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REPRODUCTIVE POTENTIAL AND EGG LAYING PERFORMANCE OF QUAIL IN SAVANNAH ECOLOGICAL ZONE OF GHANA

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Abstract
The purpose of the research was to ascertain the reproductive potential and egg-laying performance of Japanese quails, given the ideal management and feeding conditions in the savannah ecological zone of Ghana. The research was fashioned to cover both wet and dry seasons which are experienced in the region. 50-day-old chicks were used for the experiment in both seasons, and parameters on reproduction and egg-laying performance were studied. The overall mean values for Average Daily Gain in both wet and dry seasons were 3.64g and 2.92g respectively; whereas feed conversion ratio was 3.88g and 5.07g for wet and dry seasons respectively. The mean age of the birds at which the first egg was laid was 58 days and 56 days in wet and dry seasons respectively. It was observed in both seasons that, the total number of eggs laid increased as the weeks of lay progressed. There was no significant variation ($p \geq 0.05$) among all the external egg traits studied in both the wet and dry seasons except for egg weight which approached significance ($p=0.05$). With records of Hen-Day values being 72.04% and 88.33%, 62.54% and 87.63% accordingly in the first and second months of lay in the wet and dry season respectively; it was observed from this study that, the savanna ecological zone of Ghana presents very desirable climate and natural conditions for quail production as there was no significant effect of dry and wet seasons on the reproduction and egg-laying performance of quails.

Keywords: Egg Quality Traits, Hen Housed, Hen Day, Japanese Quail, Wet and Dry Season in Ghana

Introduction
A quail is a small avian species that belongs to the pheasant group (Mishra & Shukla, 2014). Japanese quail, compared with the different species of poultry, have the advantage of little size, great meat taste, fast growth rate, short life cycle, good reproductive potential, low feed requirements, better laying ability, and shorter time of hatching (Roshdy, Khalil, Hanafy & Mady, 2010). From the age of 6 weeks, quails start laying eggs and continue laying eggs up to 24 weeks of age. Quail eggs can be eaten as boiled, fried, or taken as egg pickles. Quails require smaller housing compared to chicken (Mishra & Shukla, 2014).
The Japanese quail is listed as Near Threatened because it is 'suspected to be undergoing a moderately rapid population decline, potentially owing to hunting and shifts in agriculture' (BirdLife International, 2016). The Japanese quail are raised mainly for their egg and meat production and also are valued research animals. Quails attain a weight of 140-180g between 5-8 weeks of age from when they can be sold in the market and reach peak egg production at the age of 5-8 weeks (Mishra & Shukla, 2014).
In the Northern Region of Ghana, the adoption of quail farming remains low in comparison with the high numbers of farmers keeping chicken or guinea fowl. Quail farming is faced with certain challenges such as the lack of adequate information on quail husbandry under local conditions. Although few works have been

carried out on the general growth and survival of quail in other regions of the world; it is beneficial to find out the reproductive performance of this bird under the arid conditions of the savannah ecological zone of Ghana. This study, therefore, assessed the reproductive potential and egg-laying performance of the Japanese quail in the savannah ecological zone of Ghana.

Materials and Methods

Study Site

The research was conducted at the Nyankpala campus of the University for Development Studies. Nyankpala is located in the Tolon District and about 20 km south-west of Tamale, the capital of Northern Region. Its coordinates are 9°24'0" N and 0°58'60" W in the Guinea Savannah Zone (Ziblim, Adusei-Boateng & Aikins 2014). It has an average rainfall and temperature of 1024.4mm and 28.30ºC respectively (Ziblim *et al*., 2014). The study area is described by an exceptionally extensive stretch of the dry season spreading over from November to March.

Design of Experiment

The experimental research was conducted for eight months; 1st September 2017 to 23rd January 2018 representing the wet season. Although the wet season experiment overlapped into the dry season, data on initial growth performance and egg production used were within the wet season. The experiment was repeated in the dry season, which began from 30th November 2017 to 24th April 2018.

