**Journal of Applied Biosciences 214: 22689 – 22697**
**ISSN 1997-5902**

# Effects of egg weight variation on growth and reproductive performance of Japanese quail (*Coturnix japonica*) raised in Côte d'Ivoire

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Submitted 20/08/2025, Published online on 30/11/2025 in the https://www.m.elewa.org/journals/journal-of-applied-biosciences-about-jab/ https://doi.org/10.35759/JABs.214.2

## ABSTRACT
*Objective:* The purpose of this investigation was to study the effect of egg weight (W) variation on the growth and reproductive performance of Japanese quail.
*Methodology and Results:* The study was conducted at the Ismorel farm in the town of Adiaké. The 2002 collected eggs were divided into three classes: 520 for small eggs (W < 10.5 g), 932 for medium eggs (10.5 g ≤ W ≤ 11.5 g) and 520 for large eggs (W > 11.5g). The test was conducted over one year with three replications. The results showed a highly significant difference ($p < 0.001$) for hatching rate and non-significant ($p > 0.05$) for fertility rate and embryonic mortality. A strong correlation ($r = 0.70$; $p < 0.01$) was observed between egg weight and quail hatching weight. A significant effect ($p < 0.05$) of egg weight on quail weight during growth was demonstrated. Thus, the laying rate and mortality at growth and laying did not differ significantly ($p > 0.05$) for the egg and quail classes formed. However, the weight of eggs laid and mortality at start-up were influenced at $p < 0.05$ and $p < 0.01$ respectively by the weight of eggs formed at the start of the experiment.
*Conclusion and application of results:* Quail eggs weighing between 10.5 and 11.5 g produced the best reproductive performance. Quail farmers should use eggs weighing between 10.5 and 11.5 g to maximize the profitability of their farms.
**Keywords**: Quail, reproduction, quail chick

## INTRODUCTION
Quail are bred for egg and meat production, and both vary from continent to continent (Tuan and Dan, 2022). Fertility and hatchability of eggs were higher for heavy weight eggs (10.1 to 11.00 g) compared to light weight eggs (7.01 to 8.90 g) (Khalil *et al.*, 2020). Shanaway and Saadeg (2021) showed high fertility and hatchability in Japanese quail with a weight of 10.6 to 11.5 g. In contrast, Genç and Sahin (2020) reported that egg

weight had no effect on fertility and hatching of quail eggs. Raji *et al*. (2014) found good fertility, hatching rate of quail eggs with egg weight greater than 10 g. Martinez and Lee (2022) indicated that eggs with very low and too high weights did not have good fertility and hatching rates. Eggs classified into two weight groups (weight below 32 g and above 32 g) showed significant difference ($P<0.05$) in embryonic mortality rate (Moustafa, 2017) the opposite is proved by Seker *et al*. (2004) in Japanese quail. Studies have been conducted between egg weight and day-old chick weight by various authors (Tůmová and Gous, 2012; Kucukyilmaz *et al*., 2001). Klein *et al*.(2023) who studied the effects of egg weight (11.0 to 11.9 g, 12.0 to 12.9 g and 13.0 to 13.9 g) on chick weight (6.98 g, 7.56 g and 8.39 g ) of Japanese quail finally determine a correlation coefficient of 0.67 ($p <0.01$). The fact that the onset of productive age is closely related to average body weight is well known (Chen and García (2023). Early egg weight is influenced by bird weight and development during the growth phase (Braz *et al*., 2011). Kashmiri *et al*. (2011) showed that there was no significant difference between egg weights from heavy (150-160 g) and light (120-130 g) quail. The objective of this study was to evaluate the effect of egg weight on growth and reproductive parameters of Japanese quail (*Coturnix japonica*).

## MATERIALS AND METHODS

**Site and egg classes:** The present work was carried out at the Ismorel farm, 2 kilometres from the town of Adiaké (5°17'06" N latitude and 3°18'07" W longitude) located in the South-East of Côte d'Ivoire. A total of 2002 quail eggs were collected successively over three days from 18-week-old females. These eggs were classified into three groups including 532 for small eggs ($W < 10.5$ g), 946 for medium eggs ($10.5 \text{ g} \leq W \leq 11.5$ g), and 524 for large eggs ($W > 11.5$g) with mean weights ($10 \pm 0.49$ g; $11 \pm 0.23$ g; and $12.38 \pm 0.73$ g), respectively.

