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Effect of mating ratio on the laying performance, hatching characteristics, feeding and housing cost of Japanese quails

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Abstract

A total of 438 4-wk old Japanese quails (288 females and 150 males) grouped at different mating ratios were used to evaluate the laying performance. The birds were divided into 4 mating groups: 1:1, 1:2, 1:3 and 1:4. Each group comprised of 72 females while males were varied according to the mating ratios, i.e., 72, 36, 24 and 18 males, respectively. Birds were replicated thrice (24 female birds each) in a Completely Randomized Design and raised in colonies. A total of 50 eggs were collected for incubation from the respective mating ratio groups. Data were collected on laying performance, hatching characteristics and feeding and housing cost. Results revealed that the age at first lay of the birds, weight of the birds at first lay, egg weight at first lay, average number of eggs laid per bird, hen day production, average weight of eggs and feed : egg ratio were not significantly influenced by the mating ratios. Total feed intake per mating ratio group, total feed cost (₦9025.13, ₦7136.30, ₦6104.62 and ₦5753.83), floor space per mating ratio group and housing cost per group (₦4500, ₦3375, ₦3000 and ₦2812.50) increased as the mating ratio increased. Incubation weight loss and fertility were similar (P>0.05) among the mating ratios. However, hatchability was better in 1:1 (73.43%) and 1:2 (74.26%) than others. It can be concluded that mating ratio did not influence laying performance and egg fertility, however, hatchability declined as male to female ratio reduced beyond 1: 2.

Keywords: fertility, hatchability, laying performance, mating ratio and quails

Introduction

A viable means to arrest the problem of shortage of animal protein by an average Nigerian is to increase the level of production of highly reproductive animals with short generation intervals such as poultry, pigs and rabbits (Smith, 2001; Ani and Adiegwu, 2005). Japanese quail has the potential to serve as an excellent and affordable source of animal protein in Nigeria (Babangida and Ubosi, 2005; Owen and Dike, 2013). Japanese quail precocity with about 4-5 generations within a year and high laying rate among other prospects has encouraged its breeding in Nigeria.

The primary aim of a breeder is to maximise the production of chicks in an economic fashion. The number of chicks to be obtained from a breeding flock largely depends on the reproductive traits such as number of eggs, fertility, hatchability and embryonic mortality. Egg number is the major index of performance of commercial layers as it accounts for about 90% of the income in egg production farm (Oluyemi

and Roberts, 2000). From the animal breeding point of view, an animal with high breeding value must have a sufficient number of chicks to better transform its superiority to the next generation.
Fertility is defined as the number of fertile eggs per bird and determined by both the genetic and environmental factors such as genetic structure, mating ratio, parental age, rate of laying, climatic conditions (Kulenkamp *et al*., 1973). Fertility is a low heritable trait and requires a complex genetic improvement programme (Wolc *et al*., 2009). Investigations of some management methods on fertility in Japanese quails, such as stocking density, mating ratio and rearing type by Altan and Oguz (1993) and Kirmizibayrak and Altinel (2001)) indicated that grouping a single male with 2 to 5 females in a colony cage will generally give high fertility. North and Bell (1990) stated that sex ratio is an important factor affecting fertility, too many males and few males lead to reduced fertility. For the optimum fertility of Japanese quails, required male-female ratio must be between 1:1 and 1:3 (Gebreil, 2002; Yurdakul, 2006). In another study in Japanese quails, Seker *et al*. (2004) found that optimum male-female mating ratio were 1:1 and 1:2.

Hatchability is the percentage of fertile eggs that hatch. Hatchability of fertile eggs depends on bird factors, egg collection and storage, egg factors and incubation factors (King' Ori, 2011). Ali *et al*. (2013) observed that hatchability increased by increasing the number of males in the mating ratio. Similarly, Seker *et al*. (2005) found significantly higher effect of mating ratio in terms of hatchability. Also to avoid possible financial loss to the producers that may be caused by keeping excessive number of male birds, optimum male: female ratio must be used. Hence, this study was conducted to investigate the laying performance and hatching characteristics of quails as affected by different mating ratios.