Experimental Birds and their Management

50-day-old chicks were obtained from a local poultry farmer in Tamale (Anibirds Farms). The chicks were brooded in the experimental pen for 14 days using kerosene lanterns as a source of light and heat. Rice hulls were spread in the pen as litter materials. Waterers and feeders were positioned at vantage points in the brooding pen to facilitate easy drinking and feeding. A brooding temperature range of 30ºC to 35ºC was provided for the chicks for the first two weeks. Every week, at the rate of 3.5ºC; the temperature was reduced step by step as brooding progressed. Experimental birds used in the dry season were hatched from the eggs produced by the base population (wet season cohort). From nine (9) weeks of age (wet season), the quail eggs laid were gathered and hatched. To replicate similarity between the two seasons of the experiment, 50-day old chicks were also used to start as the population of the birds in the dry season. The brooding procedure was repeated in the dry season as it was in the wet season. In the wet season, the birds were housed in a deep litter floored cage which measured 120 cm x 60 cm x 25 cm as length, width, and height respectively. Since Japanese quail chicks do not express sexual dimorphism, sex differentiation was done at week 4 when sexual dimorphism was evident in birds and by the 4th week, 21 quail hens were differentiated from 15 males. In managing the aggression between males, when signs of violence were observed, the birds were put in the ratio of one male to three females in the pen. In the dry season, the experimental birds were raised in the top space of a “two-storey” cage measuring 244 cm length, 61 cm wide and 121 cm height. As with the procedure in the wet season, a stock of fifty birds was raised and mortalities were recorded. The sex differentiation was also done at week 4 and a total of 33 birds contained 18 females and 15 males. To minimize the violence and male-to-female overstocking, the ratio of one male to three females was done. Throughout the experimental period, both experiments received equal treatment.

Formulation of Experimental Diet (Feeding Trial)

The first four weeks of the study represented the chicks’ phase, where chicks were fed with an already formulated chick mash of 22% crude protein (CP) and 3,150 kcal/kg metabolizable energy. After the chicks’ phase was the grower’s phase. The birds in this phase were then given layers’ mash of 19.2% crude protein and 2,690 kcal/kg metabolizable energy. The grower’s phase lasted for another 16 and 17 weeks in the wet and dry seasons respectively.

The ingredients for the layers mash (table 2) were thoroughly mixed and the quantities given to birds were measured daily. Japanese quail are known to be hardy and show resistance to most diseases of poultry, so no medication was administered. Also, throughout the experiment, good sanitation and hygiene were observed. Water was provided ad libitum. Table 1 shows the nutrient composition of the feed used.

Table 1: Nutritional Composition and Value of Feed Mixture for Japanese Quails

Nutrient	Age of birds (weeks)	
	0-4	**4-21**
Metabolizable Energy (Kcal/kg)	3150	**2690**
Crude Protein (%)	22.00	**19.2**
Crude Fat (%)	7.50	**-**
Fibre (%)	2.50	**-**
Lysine (%)	1.30	**-**
Calcium (%)	0.80	**0.4**
Phosphorus (%)	0.30	**0.8**
Sodium (%)	0.20	**-**
Methionine (%)	0.60	**0.5**
Methionine + Cystine (%)	0.95	**-**

Source: *Prabakaran (2003)*

Table 2: Proportion of Ingredients for Feed Formulation for Japanese Quail after Four Weeks

Ingredient	Quantity (Kg)	Percentage (%)
Maize	55	55
Fishmeal	12	12
Wheat bran	11	11
Soybean meal	9	9
Oyster shell	8	8
Concentrate	5	5
Total	100	100

Source: *Experiment data (2019)*

Feed Intake

Every morning, the feed was measured and given to the birds. To determine the total amount of feed consumed, the leftover feed was weighed before administering a new feed the next morning. The feed intake of the birds was the difference between the quantity of feed given and feed left.

Observation and Data Collection

Reproduction and egg parameters were taken from the 6th week of the experiment when birds had attained sexual maturity. The same procedure was repeated for both the wet and dry seasons. The daily collection of the quail eggs was done in the mornings, afternoons, and evenings. The same regularity was done with the daily recording of the 'In-pen' temperature; in the morning, at noon and in the evening for the first six weeks of the experiment in both seasons. Mortality was also recorded when sighted, for the first six weeks of the experiment in both seasons.

