Archiva Zootechnica 28:1, 157-166, 2025
DOI: 10.2478/azibna-2025-0009

Comparative fertility and hatchability of quail eggs based on storage days and egg measurements

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ABSTRACT

Fertility and hatchability of quail eggs as influenced by different pre-incubation storage days and some egg measurements were evaluated. The eggs were sourced from the quail breeding unit on the Lagos State University Livestock Farm where the hens are naturally mated by the male in cages, at the ratio of 1:4, male to female ratio. Eggs were collected over a 14-day period on a daily basis from the cages and stored at room temperature. The eggs were labelled and assigned unique ID indicating the cage, day of lay and serial number within the cage. Measurements of the eggs weight, length, width, horizontal circumference, vertical circumference, egg volume by water displacement was determined, the storage days was determined by constructing five ordinal groups of three days each. A total of 535 eggs were set in incubator, candled at the 14th day of incubation and evaluated for fertility. Fertile eggs were identified and set in the hatcher for the last three days of incubation. The number of fertile eggs and hatched chicks were recorded. Counts of fertile eggs and hatched chicks were made for estimation of fertility and hatchability of the eggs. Fertility was highest (85.80%) in the A group (0 – 2 days) which consistently declined to 25.53% in the E group (12 – 14 days). Hatchability followed the same trend with the A group recording the highest value (81.38%) of the fertilized eggs, while the D group (9 – 11 days) had the least hatchability of 21.05%. The Chi-squared test of independence of storage days on fertility and hatchability were both highly significant ($P<0.001$). The binary logistic regression revealed that egg volume and storage days were the only significant ($P<0.05$) sources of deviation on fertility of eggs, while egg width and storage days were both highly significant ($P<0.01$) on hatchability of quail eggs. The study revealed that quail eggs are best stored for not more than one week for higher fertility and hatchability.

Keywords: Quail, storage days, egg sizes, fertility, hatchability

INTRODUCTION

Quails are small birds that get reared for meat and egg production (Arunrao *et al*., 2023), characterized by relatively shorter production cycle with up to four generations per annum (Nasar *et al*., 2016), a higher egg laying rate, and a healthier source of meat and egg products (Taha *et al*., 2019).

Sustainable and successful quail production is hinged on a steady supply of day-old chicks from the hatcheries whose productivity is greatly influenced by fertility and hatchability of incubated eggs. Fertility and hatchability are important economic factors (Hristakieva *et al*., 2022) and both represent the major components of reproductive performance which are sensitive to environmental and genetic factors (Abd El-Hack *et al*., 2019 and Widiyaningrum *et al*., 2016).

Aside from genetics, breeder age, nutrition, egg quality and incubator / hatcher factors, pre-incubation storage temperature and relative humidity can affect fertility and hatchability of eggs (Attila 2020, Archer *et al.,* 2017 and Ramil *et al.,* 2017). Thus, the duo challenges of inimical environmental conditions of the study area, Epe-Lagos, Nigeria with high ambient temperatures and relative humidity coupled with underdeveloped infrastructure and epileptic electricity supply to attenuate these hostile environmental effects on egg fertility and hatchability makes this study a worthy effort.

The study aims to estimate and investigate the influence of pre-incubation storage periods and egg measurements on fertility and hatchability of quail eggs and make appropriate recommendations on the optimal storage days prior to incubation for successful hatchery operations and optimal return on investment.

MATERIALS AND METHODS

Study Site

This study was conducted at the hatchery of the Livestock Farm, School of Agriculture, Lagos State University, Epe, Lagos situated at latitude 6°35‘34.7”N and longitude 3°59’56.9”E. The study site is located in the humid tropical region with average temperature of 28^{0}C, humidity of 56% and annual average rainfall of 1230mm.

Experimental Units

A total of 150 sexually matured quail birds comprising 120 female and 30 male chicks were housed in 15 cages, each cage consist of 8 female and 2 male chicks. Eggs were daily picked from the cages for a period of 14 days.

Management Practices

The quail birds were fed commercially compounded layer 1 ration comprising 16.50% crude protein and 2650Kcal metabolizable energy as indicated in Table 1. The birds were fed daily 10% of average body weight divided into two for morning and evening feeding. Water was freely given *ad libitum* to the birds all through the experiment.