Materials and Methods

Site of experiment

This rearing of the birds was carried out at the Teaching and Research Farms of the Federal University of Agriculture, Abeokuta. The area lies on latitude $7^0$10'N and longitude $3^0$2'E, it is 76m above sea level and located in the tropical rainforest vegetation zone with an average temperature of 34.7^{0}C and relative humidity of 82% (Google Earth, 2015). Incubation of eggs took place at Obasanjo Farms Nigeria, Owiwi Hatchery, Abeokuta, Ogun State, Nigeria.

Source of birds

A total of 438 4-wk old quails comprising 150 males and 288 females were randomly selected from a brooded flock at the University Farms.

Experimental design and management

The selected birds were divided into 4 mating groups: 1:1, 1:2, 1:3 and 1:4. Each group comprised of 72 females while the number of males was varied according to the mating ratios, i.e., 72, 36, 24 and 18 males in 1:1, 1:2, 1:3 and 1:4 groups, respectively. Birds were replicated (24 female birds each) thrice in a Completely Randomized Design (CRD) and raised in colonies. Feed and water were provided *ad libitum* for the birds during the experiment. Birds were fed diet containing 24.10% crude protein and 12.19 MJ/kg metabolisable energy at the growing phase (4-6 wk) and 20.2% crude protein and 12.72MJ/kg metabolisable energy at the laying phase (> 6 wk) as shown in Table 1. Antibiotics and multivitamins were administered as at when due. Birds were housed in cages made of wood and wire mesh with 200 sq cm space area per bird. All cages were placed in a pen of simple design constructed with wooden planks and wire nets while the roof was covered with iron sheet and the floor was cemented. Adequate ventilation was ensured while protection against draught, rain and direct sunlight were not left out. Eggs were picked twice in a day, i.e., morning (0800 h) and evening (1600 h).

Table 1: Gross composition (%) of the experimental diets

Ingredients	4-6wk	➢ 6wk
Maize	51.05	62.65
Soya bean cake	27.86	19.16
Groundnut cake	9.29	6.39
Fish meal	3.00	3.00
Wheat offal	5.00	5.00
Bone meal	2.50	2.50
Limestone	0.50	0.50
Lysine	0.10	0.10
Methionine	0.15	0.15
Common salt	0.30	0.30
*Vitamin/mineral premix	0.25	0.25
Total	100.00	100.00
Calculated analysis		
Crude protein (%)	24.10	20.20
ME (MJ/kg)	12.19	12.72
Ether Extract (%)	4.00	4.00
Crude fibre (%)	3.80	3.30
Calcium (%)	1.20	1.20
Phosphorus (%)	0.60	0.50

Vitamin/mineral premix contains Vit. A - 4,000,000.00 IU; Vit D3 – 800,000.00IU; Vit. E – 9,200.00mg; Vit K – 800.00mg; thiamin (B_1) – 720.00mg; Riboflavin (B_2) – 2,000.00mg; Pyrodixine (B_2) – 1,200.00mg; Vit. B_{12} – 6.00mg; Biotin – 24.00mg; Niacin – 11,000.00gm; Panthothenic acid – 3,000.00gm; Folic acid – 300.00gm; Chlorine chloride – 120,000.00gm; Iron – 8,000.00gm; Manganese – 16,000.00gm; Copper – 1,200.00gm; Zinc – 12,000.00gm; Cobalt – 80.00mg; Iodine – 400.00gm; Selemium – 80.00gm; Antioxidants – 500.00mg.

Birds were replicated (24 female birds each) thrice in a Completely Randomized Design (CRD) and raised in colony as shown in Figure 1.