Measurement of Traits

Measurements of parameters were determined using the following formulae according to Dauda, Momoh, Dim, & Ogah (2014). The daily number of eggs gathered from the cage were appropriately recorded. Eggs were individually weighed on a 0.01g nearest-accuracy digital balance (Sartorius CP224S Analytical Balance™; Göttingen, Germany) to obtain the egg weights. With the aid of digital calipers (MITUTOYO digital Vernier caliper™; Japan) to the nearest to 0.01mm, the longitudinal lengths and widths of eggs were individually measured and recorded. The circumference width and corresponding circumference length of the eggs were measured using a thread and matched onto a standard metric ruler for reading and recording. The observation was also done on mortality during the first six weeks of the experiment.

Egg Production

For three (3) months, the total number of eggs produced was recorded monthly. The following measures for egg production were determined;

(a) Hen Housed Production (% HHP):

$$\% \text{ HHP} = \frac{\text{Total eggs laid}}{\text{No.of birds housed x No of days since housed}} \; X \; \frac{100}{1}$$

(b) Hen Day Production (% HDP):

$$\text{HDP} = \frac{\text{Total eggs laid}}{\text{Number of birds housed x Number of days since hen laid}} \; X \; \frac{100}{1}$$

(c) Egg number per hen:

The average number of egg per hen housed was determined as:

$$\text{Egg number per hen} = \frac{\text{Total eggs laid}}{\text{Number of hens housed}}$$

Statistical Analysis

Statistical analysis of all data obtained was performed using GENSTAT Discovery (2013 Edition). After data obtained had been tested for normality, statistical procedures such as T-tests and Analysis of Variance were carried out to test for differences among means at a 5% significance level. Fisher's Protected Least Significant Difference (LSD) test was used to separate the means that appeared significant.

Results

Feed Consumption Rate

Table 3 presents the means and standard error of means of ADG (Average Daily Gain), FI (Feed Intake), and FCR (Feed Conversion Ratio) for both the wet and dry seasons. The average daily gain for the wet and dry seasons for (week 0 - week 1) was 1.85g and 1.78g respectively. On ADG, there was no chronological increase with age in both seasons, but as birds advanced in age, FI increased in both seasons. FCR estimates were 2.33g (wet), 2.15g (dry) at week 2, and 6.10g (wet), 9.93g (dry) at week 6. It was observed that there was a gradual increase in the FCR in the initial stage of the birds but as quails attained maturity, the FCR largely increased.

Table 3: Means of ADG (g), FI (g) and FCR (g) of Japanese Quails

WEEKS	ADG (g)		FI (g)		FCR (g)	
	Wet	Dry	Wet	Dry	Wet	Dry
0-1	1.85	1.78	7.60	7.37	4.10	4.15
1-2	4.29	4.29	10.01	9.21	2.33	2.15
2-3	5.71	5.71	12.07	10.30	2.11	1.80
3-4	4.29	1.43	13.78	11.12	3.21	7.79
4-5	2.86	2.86	15.53	13.24	5.44	4.63
5-6	2.86	1.43	17.43	14.18	6.10	9.93
Overall Mean	**3.64**	**2.92**	**12.74**	**10.90**	**3.88**	**5.07**
SEM	**0.56**	**0.72**	**1.48**	**1.03**	**0.67**	**1.31**

ADG - Average Daily Gain, FCR – Feed Conversion Ratio and FI - Feed Intake

Source: *Experiment data (2019)*

Reproductive Performance

The mean ages at the first egg of the experimental birds are presented in Table 4. The age at which the quails laid their first eggs were in the range of 44 to 72 days in the wet season and 48-67 days in the dry season. Mean values of 58.0±1.58 and 55.5±1.19 days were recorded in the wet and dry seasons respectively. Table 5 shows the egg number per bird and total egg count for the first 3 months of lay. As the months of production progressed, there was a simultaneous increase in the egg numbers and egg weight as presented in Table 5. Per the 21 hens, the total egg count recorded were 469, 575, and 497 for 1st, 2nd, and 3rd months respectively in the wet season. Also, per 18 hens, total egg counts obtained in the dry season were 349, 489, and 465 for 1st, 2nd, and 3rd months respectively. Table 6 displays the hen-day and hen-housed egg productions. In both seasons, as the month of lay advanced, there was a simultaneous increase in the values for hen-day and hen housed egg production accordingly.

