highest in the medium-sized eggs (Table 4).

Effect of Age and Egg Size on Hatching Weight of Quail Chicks

In the present study, hatching weight of the quail chicks significantly declined as the quails grew from 40-46 weeks of age. This result does not agree with Yannakopoulos and Tserveni-Gousi (1987) who reported increased chick weight as quails aged from 7-22 weeks eventhough they used younger birds than those used in this study. But Shanawany (1984) obtained a contradictory results and did not find any effect of flock age on hatching weight in broiler breeder chickens. The reduction in hatching weight could be due to the reduction in egg weight with increasing age of birds as observed in this study at 46 weeks of age; because larger eggs are known to provide more nutrients (Williams, 1994) for the norishment of embryo than smaller eggs. It could also mean retrogression of reproductive ability in older quails. Regarding egg size, hatching weight of the quail chicks increased significantly with advancement in egg size. Correspondently, Uddin et al. (1994) reported positive correlation between egg weight and hatching weight in the same breed. A previous study also showed that larger indigenous Venda chicken eggs hatched heavier chicks than smaller eggs (Ng'ambi et al., 2013). Similar results were reported by Ramaphala and Mbajiorgu (2013) who found the hatching weight (49.01, 44.13 and 42.33g) for large, medium and small size eggs from Cobb 500 chickens respectively. Chick weight was the highest in heavier eggs with the medium group having higher chick weight over the small egg group (Ayeni et al., 2018). Larger eggs contain more nutrients than smaller and medium size eggs therefore, chick weight increased as egg size increase (Williams, 1994; Ulmer-Franco et al., 2010) hence more yolk attachment at hatch (Hassan et al., 2005; Woanski et al., 2006) which was utilised by the chicks might cause the increase in hatch weight. Asuquo and Okon (1993) contradictorily observed that medium-sized eggs hatched heavier chicks than their smaller or larger counterparts without giving any biological explanations.

Effect of Age and Egg Size on Growth of Quail Chicks

The quail chicks grew faster as the parental age increased irrespective of their hatching weight – affirming the notion that, the Japanese quail is a fast growing bird (Roshdy et al., 2010). Though chick growth on days 7 and 21 did not significantly vary among the various age groups, it was significantly slow in the youngest parent group (week 40) on day 14 perhaps due to poor management or environment. Egg size had significant effect on the growth of the quail chicks as the growth decreasd with decrease in egg size. The results of the present study completely agree with Petek et al. (2003) who found higher growth rates in broiler chickens hatched from heavier eggs and their findings based on higher feed intake but partially agree with Ng'ambi et al. (2013) who found non-significant and intermittent differences in growth rate of indigenous Venda chickens though they also recorded the highest growth in the heaviest egg.

Effect of Age and Egg Size on Mortality of Quail Chicks

Chick mortality is directly a concern to farmers but can indirectly affect the operability of the hatchery industry. Lower chick mortality would mean higher income to farmers, high patronage to hatcheries and increased supply of quails to meet the consumer demand and the vice versa. Therefore, the low mortality in younger quails makes eggs from younger quails more suitable for incubation than those from older birds though the present results do not show any significant effect of age on chick mortality. In terms of chick mortality, bigger eggs are better than smaller then medium eggs. The present findings do not agree with some previous studies which showed higher mortality rates for chicks produced from heavier eggs than smaller eggs (Alabi et al., 2012b; Ng'ambi et al., 2013).

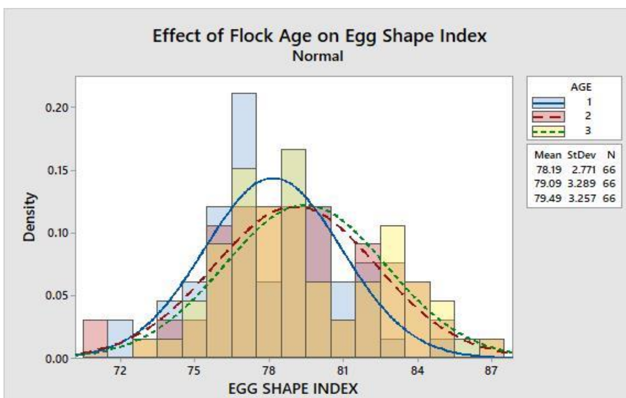

Figure 1. Effect of Egg Size on Egg Shape Index

Age of the quails significantly affected the egg shape. The highest egg shape index (79.5%) was recorded in the oldest age group followed by 79.1% at the age of 43 weeks. The lowest egg shape index (78.2%) was observed at the youngest age (Figure 1). Figure 2 shows that egg shape index was significantly influenced by egg size. The highest egg shape index (79.7%) was found in the medium class followed by the small class (79.6%) and the lowest egg shape index (77.5%) was recorded in the heavy egg class (Figure 2). The results indicate significant but intermittent age and egg size interaction effect on the shape of the Japanese quail eggs. However, the least (77.3%) and the highest (81.2%) egg shape indexes were recorded in the heavy and medium eggs collected during the 40th and 46th weeks of age, and in the small eggs collected at the age of 40 weeks. Generally, egg shape index ranged from 77.3 to 79.7% across the ages and egg sizes (Figure 3).