	Mating ratios							
Space requirement	1:1 0.6m x 1.6m		1:2 0.6m x 1.2m		1:3 0.6m x 1.07m		1:4 0.6m x 1.0m	
Replicates	M	F	M	F	M	F	M	F
1	24	24	12	24	8	24	6	24
2	24	24	12	24	8	24	6	24
3	24	24	12	24	8	24	6	24
Total	72	72	36	72	24	72	18	72

* $0.02m^2$ space per bird M: Male, F: Female

Figure 1: Illustration of arrangement of birds in the different colony mating ratio

Egg collection

A total of 600 hatchable quail eggs were selected from eggs laid by the birds at the 10th wk in lay. Collection was done within 3 d and stored in refrigerator at 7°C to get enough number of eggs. From each mating group 150 eggs were randomly selected.

Egg management

Eggs were fumigated using potassium tetraoxomanganate VII ($KMnO_4$) and formaldehyde (HCHO) at ratio 1:2. The treatment lasted for 20 min in a closed chamber. The eggs were set in egg trays with broad ends upward to prevent rupture of air cell. Each egg tray was labeled according to mating ratio groups and individual egg was numbered prior to setting to facilitate data collection on replicate and individual basis, respectively.

Eggs were set in Petersime incubator (B-9870 model). Temperature (37.5°C) and humidity were automatically regulated. Egg turning was automatic on hourly basis to prevent developing embryos from adhering to the shell and to ensure uniform distribution of nutrients. On the 15th day of incubation, the eggs were tested for fertility. All the infertile eggs were discarded while the fertile eggs were transferred into the hatching compartment where they spent 2 d to complete the incubation period.

Data collection - laying performance

The laying performance was studied for 12 wk and the following records were taken:

1. Age at first lay- age of bird when the first egg was laid.
2. Weight of egg at first lay- weight of first egg laid.
3. Bird weight at first lay- the weight of bird as at when the first egg was laid.
4. Total egg laid by the group – total number of eggs laid by the group.
5. Hen day production- number of eggs collected divided by number of birds alive as at that day multiplied by 100.
6. Mortality – number of dead birds expressed as a percentage of the total number of birds.
7. Feed intake per bird- average feed consumed per bird throughout the experimental period.
8. Feed: egg- ratio of average weight of feed consumed per bird to average weight of egg laid per bird.

Feeding and housing cost per replicate (colony)

1. Feeding cost- the total feed consumed by each replicate multiplied by the cost per kg of feed
2. Housing cost- the total floor space required for each replicate multiplied by the cost per m^2 of floor space.

Hatching characteristics - Determination of incubation weight loss

The eggs were weighed before setting and on the 15^{th} day, incubation weight loss was determined using the formula below:
Weight loss (g) = Initial weight (g) – Final weight (g)

$$\text{Weight loss (\%)} = \frac{\text{Weight loss (g)}}{\text{Initial weight}} \text{ x } 100$$

Fertility (%)

This was determined using the formula below:

$$\text{Fertility (\%)} = \frac{\text{Number of fertile eggs}}{\text{Number of eggs set}} \text{ x } 100$$

Hatchability (%)

This was determined using the formula below:

$$\text{Hatchabilty (\%)} = \frac{\text{Number of chicks hatched}}{\text{Number of fertile eggs}} \text{ x } 100$$

Hatch weight (g)

The weight of birds at hatch was determined by weighing the birds hatched in each replicate divided by the number of birds hatched per replicate.

$$\text{Hatch weight (g)} = \frac{\text{Total weight of birds hatched}}{\text{Number of birds hatched}} \text{ x } 100$$

Determination of embryonic mortality

This was carried out in the laboratory. The unhatched incubated eggs were gently broken to observe the stage of embryonic mortality. This was categorized into Dead-in-germ (early embryonic mortality) and Dead-in-shell (late embryonic mortality).

$$\text{Dead} - \text{in} - \text{germ (\%)} = \frac{\text{Number of Dead} - \text{in} - \text{germ}}{\text{Number of fertile eggs}} \text{ x } 100$$

$$\text{Dead} - \text{in} - \text{shell (\%)} = \frac{\text{Number of Dead} - \text{in} - \text{shell}}{\text{Number of fertile eggs}} \text{ x } 100$$

Egg: chick

This was evaluated as the ratio of egg weight to chick weight,

Statistical analysis

Data collected were subjected to Analysis of Variance in a Completely Randomized Design (CRD) using SAS (1999) while significantly (P<0.05) different means were compared using Duncan's Multiple Range Test in the software package.