Table 4: Mean Ages of Quails at First Egg

Parameter/Season	**Wet Season**	**SEM**	**Dry Season**	**SEM**
Age at first egg (days)	44	1.58	48	1.19
Overall mean	58.00		55.50	

SEM – Standard Error Mean

Source: *Experiment data (2019)*

Table 5: Total Egg Counts and Egg Number Per Bird for the First 3 Months of the Lay

MONTH OF LAY	TOTAL EGG COUNT		EGG NO. PER BIRD		
	Wet Season (n=21)	Dry Season (n=18)	Wet Season	Dry Season	P-Value
1	469	349	22.33	19.39	0.06
2	575	489	27.38	27.17	< 0.001
3	497	465	23.67	25.83	0.09
Overall Mean	513.67	434.33	24.46	24.13	
SEM	0.333	0.396	1.510	2.401	

SEM – Standard Error Mean

Source: *Experiment data (2019)*

Table 6: Values of the First Three Months of Hen Housed and Hen-Day Egg Production of Quails

MONTH OF LAY	HEN-HOUSED (%)		HEN-DAY (%)	
	Wet Season	Dry Season	Wet Season	Dry Season
1	29.78	25.85	72.04	62.54
2	36.51	36.22	88.33	87.63
3	31.56	34.44	76.34	83.33

Source: *Experiment data (2019)*

External Egg Quality Traits

All the external qualities of the eggs (length, width, shape index, circumference length, and circumference width) show no significant differences between the wet and the dry seasons except for egg weight which was statistically significant (p = 0.05). Egg weight was higher in the wet season as compared to the dry season (Table 7).

Table 7: External Egg Quality Traits of Japanese Quails

PARAMETERS	WET SEASON		DRY SEASON		
	Mean ±SD	Range	Mean ±SD	Range	P-value
Egg weight (g)	9.17 ±1.27	5.41 – 12.31	8.86 ±0.98	5.68– 11.81	0.050
Egg Length (mm)	30.31 ±1.70	21.01– 33.91	29.77±1.70	22.55-33.02	0.831
Egg width (mm)	23.47 ±1.46	17.22– 26.91	23.21±1.28	20.43-27.10	0.748
Circumference length (mm)	9.17 ±0.78	6.30 - 10.21	8.42 ±0.65	6.61-10.00	0.251

Circumference width (mm)	7.67 ±0.65	6.01 – 8.98	7.44 ±0.49	6.01-8.13	0.554
Shape index (%)	77.46 ±2.61	68.63– 83.75	78.05±3.47	70.45-95.39	0.318

SD – Standard Deviation

Source: *Experiment data (2019)*

Temperature and Mortality in the Wet Season

Figure 1 shows the relationship between temperature and mortality and how they varied with the age of the birds in the wet season. It can be observed that the mortality rate decreased with age. Per temperature and mortality, the minimum temperature recorded with cases of mortalities were in the range of 21°C to 28°C; while the maximum temperature figures were in the range of 29°C to 36°C. Low temperatures (below 30°C) contributed to the mortality of quails in their early stage (Days 1 to 11).