**Incubation:** The incubator was disinfected and preheated two days before the arrival of the quail eggs. The eggs were arranged in trays so that all classes were represented in each tray. During the 14-day quail incubation, the temperature was 37.8°C and the relative humidity was 60%. The eggs were turned twice a day after 3 days of incubation until day 14. On day 14, the eggs were transferred to hatcher trays at 37.5°C and 70% relative humidity so that each class was present in a hatcher tray. After day 17, which represents the day of maximum hatching, the quail chicks were collected according to the different predefined classes for their transfer to the brooder.

**Rearing and Management of Quail Chicks:** The brooder was disinfected and preheated by the radiant heater before the arrival of the quail chicks. Each class of quail was subdivided into 3 groups according to the egg classes. The troughs and rearing house were washed and cleaned daily. The animals were provided with natural light. Water and feed for the quails were given *ad libitum*. The feed composition was made according to the rearing phases. Table I represents the centesimal mass composition.

**Table 1:** Quail feed mass composition (centesimal)

| | **Rearing phases** | | |
|---|---|---|---|
| Raw material | Start-up | Growth | Laying |
| Maize % | 58.9 | 59.8 | 48.2 |
| Soybeans % | 20 | 16 | 16 |
| Wheat % | 15 | 18 | 25 |

| | | | |
|---|---|---|---|
| Fish % | 1.1 | 1 | 2 |
| Shellfish % | 0 | 0.2 | 3.8 |
| Pre-mixed % | 5 | 5 | 5 |
| Total % | 100 | 100 | 100 |

**Growth and reproduction parameters:** The collected eggs were weighed on the same day. The quail were weighed with an electronic scale of sensitivity 1/100 mg of brand DIGITAL BALANCE on the first day and every weekend until the fifth week according to the different classes. The mortality rate was evaluated during the three phases of rearing. The laying rate was calculated per day on each class. Hatching rate, fertility and embryonic mortality were determined on each class considering hatched and unhatched eggs that were subsequently broken. All these parameters are recorded in Table 2.

**Table 2:** Different calculation parameters

| Parameters | Formulas |
|---|---|
| Mortality rate (MR) = | $\frac{\text{Number of dead birds}}{\text{Number of placed birds}} \times 100$ |
| Laying rate (LR) = | $\frac{\text{Total number of eggs laid}}{\text{Number of live quails}} \times 100$ |
| Hatching rate (HR) = | $\frac{\text{Number of eggs hatched}}{\text{Total number of eggs incubated}} \times 100$ |
| Fertility rate (FR) = | $\frac{\text{Total number of embryos}}{\text{Total number of incubated eggs}} \times 100$ |
| Embryo mortality rate (EMR) = | $\frac{\text{Number of dead embryos}}{\text{Total number of embryos}} \times 100$ |

**Statistical analysis:** The collected data such as hatching rate, fertility rate and embryonic mortality rate, were analysed using the Chi-square test. The data of the laying rate and the comparison between the different starting egg weights were subjected to an analysis of variance (ANOVA) with the software R Studio version 3.1.3 and the graphs assigned to these data were made using Excel software. The data on the weight of the quails from the first day to the 35th day, were submitted for an analysis of covariance (ANCOVA). Pearson's correlation was used between the starting egg weight and the initial quail weight. All these data were considered significant at the 5% level.

## RESULTS

**Comparison of the different weight classes of eggs and starting quail chicks:** Statistical analyses showed a significant difference ($p < 0.05$) between the mean weights of different egg weight classes formed at the start of the experiment (Table 3). This significant difference was also true for the quail chicks from these different egg weight classes. The average weight of eggs and quail was high for eggs in W class > 11.5 g and lower for those in

W class < 10.5 g. A strong correlation (r = 0.70; p < 0.01) was observed between egg weight and quail chick weight at hatching.

**Table 3:** Comparison of average egg weight (W) and average quail weight by egg weight class

| | Egg class (g) | | |
|---|---|---|---|
| | W < 10.5 | 10.5 ≤ W ≤ 11.5 | W > 11.5 |
| Number of eggs | 532 | 946 | 524 |
| Average egg weight | 10.00 ± 0.49 [c] | 11,00 ± 0.23 [b] | 12.38 ± 0.73 [a] |
| Number of quail chicks | 226 | 606 | 338 |
| Average quail chick weight | 6.45 ± 0.53 [c] | 7.33 ± 0.52 [b] | 8.02 ± 0.52 [a] |

The mean values designated in line with the different letters (a, b, and c) differ significantly at p < 0.05

**Effect of egg weight on fertility, hatching and embryonic mortality rates:** Egg weight showed no significant difference (p > 0.05) in fertility rate and embryonic mortality (Table 4 and 5). However, a highly significant difference (p < 0.001) was observed by egg weight on hatching rate. Eggs from egg weight classes 10.5 ≤ W ≤ 11.5 g and W > 11.5 g showed similarity in hatching rate at 69.49 and 68.98%, respectively, while those from W < 10.5 g showed hatching rate at 47.48% (Table 4).