Results and Discussion

Effect of mating ratio on the laying performance of Japanese quails

The laying performance of Japanese quails as influenced by different mating ratios is presented in Table 2. The feed intakes (total and average daily) per bird were different (P< 0.05) among the mating ratio groups. Feed intakes did not show any definite trend across the groups with the highest (P<0.05) total and average feed intake recorded in 1:2 mating ratio group (1966.57g and 23.42g, respectively) and least in 1:4 group (1865.31g and 22.21g, respectively) though comparable with values obtained in 1:3 (1892.55g and 22.53g, respectively). However, mating ratio did not significantly affect the age at first lay of the birds, weight of the birds at first lay, egg weight at first lay, average egg laid per bird, hen day production, average weight of eggs, daily feed intake per bird and feed to egg ratio, birds' age at first lay was between 31 and 33 d. The average bird weight at first lay across the groups ranged from 125 to 139 g. Weight of first egg laid in each group ranged from 6.53 to 7.07 g. The range of average number of eggs laid per bird and the hen day production across the groups were 44.74-46.79 eggs and 53.26 - 55.70%, respectively. Feed to egg ratio obtained across the groups range was 4.09- 4.31.

Figure 2 represents fortnight hen day production of quails subjected to different mating ratios. Generally, hen day production increased in all the mating ratio groups from the start till the tenth wk after which a sharp fall was noticed. In the first 2 wk, 1:1 mating ratio group production appeared best when compared to the rest while the poorest was observed in 1:4 mating ratio group. However, 1:2 and 1:3 mating ratios showed almost similar production.

Table 2: Effect of mating ratios on the laying performance of Japanese quails

	Mating ratio			
Parameter	1:1	1:2	1:3	1:4
Age at first lay (d)	32.33± 0.58	33.00 ± 1.73	31.00± 1.00	33.00± 1.00
Bird weight at first lay (g)	125.22 ± 7.13	139.58 ± 5.73	127.08 ± 3.61	137.50 ± 16.54
Egg weight at first lay (g)	7.00 ± 0.10	6.53 ± 0.15	7.07 ± 0.15	6.97 ± 0.76
Average egg laid/bird	45.13 ± 2.42	46.79 ± 4.84	45.99 ± 5.44	44.74 ± 1.42
Hen day production (%)	53.72 ± 2.89	55.70 ± 5.76	54.75 ± 6.47	53.26 ± 1.69
Average egg weight (g)	9.83 ± 0.87	10.33 ± 0.05	10.24 ± 0.56	9.88 ± 0.08
Total egg weight/bird (g)	442.14 ± 17.27	483.31 ±48.78	472.48 ± 77.29	442.04 ± 17.54
Total feed intake/female bird (g/bird)	1865.31^c ± 4.12	1966.57^a ± 7.40	1892.55^{bc} ± 33.93	1902.72^b ± 1.25
Av. feed intake/bird /d (g/bird/day)	22.21^c ± 0.04	23.42^a ± 0.09	22.53^{bc} ± 0.41	22.65^b ± 0.01
Feed:egg	4.22 ± 0.17	4.10 ± 0.44	4.09 ± 0.76	4.31 ± 0.17

^{abc}Means with different superscript on the same row differ significantly ($p<0.05$)

Though 1:1 mating group had the best start, the production at the peak was least when compared to the rest. Birds in 1:2 mating ratio group showed a rapid increase between the fourth and eighth wk, followed by a gradual increase and finally a sharp decline in production. The production at the peak in 1:2 and 1:3 groups was similar. 1:3 group similarly had a rapid increase between the fourth and eighth wk but a slight increase between the eighth and tenth wk before it declined. The production trend in 1:4 mating ratio group was a sharp (2^{nd} – 4^{th} wk), gradual (4^{th} -6^{th} wk), steep (8^{th} -10^{th} wk) rise and then sharp decline (10^{th} -12^{th} wk) in production.