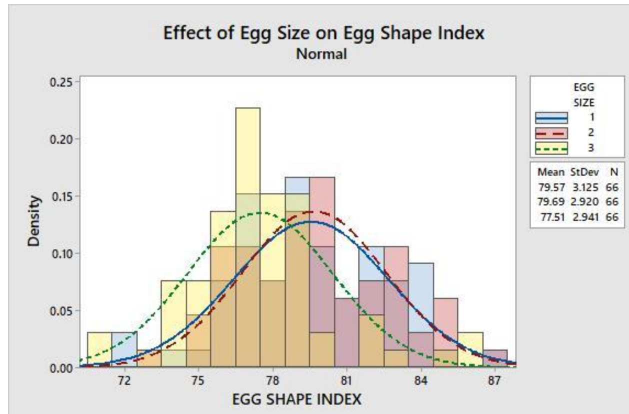

Figure 2. Effect of Egg Size on Egg Shape Index

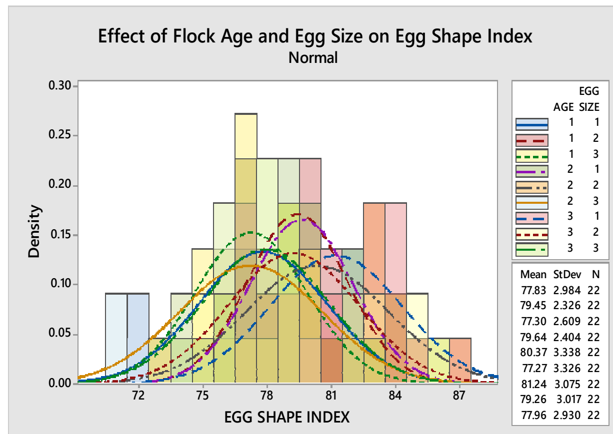

Figure 3. Effect of Age and Egg Size on Egg Shape Index

Effect of Age, Egg Size and their Interaction on Egg Shape Index

Egg shape is the ratio of egg width to egg length express as a percentage (Cavero and Schmutz, 2009). Egg shape does not attract the attention of farmers and consumers and less regarded by most researchers; but determines consumers' acceptability because round eggs are known to break easier than elongated ones (Alsobayel and Albadry, 2011). The trait, however, is prime in the hatchery enterprise due to its influential effect on embryonic development and egg hatchability (Ayeni et al., 2018). Low hatchability had been associated with rounder eggs because they fit improperly into setter trays during incubation (Icken et al., 2006; Cavero and Schmutz, 2009; Blanco et al., 2014). Though there is no ideal egg shape for domestic quail egg. According to Altuntas and Şekeroğlu (2008), eggs from all the egg size groups at all the ages are round (> 76%) and so inappropriate for higher hatchability (Icken et al., 2006; Cavero and Schmutz, 2009; Blanco et al., 2014). This would inecrease hatchery losses and decrease farmers' interest in keeping the bird especially in areas where they are newly emerging. Moreover, eggs collected from the quails of all ages had shape indexes close to the egg shape indexes propagated by Aygun (2013) for the domestic chicken. The increasing order of egg shape index of the eggs with age means that as the quails grew, their eggs became rounder – which is not good for high hatchability (Icken et al., 2006; Cavero and Schmutz, 2009; Blanco et al., 2014) and so eggs from older quails should be the least choice for hatching purposes. The results showed that hatchability was the highest in heavier quail eggs in comparison to their lighter types due to the lowest egg shape index noted by the former; because low egg shape index means elongated eggs that would fit well into setter trays (Icken et al., 2006; Cavero and Schmutz, 2009; Blanco et al., 2014). Egg shape was intermittently affected by the combined effect of the quails'age and egg size. In generality, the shape of quail eggs was significantly affected by age of the birds and the size of the eggs, thus hatchery operators should be circumspect of the age of laying birds as well as the size of eggs they collect and set for incubation. Results from the combined effect of age and egg size show that heavier eggs from younger quails had better (lower) shape for increased hatchability. But such eggs would not come from quails that are older than 43 weeks.

CONCLUSION

Fertility was highest in the youngest quail group but hatchability was highest at 43 weeks of age.The highest egg weight loss during incubation was recorded on day 12 at 46 weeks of age. The heavy eggs lost more weight during incubation than the smaller group. More embryos died in shell in eggs collected at 46 weeks of age. The highest fertility and hatchability, and the lowest dead in shelll were recorded in the medium eggs. Large and heavy quail eggs improved hatching weight and chick growth at all ages. Chick mortality was lowest in the younger quails and the heavy eggs. Egg shape was lowest (mostly oval) in the heavy and medium quail eggs at 40 and 46 weeks of age. Generally, egg shape, fertility, hatchability, chick weight and growth can be influenced by age, egg size and or their interaction.Therefore, hatchery operators must be careful of the age of birds and size of eggs before chosing eggs for incubation especially when chick weight is the prime objective.

AUTHOR CONTRIBUTIONS

The research idea was conceived by Vida Korkor Lamptey and Gabriel Adu-Aboagye. The proposal for the work was developed by Francis Kruenti and Maxwell Ansong Okai and the experiment conducted with technical advice from Gabriel Adu-Aboagye. Data was collected by Francis Kruenti, Maxwell Ansong Okai, Akua Druwaa Oduro-Owuso, Fredrick Bebanaayele and Bridget Suurbessig. Hatchery opreations were managed by Fredrick Bebanaayele and Bridget Suurbessig. Francis Kruenti analysed the data and wrote the manuscript. Maxwell Ansong Okai and Vida Korkor Lamptey proof read and it was finalized by Francis Kruenti.

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COMPETING INTERESTS

The authors have no conflict of interests.

ETHICS APPROVAL

Not applicable

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