**Table 4:** Fertility and hatching rates according to egg classes formed

| Variables | Egg class (g) | N | Fertile eggs Hatched eggs | Fertility and hatching % | Khi-2 | P-value | Sign <0.05 = * |
|---|---|---|---|---|---|---|---|
| Fertility rate | W < 10.5 | 520 | 476 | 91.54 | 0.12 | 0.94 | NS |
| | 10.5 ≤ W ≤ 11.5 | 932 | 872 | 93.56 | | | |
| | W > 11.5 | 520 | 490 | 94.23 | | | |
| Hatching rate | W < 10.5 | 476 | 226 | 47.48 | 1.32 | 0.00 | *** |
| | 10.5 ≤ W ≤ 11.5 | 872 | 606 | 69.49 | | | |
| | W > 11.5 | 490 | 338 | 68.98 | | | |

***: Very high significant difference; NS: No significant difference; N: Eggs number

**Table 5:** Embryo mortality rate according to egg classes

| Egg class (g) | N | Dead embryos | Embryonic mortality % | Khi-2 | P-value | Signe <0.05 = * |
|---|---|---|---|---|---|---|
| W < 10.5 | 490 | 152 | 31.02 | 0.12 | 0.94 | NS |
| 10.5 ≤ W ≤ 11.5 | 872 | 264 | 30.27 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| W > 11.5 | 476 | 148 | 31.09 | | | |

NS : No significant difference

**Effect of egg weight on quail weight growth:**The results of this experiment justified a significant difference ($p < 0.05$) in quail weights according to the egg and quail classes highlighted for this study. This difference in weight is favourable for quails coming from egg weights of W > 11.5 g and unfavourable for those of W < 10.5 g (Table 6).

**Table 6:** Weekly quail weight according to the egg classes formed

| | Quail weight per week (w) | | | | | | |
|---|---|---|---|---|---|---|---|
| Egg class (g) | w0 | w1 | w2 | w3 | w4 | w5 | Average |
| W < 10.5 | 6.45 ± 0.53 $^{c}$ | 21.83 ± 0.65 $^{c}$ | 61.11 ± 1.26 $^{b}$ | 98.11 ± 1.68 $^{b}$ | 130.29 ± 2.29 $^{c}$ | 151.66 ± 2.32 $^{b}$ | 93.89 ± 1.25 $^{b}$ |
| 10.5 ≤ W ≤ 11.5 | 7.33 ± 0.52 $^{b}$ | 23.53 ± 0.48 $^{b}$ | 65.41 ± 1.69 $^{ab}$ | 102.78 ± 2.27 $^{a}$ | 134.78 ± 3.08 $^{b}$ | 155.07 ± 3.12 $^{ab}$ | 97.91 ± 2.18$^{ab}$ |
| W > 11.5 | 8.02 ± 0.52 $^{a}$ | 24.84 ± 0.63 $^{a}$ | 71.16 ± 1.63 $^{a}$ | 102.01 ± 2.19 $^{ab}$ | 137.36 ± 2.97 $^{a}$ | 156.00 ± 3.01 $^{a}$ | 99.88 ± 2.19 $^{a}$ |

The designated mean values in the column with different letters (a, b and c) differ significantly at $p < 0.05$

**Effect of egg weight on egg laying and laying rate of quails:**The onset age of laying was 37 days for quails from eggs weighing W > 11.5 g, 41 days for quails from eggs weighing 10.5 ≤ W ≤ 11.5 g and 44 days for those from W > 11.5 g eggs. Indeed, during the whole study period, the laying rate was not influenced by the weight of the quails selected according to the weight of the eggs of established classes (Table 7). However, in the fifth month, a significant difference ($p < 0.05$) was recorded in the three egg classes formed. The egg laying peak was observed at the second month age of the quails according to the egg groups initiated at the beginning of the trial.