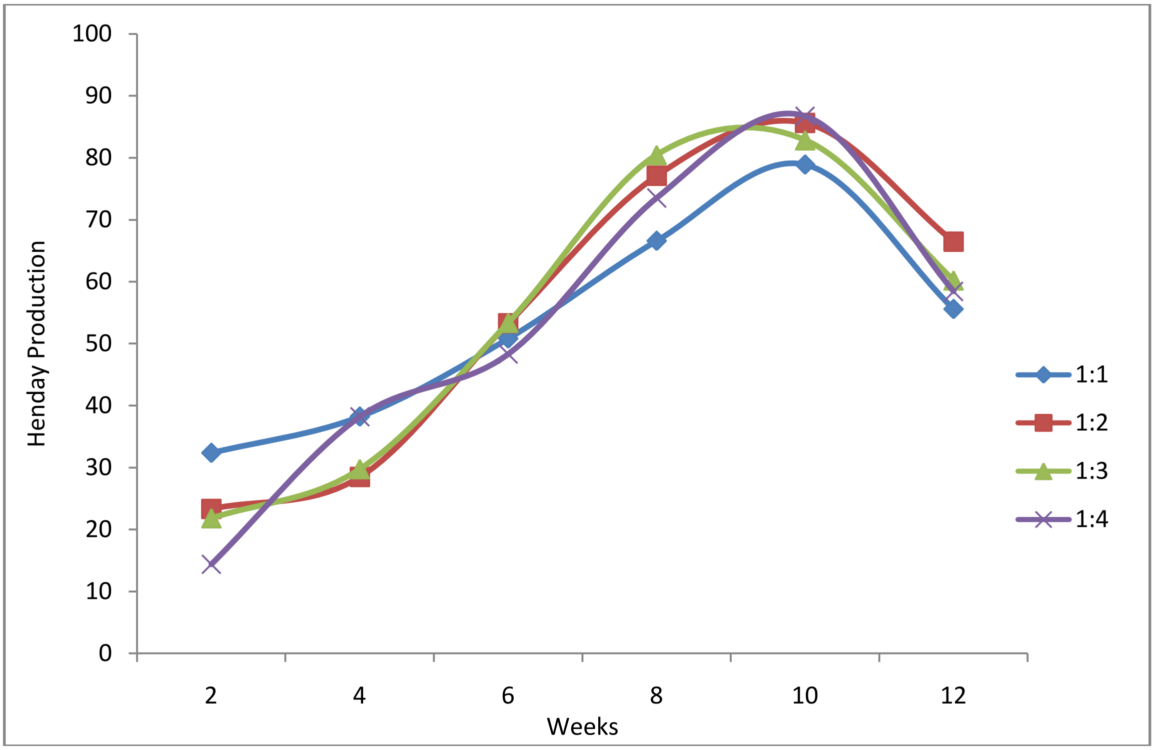

Figure 2: Fortnight hen day production of Japanese quails subjected to different mating ratios

Effect of mating ratio on the feeding and housing costs of Japanese quails

The feeding and housing cost of Japanese quails subjected to different mating ratio are presented in Table 3. All the parameters evaluated were affected (P<0.05) by the various mating ratios. There was an increase (P<0.05) in the total feed intake per mating ratio group, total feed cost, floor space per mating ratio group and housing cost per group as the mating ratio increased. Total feed intake in 1:1, 1:2, 1:3 and 1:4 are 89.54, 70.80, 60.56 and 57.08kg, respectively. The respective feed costs per group were ₦9025.13, ₦7136.30, ₦6104. 62 and ₦5753.83. Floor space per group ranged from 0.6 to 0.96m^2. Cost of housing per group are ₦4500.00 (1:1), ₦3375.00 (1:2), ₦3000.00 (1:3) and ₦2812.50 (1:4).