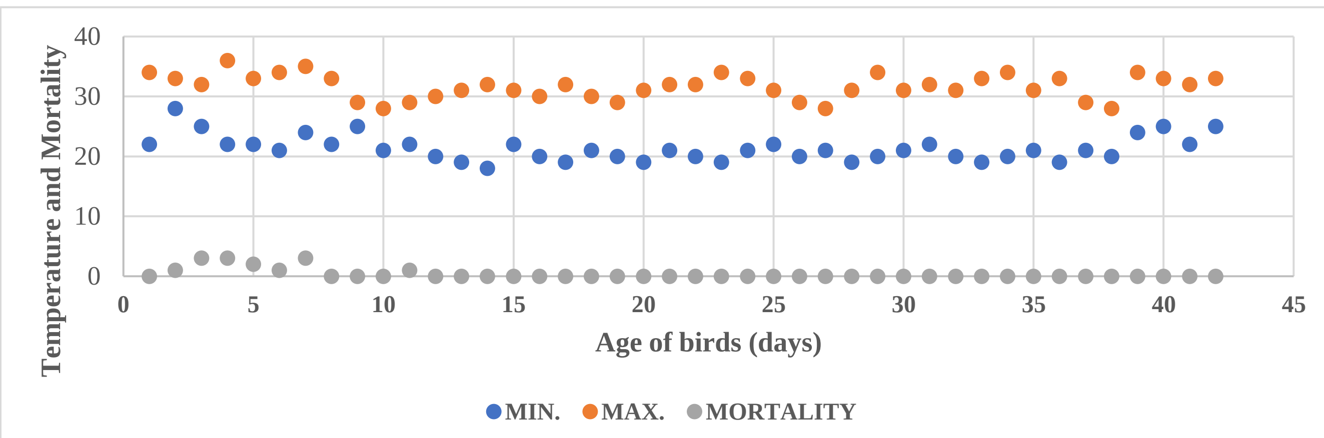

Figure 1: Minimum And Maximum Temperatures and Mortality Against Age of Birds During the Wet Season

Source: *Experiment data (2019)*

Temperature and Mortality in the Dry Season

Figure 2 shows the relationship between temperature and mortality and how they varied with the age of the birds in the dry season. It was observed that the mortality rate decreased with age. Per temperature and mortality, the minimum temperature recorded with cases of mortalities were in the range of 20°C to 29°C; while the maximum temperature figures were in the range of 32°C to 41°C. It can be observed again that, low temperatures (below 30°C) contributed to the mortalities of quails in their early stage (Days 1 to 7).

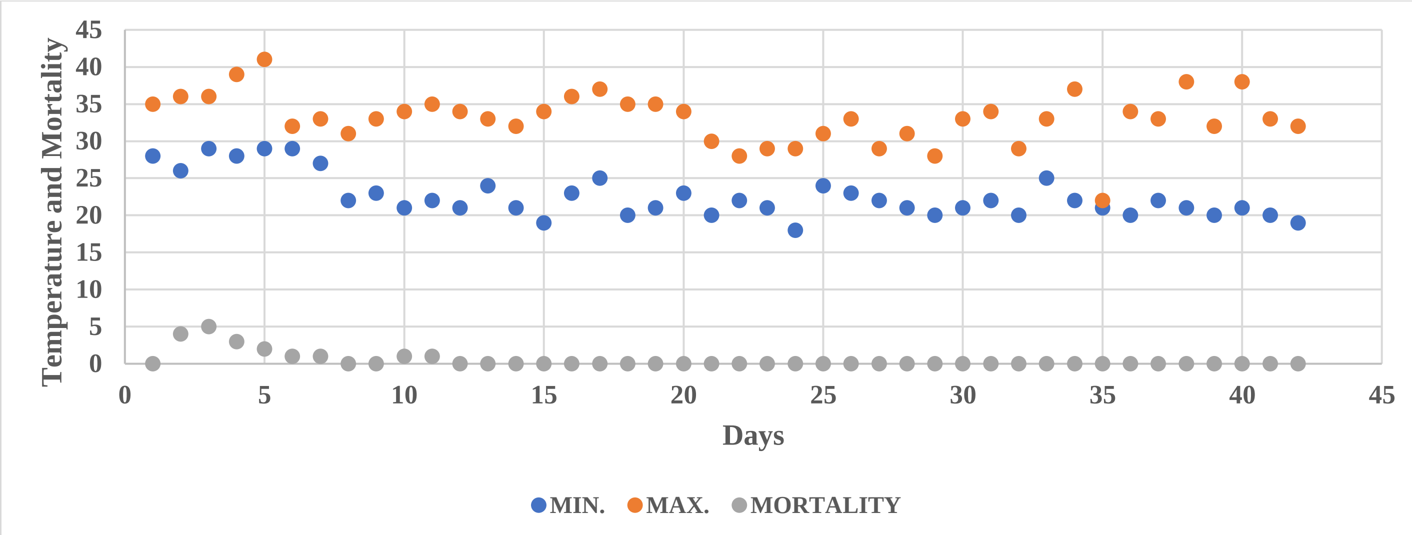

Figure 1: Minimum and Maximum Temperatures and Mortality Against the Age of Birds During the Dry Season