**Table 7:** Laying rate of quails by egg class and time

| **Egg Class (g)** | **Age at laying (days)** | **Laying rate (%) per month (M)** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **M1** | **M2** | **M3** | **M4** | **M5** | **Average** |
| W < 10.5 | 44 | 73.40 ± 28.28 $^{a}$ | 94,67 ± 5,37 $^{a}$ | 85.00 ± 4.93 $^{a}$ | 80.33 ± 6.09 $^{a}$ | 77.62 ± 3.08 $^{b}$ | 82.20 ± 15.11 $^{a}$ |
| 10.5 ≤ W ≤ 11.5 | 41 | 76.67 ± 25.83 $^{a}$ | 91,33 ± 7,04 $^{a}$ | 83.84 ± 4.94 $^{a}$ | 81.56 ± 3.36 $^{a}$ | 80.02 ± 3.25 $^{a}$ | 82.68 ± 13.15 $^{a}$ |
| W > 11.5 | 37 | 79.00 ± 23.69 $^{a}$ | 93,11 ± 6,43 $^{a}$ | 84.22 ± 4.37 $^{a}$ | 82.67 ± 3.65 $^{a}$ | 82.11 ± 3.21 $^{a}$ | 84.22 ± 12.18 $^{a}$ |
| Average | 40.67 | 76.36 ± 25.81 $^{c}$ | 93.04 ± 6.39 $^{a}$ | 84.36 ± 4.73 $^{b}$ | 81.52 ± 4.58 $^{bc}$ | 79.92 ± 3.65 $^{bc}$ | 83.04 ± 13.55 |

The mean values designated in column and row for the means with the different letters (a, b and c) differ significantly at $p < 0.05$

**Characteristics of the weight of eggs laid according to the different classes of quail and time:** There was a significant difference ($p < 0.05$) in the average egg weight in the first, third and fourth months of the trial between the groups of animals formed according to the egg classes formed. In contrast, the average egg weight in the second and fifth month did not show a significant difference ($p > 0.05$). In general, a significant difference ($p < 0.05$) was observed throughout the experiment for the formed groups. This difference is appreciable

for animals from egg weights at W > 11.5 g (Table 8).

**Table 8:** Characteristics of the laid eggs weight according to the different classes of quail and time

| Egg class (g) | Egg weight (g) per month (M) | | | | | |
|---|---|---|---|---|---|---|
| | M1 | M2 | M3 | M4 | M5 | Average |
| W < 10.5 | 9.39 ± 0.52 [b] | 10.07 ± 0.64 [a] | 10.41 ± 0.59 [a] | 10.67 ± 0.78 [b] | 11.23 ± 0.92 [a] | 10.35 ± 0.93 [b] |
| 10.5 ≤ W ≤ 11.5 | 9.60 ± 0.59 [ab] | 10.24 ± 0.56 [a] | 10.59 ± 0.64 [ab] | 10.72 ± 0.70 [b] | 11.44 ± 0.96 [a] | 10.52 ± 0.92 [b] |
| W > 11.5 | 9.85 ± 0.67 [a] | 10.31 ± 0.68 [a] | 10.82 ± 0.65 [a] | 11.07 ± 0.86 [a] | 11.52 ± 0.97 [a] | 10.72 ± 0.97 [a] |
| Moyenne | 9.61 ± 0.62 [d] | 10.21 ± 0.63 [c] | 10.61 ± 0.65 [b] | 10.82 ± 0.79 [b] | 11.39 ± 0.95 [a] | 10.53 ± 0.95 |

The mean values designated in column and row for the means with the different letters (a, b and c) differ significantly at $p < 0.05$

**Effect of egg weight on quail mortality rate for different egg classes:**In the experiment, the mortality rate at start-up was significantly ($p < 0.05$) influenced by the egg weight on the quail chicks. However, during the growth and laying phase, no significant differences ($p > 0.05$) were found between the groups of animals formed.

**Table 9:** Quail chicks mortality rates by egg and quail class

| Rearing phases | Egg class (g) | Total number | Dead individuals | Mortality rate % | Kh-2 | P-value | Sign <0.05 = * |
|---|---|---|---|---|---|---|---|
| Start-up | W < 10.5 | 226 | 11 | 4.47 | 9.75 | 0.00 | ** |
| | 10.5 ≤ W ≤ 11.5 | 606 | 7 | 1.16 | | | |
| | W > 11.5 | 338 | 9 | 2.66 | | | |
| Growth | W < 10.5 | 215 | 3 | 1.4 | 1.73 | 0.41 | NS |
| | 10.5 ≤ W ≤ 11.5 | 599 | 5 | 0.83 | | | |
| | W > 11.5 | 329 | 6 | 1.83 | | | |
| Laying | W < 10.5 | 160 | 1 | 0.63 | 0.99 | 0.61 | NS |
| | 10.5 ≤ W ≤ 11.5 | 160 | 0 | 0 | | | |
| | W > 11.5 | 160 | 1 | 0.63 | | | |