Table 3:. Effect of mating ratios on the feeding and housing cost of Japanese quails

	Mating ratio			
Parameter	1:1	1:2	1:3	1:4
No of birds	48.00[a] ± 0.00	36.00[b] ± 0.00	32.00[c] ± 0.00	30.00[d] ± 0.00
Total feed intake (g)	89.54[a] ± 19.76	70.80[b] ± 26.63	60.56[c] ± 10.86	57.08[d] ± 37.53
Total feed cost (₦)	9025.13[a] ± 19.91	7136.30[b] ± 26.84	6104. 62[c] ± 10.91	5753.83[d] ± 3.78
Floor space/group (m^2)	0.96[a] ± 0.00	0.72[b] ± 0.00	0.64[c] ± 0.00	0.60[d] ± 0.00
Housing cost/group (₦)	4500.00[a] ± 0.00	3375.00[b] ± 0.00	3000.00[c] ± 0.00	2812.50[d] ± 0.00

[abc]Means with different superscript on the same row differ significantly (p<0.05)
Floor space/bird (m^2)= 0.02, Housing cost / bird (₦)= 93.75 and Feed cost per kg (₦)= 100.

Effects of mating ration on incubation weight loss of Japanese quail eggs

The incubation weight loss of eggs obtained from Japanese quails subjected to different mating ratios is presented in Table 4. All the parameters measured were not significantly influenced by the mating ratio. The initial weight and final weight of the eggs range was 9.83 -10.33 g and 8.40-9.57 g, respectively. Weight loss ranged between 1.10 and 1.53 g. The respective percentage incubation weight loss in 1:1, 1:2, 1:3 and 1:4 are 14.52, 14.83, 10.82 and 13.27%.

Table 4: Effect of mating ratio on incubation weight loss of Japanese quail eggs

	Mating ratio			
Parameters	1:1	1:2	1:3	1:4
Initial weight (g)	9.83±0.87	10.33±0.05	10.24±0.56	9.88±0.08
Final weight (g)	8.40±1.04	8.80±0.92	9.13±0.61	9.57±1.37
Weight loss (g)	1.43±0.73	1.53±0.89	1.10±0.12	1.31±1.38
Weight loss (%)	14.52±4.10	14.83±8.68	10.82±1.41	13.27±13.89

Effect of mating ratio on the hatching characteristics of Japanese eggs

In Table 5, the effect of mating ratio on hatching characteristics of quail eggs is shown. In all the parameters, significant differences were obtained only on the percentage hatchability, total mortality, early mortality and late mortality. Hatchability percentage was similar (P> 0.05) in 1:1 and 1:2 mating ratio groups, however, values in the two groups were significantly higher than 58.09% and 53.11% recorded in 1:3 and 1:4 mating groups, respectively. Total embryonic mortality was least (P>0.05) in 1:1 and 1:2 mating ratio groups (26.57 and 25.74%, respectively). Early mortality was highest (P<0.05) in 1:4 mating group (34.93%) and least in 1: 2 mating group (15.34%) however, similar (P>0.05) percentage was recorded in 1:1 (21.95%) and 1:3 (25.77%). Percentage fertility across the groups are 89.00, 92.53, 96.92 and 90.67%. Chick hatch weight ranged from 6.34 to 6.74g and the egg to chick ratio ranged from 1.51 to 1.59.