Source: *Experiment data (2019)*

Discussion

Reproductive Performance

The mean age at first egg obtained in this study (58 days and 56 days for wet and dry seasons respectively) agrees with Marks (1996), who reported the range of 45.3-58.9 days for Japanese quail. The findings of this study also agree with the range El-Deen, Nour, El-Tahawy & Fouad (2015) reported as 50.94 - 61.22 on Japanese quails in Egypt. Dauda *et al.* (2014), who studied the growth, egg production and reproductive performance of Japanese quails reared in the southern Guinea Zone of Nigeria (where the birds were fed formulated diet containing 2700 Kcal/Kg metabolizable energy and 18% crude protein) recorded a value of 54.49±0.20 days. Sezer, Berberoglu & Ulutas (2006) documented the age at the first egg as 45.82±0.22 days which agrees with the findings of this study. The reason for differences in age at first egg can be ascribed to differences in feeding and management practices. Dauda *et al.* (2014) stated that 'when quails lay their first egg at an early age, the advantage is that, it could lead to reduced generation interval' but on a large scale egg production; ready market may not be found for many small eggs which the birds produce at an early age. But if 'first egg laid at an early age' is met with a simultaneous body weight increase, there could also be an increase in the size of the egg. The total egg production per hen (73.38 and 72.39 eggs per quail hen in wet and dry seasons respectively) for the 3 months of the experiment is higher than the value of 62.43±0.23 reported by Dauda *et al.* (2014) but in line with the value Daikwo, Dim & Momoh, (2011) reported; which was 72.19±0.22 eggs. Dauda *et al.* (2014) had 17.31±0.05, 21.93±0.08, and 23.19±0.11 as the eggs per bird in the first, second, and third months respectively. The findings in this study were fairly higher. Dauda *et al.* (2014) stated that in Japanese quail, egg production is likely to vary. The variations could be attributed to the differences in breeds or strains in Japanese quail, environmental conditions, management of birds, and feeding. Dauda *et al.* (2014) reported lower values of % HHP and % HDP than those recorded in this study (both in the wet and dry seasons). Factors such as feeding, management, and climatic conditions could have accounted for the variation in values. With high % HHP and % HDP, there is an assurance of a sufficient supply of quail eggs to buyers. High hen-day values show the effectiveness of the quail production while hen-house production also shows the good management of birds.

External Egg Quality Traits

A similar experiment conducted by Bagh, Panigrahi, Panda, Pradhan, Mallik, Majhi, & Rout (2016) in India with three varieties of Japanese quails under similar feeding arrangement as our experiment shows similar findings to our study in northern Ghana. For three different varieties of Japanese quails, the weight of the quail eggs reported by Bagh *et al.* (2016) was 11.6±0.03g, 10.58±0.30g, and 10.58±0.26g. The egg length (mm) were 32.51±0.33, 31.43±0.23 and 31.43±0.40; egg width (mm) were 25.83±0.88, 24.74±0.24 and 24.33±0.27; circumference length (mm) were 9.53±0.40, 8.79±0.11, and 9.69±0.06; circumference width (mm) were 8.37±0.08, 7.76±0.14 and 8.42±0.2 and egg shape index (%) were 72.88±3.14, 72.13±0.88 and 69.93±1.51. These findings are similar to the results obtained in this experiment. Hrnčár, Hanusová, Hanus & Bujko (2014) reported slightly higher values of egg width, egg length and egg weight than those obtained in this study but egg shape index for wet season (77.46 ±2.61%) and dry season (78.05 ±3.47%) agrees with Hrnčár *et al.* (2014) who recorded 76.70% and 78.18% as values of egg shape index while Zita, Ledvinka, Klesalovázita, Ledvinka & Klesalová (2013) had 77.85%.

Temperature and Mortality

In this study, it was observed that mortalities were recorded when the temperatures of brooding the quail chicks (from 35°C to 40°C) were not met, from hatch to one week of age as recommended by Maurice and Gerry (2008) and Mondry (2016) who both wrote a review on raising Japanese quail and quail farming in tropical regions respectively. Generally, as the age of birds advances, their mortality rate reduces, as also reported by Dauda *et al*. (2014). The differences in incubator used for hatching, environmental conditions, stocking density, the system of housing, management of birds, and prevalence of diseases are among the causes of variations in mortality rates.

Conclusion

The findings of this study show that the environmental conditions of the guinea savannah ecological zone are suitable for quail production per the reproductive performance recorded. The high hen-day and hen-house egg production values obtained show the possibility of an adequate supply of quail eggs to consumers. Also, the season showed no significant difference in the reproduction and egg-laying performance of quails.

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