****:** Highly significant difference; NS: Not significant difference

## DISCUSSION

The results of this study showed a significant difference between the groups of egg weights formed and the quail produced from them. In addition, a strong correlation was found between egg weight and quail weight. The results of this study were similar to those of these authors (Uddin *et al.*, 1994; Yildirim & Yetisir., 1998; Murad *et al*., 2001; Khurshid *et al*., 2004 and Alkan *et al*., 2008) who found a correlation ranging from 0.67 to 0.72. This concordance of results could be explained by the storage conditions of the eggs before their transport to the hatchery. The present work did not show any significant difference in fertility rate. Therefore, egg weight had no influence on the fertility rate. The fertility rate was better for all three egg weight groups, which is due to the fertility of the breeding males, the ideal breeding pairing of one male to three females and the availability of females for mating.

Genç and Şahin (2020) showed that egg weight had no effect on the fertility rate of quail. In contrast, Seker *et al* (2005), Alkan *et al* (2008), Khalil *et al* (2020), Shanaway and Saadeg (2021) found a significant difference in fertility rate between egg weight groups. Egg weight had a significant effect on hatching rate. The heavy and medium class eggs showed higher hatching rates than the light class eggs. This difference in hatching rate could be explained by the temperature and relative humidity of the air in the incubator. These factors are characterised by the type and weight of the egg. These results are in agreement with those of Ozcelik and Ozbey (2004), Seker *et al* (2005) and Alkan *et al* (2008) who reported a significant difference in egg weight on hatch rate. These authors reported a higher hatching rate for heavy weight eggs than for light weight eggs. In contrast, Altan *et al* (1995) and Saylam (1999) found a non-significant difference between egg weight groups and egg hatchability. Embryo mortality rates were similar for all egg weight groups. The embryo mortality rates were 31.02%, 30.27% and 31.09% for light, medium and heavy weight eggs respectively. This higher embryonic mortality rate may be due to the experimental conditions in the incubator. Farooq *et al* (2001) have documented such mortalities. On the other hand, Sergeeva (1976) and Seker *et al*. (2004) showed a high mortality rate in lord quail eggs than light ones. The results of the statistical analysis showed a significant difference in the weight growth of the quails depending on the egg classes formed at the start of the experiment. Some researchers have already explained that the chick grows according to the weight of the egg. These results corroborate those of Martinez and Lee (2022) who found that chick weight and subsequent chick growth are closely related to egg weight. Quails from the heavier eggs started laying at the age of 37 days. This would be due to the physiological conditions that allowed the quails to quickly establish their reproductive systems and subsequently lay eggs. No significant difference was recorded in the laying rate of quails from different egg classes. This non-significant difference could be explained by a balanced diet and a well followed prophylaxis during the experiment. A significant difference was observed for the egg weight of quails from different egg classes. Lower and middle weight quails had no difference in egg weight. The quails from the large eggs had higher average weights than the others, which would explain the large egg laying. Braz *et al* (2011) showed that the egg weight of the birds and their development during the growth phase are factors that influence egg weight. These results differ from those of Kashmiri *et al*. (2011) who showed a non-significant difference between animal weight and egg weight. The quail chicks showed a significant mortality rate at start-up. This significant difference at start-up could be explained by internal or external congenital malformations. However, during growth and egg laying, quail mortality did not show any significant difference. Furthermore, these mortalities did not exceed 2% in these phases of rearing. This is due to the viability and hardiness of the quails in rearing (Minvielle, 2004).

## CONCLUSION AND APPLICATION OF RESULTS

At the end of this study, egg weight and quail chicks weight showed a positive correlation. Indeed, egg weight had an influence on hatching rate, quail weight at growth, weight of eggs laid, and mortality of quail at start-up. However, egg weight had no significant effect on fertility rate, embryonic mortality, laying rate and mortality at growth and laying.

Prioritize medium and large eggs, for hatching purposes, farmers should preferentially select eggs from the medium (10.5 – 11.5 g) and large (> 11.5 g) weight classes. These eggs demonstrated a significantly higher hatching rate (69%) compared to small eggs (47%). Avoid small eggs for breeding, eggs weighing less than 10.5 g should be diverted for table egg consumption rather than incubation, as they result in poorer hatchability and smaller chicks.

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