Table 1. Proximate composition of Layer 1 Crumble feed used in the study**

Content	Proportion
Crude Protein (Min)	16.50%
Crude Fat (Min)	4.50%
Crude Fibre (Max)	5.00%
Calcium (Min)	3.60%
Av. Phosphorus (Min)	0.45%
Lysine (Min)	0.80%
Methionine (Min)	0.40%
Metabolizable Energy (Min)	2650Kcal/kg

**Chikun Layer 1 Crumble

Egg Collection and Handling

The eggs were collected daily from the birds for 14 days and were cleaned and tagged with a paper tape for labelling. The egg IDs were written on the paper tape, and the tape was pasted near the narrow end of the eggs. Eggs were kept in a cool and dry place, prior to incubation.

In all 606 quail eggs were collected from the birds during the period of study and each egg was tagged and labelled using the cage number, date of lay and egg serial number within the cage and day.

The eggs were checked for any deformities before they were placed in the setting tray, and out of the total 606 eggs collected, a total of 535 eggs were selected for incubation after physically examining the eggs for their quality, while the excluded 71 eggs comprised of cracked, malformed or thin shelled eggs which were disposed. The incubator was cleaned and disinfected before setting the eggs, while the eggs were cleaned and sanitized before placing in the incubator.

Incubation and Hatching of Eggs

The eggs were set in an automatic incubator model (Sportman 1320) with a preset temperature of 100.5°F and optimal relative humidity between 55 and 60%. The incubator was set to turn the eggs at hourly interval.

Eggs were candled on the 14th day of incubation to test for fertile eggs based on the opaqueness of the egg when light is passed through it in the candling box. At this stage, all non-fertile, cracked or bad eggs were removed from the incubator and the fertility (%) was estimated. The fertile eggs were placed in the hatching tray and records of hatched, pipped and dead in shell birds were recorded.

Data Collection

Soon after lay and prior to storage, data was collected on the egg weight (g), egg length (mm), egg width (mm), vertical circumference (cm), horizontal circumference width (cm) and the volume (ml).

Egg weight was measured using a digital scale sensitive to 0.00g, while the length and width were measured with a digital Vernier calliper sensitive to 0.00mm. Vertical and horizontal circumferences were determined using a graduated flex tape along the length and width of the egg. Egg volume is by water displacement using a 50ml beaker where the difference in the initial volume of water and rise in volume of the water in the beaker was taken to be the egg volume.

Data handling and manipulation

Data collected were entered and stored in a Microsoft Excel® worksheet. Ordinal classes were constructed for the number of days in storage before incubation as; A (0-2), B (3-5), C (6-8), D (9-11) and E (12-14) days respectively.

Statistical Analyses

All statistical analyses were conducted using Minitab® Statistical Software (Version 17). Statistical analyses included: counts, proportions, basic descriptive, Chi squared test of independence and binary logistics regression.

The dependent variable for binary logistic regression is a categorical variable with two categories (denoted as y in equation 1) which in this instance for fertility is either fertile or non-fertile, and in the case of hatchability, the binary outcome is either hatched or not hatched. This event is transformed using the logit transformation into a probability ranging from 0 to 1 (equation 1) in the statistical model (Harris, 2021).

A statistical form of the binary logistic regression model is given as;

$$p\ (y) = \frac{1}{1+e^{-(b_0+b_1x_1+b_2x_2)}}$$

where p(y) stands for the probability of one category (fertile) of the dependent variable y, the b are coefficients of the independent variables or predictors, and the x are the independent variables.

RESULTS AND DISCUSSION

Egg distribution by storage days

Eggs collected across the five storage days group accounted for 31.59%, 30.28%, 18.50%, 10.84% and 8.79% respectively of the 535 eggs incubated. There was a consistent decline in the proportion of eggs that were laid as the storage days increased (Table 2). The consistent decline in the number of eggs set as storage day increases was due to the fact that some eggs that had physical or obvious errors (malformed, cracked or broken) were eliminated prior to egg setting, and such incidence increases with days in storage.

Egg fertility by storage days

Storage days group A (0 – 2 days) accounted for 37.37% of all fertile eggs across the five groups and 85.80% of the within group fertile eggs (Tabel 2). These values consistently decreased as storage days increased, with the least proportion recorded in group E (12 – 14 days) which accounted for a meagre 3.09% of fertile eggs across the groups, and 25.53% of within group fertility. Storage days group E accounted for only 8.79% of total eggs set (Table 2).