Table 5: Effects of mating ratios on hatching characteristics of quails

	Mating ratio			
Parameter	1:1	1:2	1:3	1:4
Average egg weight (g)	9.83±0.87	10.33±0.05	10.24±0.56	9.88±0.08
Fertility (%)	89.00±12.77	92.53±2.50	96.92±0.58	90.67±10.07
Hatchability (%)	73.43^{a}±18.47	74.26^{a}±15.57	58.09^{b}±2.70	53.11^{c}±11.84
Total mortality (%)	26.57^{c}±18.47	25.74^{c}±15.57	41.91^{b}±2.07	46.89^{a}±11.83
Early mortality (%)	21.95^{b}±14.91	15.24^{c}±9.86	25.77^{b}±9.87	34.93^{a}±12.54
Late mortality (%)	4.62^{c}±4.77	10.49^{b}±6.18	16.14^{a}±8.56	11.96^{b}±1.43
Chick weight (g)	6.34±0.18	6.74±0.77	6.45±0.14	6.45±0.21
Egg : Chick	1.55±0.13	1.55±0.19	1.59±0.12	1.51±0.04

^{abc}Means with different superscript on the same row differ significantly ($p<0.05$)

Age at first lay (31- 33days) of the birds was earlier in this study than 5-6weeks reported by Owen and Dike (2013) and 51-53days reported by Ayoola (2014) and this could be as result of rapid weight gain of the birds. The weight of birds at first lay was slightly lower when compared to the report by Ayoola (2014), however values were still within the range (120- 160g) reported by Ortlieb (2013). Relatively smaller egg weight at first lay obtained in this study could be adduced to relatively early maturity and smaller body weight of the birds. Oluyemi and Roberts (2000) stated that the average egg weight of a laying flock increases as the birds get older mainly due to physical and physiological changes. According to Duplessis and Erasmus (1972), the age of hen at lay showed a constant and significant effect on egg weight. Similar egg weight noted in this study agrees with the report by Baser *et al* (2002) who stated that egg weight is not significantly affected by the male to female ratio.

Egg number is the major index of performance of commercial layer as it accounts for about 90% of the income in egg production farm (Oluyemi and Roberts, 2000). Average egg laid per bird and hen day production showed no influence of mating ratio in this study. Oluyemi and Roberts (2000) indicated that some environmental factors such as nutrition, ambient temperature, humidity and diseases affect the egg number and quality of eggs laid. Contrarily, Mahesh *et al.* (2005) observed differences in egg produced by Fayoumi layers at 1:8 (46), 1:9 (48) and 1:10 (45) male to female mating ratios, however, he could not adduce any reason for the variation.

Variations in feed intakes among the different groups did not give a clear picture of varying mating ratios as no definite trend was observed. However the daily feed consumed was within the adult quail daily feed requirement (20-25g) as reported by Ani *et al*, (2009). Considering only the feed consumed by female in each group relative to the corresponding weight of egg laid, feed to egg ratio was similar. This is probably due to the fact that female number per group was kept constant while the male number was varied.

Increase in feed intake per group as the mating ratio increased was as a result of the variation in number of birds per group. The significant increase in cost of feed consumed in this study indicates that colony variation in mating ratio increased feeding cost. In this study, housing cost per group varied with varying mating ratio. Generally, increase in feeding and housing cost with increase in mating ratio is in agreement with Dogan *et al.* (2013) who stated that keeping excessive amount of males could lead to financial loss.

The sudden decline in hen day production at the tenth week of lay could be attributed to high ambient temperature (30^{o}C) and low relative humidity (42%) during the period (January- May, 2015). Munir and Muhammed (2010) reported that ambient temperatures above 30^{o}C are considered to have detrimental effect on the performance of laying hens. Daghir (1995) also stated that the maximum temperature associated with satisfactory laying performance of hens is approximately 30^{o}C at a relative humidity of 75%. Ogbogu (1988) noted that the comfort zone for layers is between 13 and 21^{o}C and that at 30 - 40^{o}C, the egg size and number produced dropped drastically due to reduced feed intake. Temperature is just one of the major factors that affect the productivity of farm animals including egg production. Villacorte (1997) opined that animals exposed to heat stress are prone to thermal imbalance or disrupted homeostasis which may lead to an increase respiration rate, decrease physical activity, feed consumption, feed efficiency, egg production, egg weight and poor egg shell quality. These physiological changes and various effects on production parameters would result to significant economic losses.