Table 2. Distribution of eggs by fertility and storage days

Egg Status	A (0-2 days)	B (3-5 days)	C (6-8 days)	D (9-11 days)	E (12-14 days)	Total
Fertile	145	138	74	19	12	388
Non fertile	24	24	25	39	35	147
Total	169	162	99	58	47	535

The consistent decline in the proportion of fertile eggs with increasing storage days may be attributed to the fact that embryonic development in fertile eggs commence as soon as eggs are laid except when such eggs are kept under environmental conditions that prevents further development of the embryo. Since these eggs were stored at room temperature, it is expected that the longer the pre-incubation storage days, the higher the risk of such eggs not been fertile since the prevailing environmental condition is inimical to the further growth and development of the embryo. This observation is consistent with the report of Taha *et al*. (2019) who reported that there was significant decrease in the fertility of Japanese quail eggs ranging from 96.46% to 78.62% with increasing storage time.

With an estimated Pearson Chi-Square value of 126.33 in the test of independence of egg storage days and fertility of the quail eggs, the probability of this been due to chance alone is very unlikely and thus is highly significant ($P<0.0001$). This therefore confirms that there is a very strong association between fertility and storage days of quail eggs.

Egg hatchability by storage days

As storage time increases from groups A to D, hatchability markedly decreases with marginal increase in group E (Figure 1). Expectedly this trend is similar to the proportions of non-hatching eggs which conversely increases with increasing storage time. Eggs that were stored for longer periods prior to incubation had significantly (P<0.05) lower hatchability as a result of increased embryonic mortality when compared to eggs from that were stored for shorter periods. This observation is in agreement with report of Özlü (2021) who reported similar observation.

Storage duration is a critical factor in determining the hatchability of quail eggs, with shorter storage times leading to higher hatchability, while longer storage results in significantly increased the proportion of non-hatching eggs.

The marginal surge in hatchability recorded in group E (12 -14 days) after the consistent decline with increasing storage days may be attributed to the relatively smaller number of fertilized eggs (n=12) recorded in that group.

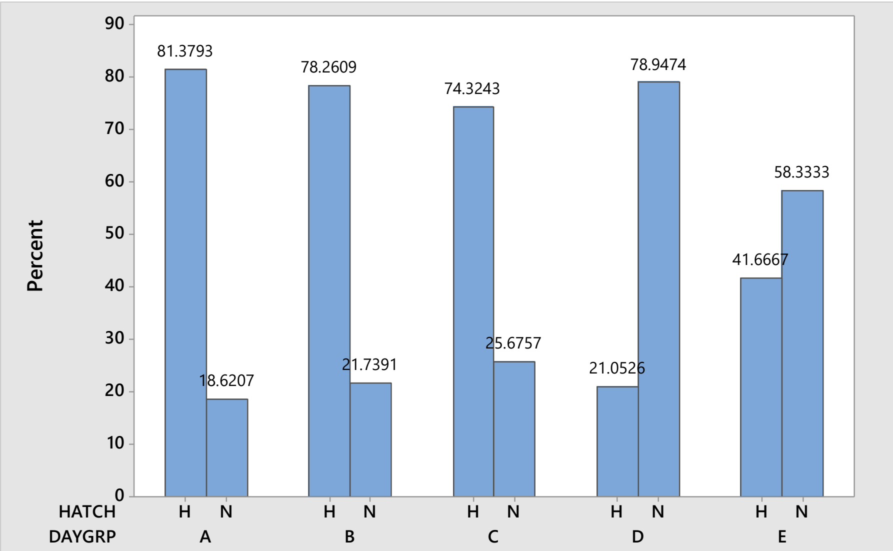

Figure 1: Distribution of fertile eggs by hatchability and storage days

The decrease in the number of chicks hatched as storage days increases indicated that hatchability declines with increased egg storage days due mostly to the loss of moisture content and carbon dioxide through the eggshell pores as supported by Abou-Kassem *et al*. (2024) who reported that longer storage times leads to lower hatchability and as storage periods increase, the eggs lose moisture and CO_2 through eggshell pores, the yolk and albumen pH rise and the vitelline and albumen height decreases. The timing of the carbon dioxide loss is crucial as excessive Carbon Dioxide loss during egg storage raises the pH of the albumen which could be detrimental to the survivability of the developing embryo, thereby resulting in increased of embryonic death.