The egg incubation weight loss is an important parameter for incubation. It has been used to estimate vital gas exchange (Paganelli *et al.,* 1978) and has being correlated with the rate of embryonic metabolism and development (Rahn and Ar, 1980; Burton and Tullett, 1983). Most of the water of the egg is initially in the albumen which declines continuously during incubation as a result of water loss to the ambient air and movement to the compartments (Romanoff, 1967). Incubation weight loss in this study did not reflect the effect of mating ratios. Incubation weight loss range in this study is lower than the values of 24.76% reported by Say-lam (1999) and 20.90% reported by Saylam and Sarica (1999) in quail eggs, however, close to value of 12.94% reported by Soliman *et al.* (1994) for quail eggs and 11.24% reported by Reis *et al.* (1997) in chicken eggs. Differences in egg incubation weight loss in this study with earlier reports could be as a result of differences in pre-incubation storage time and conditions as well as incubation conditions (e.g. temperature and humidity).

Fertility depends on various factors such as storage period, breed, season, pre-incubation, lighting, level of nutrition, mating ratio and time of mating (Miazi *et al*., 2012). Similar result of fertility among the different mating ratio groups in this study indicates that even a male can satisfactorily and successfully mate four females and is in consonance with the findings of Mandour *et al.* (1993) who reported non-significant effect of mating ratio from 1M:1F to 1M:4F on fertility in quail. However, results contradict the results of Dogan *et al*. (2013) who reported highest fertility in 1M:1F and 1M:2F mating groups as compared to 1M:4F and 1M:5F mating groups. Narahari *et al.* (1988) and Ipek *et al*. (2004) also reported a significant effect of male to female ratio on fertility. Ipek *et al*. (2004) indicated that the best fertility rate were obtained in 1M: 2F and 1M: 3F and a decline in 1M: 1F and 1M: 5F groups. Gebreil (2002) studied the effect of sex ratio on reproductive performance in quail and stated that for optimum fertility ratio of Japanese quails, required male-female ratio must be between 1M:1F and 1M:3F.

Ali *et al*. (2013) observed that hatchability increased with increasing number of males in the mating ratio which corroborates the result of this study. This result is also similar to the results of the studies by Seker *et al*. (2005), who found statistically higher effect of mating ratio in terms of hatchability. However, the result is at variance with the result by Ipek *et al*. (2004) who stated that hatchability of fertile eggs did not vary with mating ratio.

Similar hatch weight of chicks observed in this study could be attributed to similarity in weight of eggs set which is at variance with the result of Ali *et al.* (2013) in quails stating that mating ratio 1:3 had highest chick weight (8.16 g) followed by 1:1 (7.65 g), 1:4 (7.53 g) and 1:2 (7.41 g). Seker *et al*. (2004) also found that mating ratio had a significant effect on the egg weight which ultimately affected the chick weight. In another similar study conducted on domestic fowl, Wilson (1991) reported that a positive parallel correlation exists between egg weight and hatched chick weight.

Total embryonic mortality increased with decline in number of male per group which is in accordance with earlier reports by Ali *et al*. (2013) and Seker *et al*. (2005). In a related study, Suthar *et al*., (2012) explained that increasing number of hens for one cock produced relatively weaker chicks and hence higher mortality. However, Fairchild and Christensen (2005) indicated that cock: hen ratio does not play any part in embryonic mortality. Alsobayel and Albadry (2012) also emphasized that early embryonic mortality, late embryonic mortality and total embryonic mortality for the different sex ratios were not significantly different. Egg to chick ratio was not affected by mating ratio due to similar weight of eggs incubated and chicks hatched in the various groups.

Conclusion

It can be concluded that the laying performance showed no influence of mating ratio, however, feeding and housing cost per colony increased as the number of males increased. Also, male to female ratio did not significantly affect incubation weight loss, fertility of eggs, chick weight and egg to chick weight ratio. However, hatchability of quail eggs increased with increasing number of males. Conversely, total embryonic mortality increased with decline in number of males per group.

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