Other researchers (Ayeni *et al*., 2020; Molapo *et al*., 2021; Nasri *et al*., 2019 and Salamon, 2020) similarly reported that pre incubation egg storage time impact hatchability of the eggs.

Effects of egg sizes on fertility of eggs

The likelihood of egg fertility in the entire study was 72.52%. The deviance from the binary logistic regression for egg sizes on fertility indicated that the seven variables studied accounted for 19.31% of the total deviance, and Akaike Information Criterion (AIC) of 523.63. Out of the seven variables studied, only egg volume and storage days exerted significant (P<0.05) influence on fertility of the eggs (Table 3).

The deviance regression equation is given as: Y' = 1.70 + 0.385 EGGWT + 0.062 EGGLT + 0.072 EGGWD - 0.1034 CIRLT + 0.0694 CIRWD - 0.277 VOL - 0.2716 STORAGE DAYS

Egg weight has a coefficient of 0.385, though not a significant (P>0.05) source of variation, which indicated that as egg weight increases, fertility is slightly more likely to increase. It is noteworthy that the influence of egg weight Sizes of the eggs has an impact on the fertility of eggs (Agaviezor *et al*., 2020) who reported that maximum fertility was observed in light and medium weight eggs. However, Storage days had a coefficient of -0.2716 which indicated a negative relationship between storage days and fertility. This implies that longer pre-incubation storage reduces fertility in the eggs.

Table 3. Deviance table of egg sizes on fertility and hatchability

	Fertility		Hatchability	
Source	**df**	**Mean square**	**df**	**Mean square**
Egg weight (EGGWT)	1	3.6556	1	0.0129
Egg length (EGGLT)	1	0.3406	1	2.4279
Egg width (EGGWD)	1	0.2512	1	8.5445**
Length Circumference (CIRLT)	1	1.8206	1	1.5040
Width Circumference (CIRWD)	1	1.4062	1	1.0308
Egg Volume (VOL)	1	4.2706*	1	0.0030
Storage Days	1	89.6702***	1	22.1571***
Error	527	0.9632	380	1.0203

*=p<0.05, **=p<0.01, ***p=<0.001

The measure of association between the response variable and predicted probabilities indicated a Concordant and Discordant pairs of 77.0% and 22.6% respectively with Ties of 0.4%.

Effects of egg sizes on hatchability of eggs

The probability of hatchability of fertile eggs in the study was 74.74%. Two out of the seven egg sizes investigated (egg width and storage days) were highly significant ($P<0.01$) sources of variation in the deviance of the egg sizes on hatchability (Table 3), with 11.59% of the total variation explained by the model, with an AIC of 403.73.

The direct relationship between egg width and hatchability suggests that the higher the egg width, the more likely such eggs will hatch, whereas the reverse is the case with storage days that had an inverse association with hatchability, indicating that longer storage days decreases the likelihood of hatching.

The binary logistic regression equation for hatchability is represented as:

$$Y' = -2.65 + 0.027\ EGGWT - 0.176\ EGGLT + 0.562\ EGGWD - 0.1065\ CIRLT + 0.0684\ CIRWD + 0.009\ VOL - 0.1898\ STORAGE\ DAYS.$$

The Concordant and Discordant pairs in the measures of association had 70.6% and 29.0% respectively with Ties of 0.5%.

CONCLUSION

Fertility and hatchability of quail eggs can be impacted by the length of the pre-incubation storage days.

Fertility declines with increasing storage days prior to incubation.

Hatchability of fertile eggs are negatively impacted by the length of pre-incubation storage.

Binary logistic regression revealed that fertility was significantly ($P<0.05$) influenced by egg volume and storage days, while hatchability was highly significantly ($P<0.001$) influenced by egg width and length of storage days.

Eggs should be stored for more than one week prior to incubation for higher fertility and hatchability of the incubated eggs.

Results from this study should be further explored to identify other non-genetic factors affecting fertility and hatchability of quail eggs.

ACKNOWLEDGEMENTS

The authors wish to appreciate all members of the Graduating Students of the 2023/2024 academic session under our supervision for their roles in animal handling and data collection during the course of this study.

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