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ORIGINAL RESEARCH ARTICLE

Effects of mating ratio, housing type and photoperiod on the reproductive performance of Japanese quail (*Coturnix coturnix japonica*)

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ABSTRACT

The study aimed at understanding the effect of mating ratio, housing type and photoperiod on the reproductive performance of Japanese quails in a twelve - week trial. Five hundred and fifty - two (552) six weeks old Japanese quails (156 males, 396 females) were randomly allocated using Completely randomised design in a 2×3×6 factorial arrangement of housing at 2 levels (deep litter and cage), photoperiod at 3 levels (13L:11D, 15L:9D and 18L:6D) and mating ratio at 6 levels (1:1, 1:2, 1:3, 1:4, 1:5 and 1:6). Mating ratio, housing type and photoperiod had significant (p<0.01) effect on percentage egg number at the 13th, 16th and 18th week of age. The highest percentage egg number were observed with quail reared on deep litter with 1:5 mating ratio, subjected to 15L:9D photoperiod regime at the 13th (97.14%) and 18th (91.43%) week of age while the lowest were observed with quail reared on cage with 1:4 mating ratio, subjected to 13L:11D photoperiod regime at the 13th (2.38%) and 18th (5.95%). Mating ratio, housing type and photoperiod also had significant (p<0.01) effect on egg weight at 10th week of age. The highest egg weight was recorded for quail raised on deep litter with 1:1 mating ratio, subjected to 13L:11D photoperiod regime (10.88g) while the lowest were recorded for quail reared on cage with 1:3 mating ratio, subjected to 13L:11D photoperiod regime (8.88g). Photoperiod had significant (p<0.05) effect on percentage hatch. The highest percentage hatch was observed at 13L:11D (76.66%) while the lowest were recorded at 15L:9D photoperiod regime (66.34%). Housing type had significant (p<0.01) effect on percentage hatchability, hatch and embryonic mortality. Deep litter gave the better performance on the reproductive traits considered. It was concluded that 1:5 mating ratio in combination with 15L:9D photoperiod regime on a deep litter system can give a good reproductive performance.

Keywords: Mating ratio, Housing type, Photoperiod, Egg number, Egg weight.

INTRODUCTION

Poultry production is one of the major sectors of the livestock industry in Nigeria. This sector was hitherto, dominated by the rearing of chickens (Adene and Oguntade, 2006). However, there are new entrants in to the sector. One of the birds slowly gaining prominence is the Japanese quail (*Coturnix coturnix japonica*) (Egbeyale *et al*., 2013). The Japanese quail was introduced to Nigeria only in 1992 (NVRI, 1994) and since then, quail farming have been growing in population. The purpose was to diversify the poultry sub sector and help supplement domestic chicken through massive quail farming by Nigerian farmers. Japanese quails are suited for commercial rearing for egg and meat production under intensive management (Egbeyale *et al.,* 2013). This is because of their hardiness, ability to thrive in small cages, relative short generation interval and low cost of production (Odunsi *et al*., 2007; Ojo *et al*., 2011).

Reproductive traits such as egg number, fertility, hatchability and embryonic mortality are important factors affecting the number of chicks that can be obtained from a breeding flock. Jadhav and Siddiqui (2007) observed that quails start to lay at 6-7 weeks of age, reach peak production at 13–14 weeks then plateaued and declines from 25 weeks. Several environmental components have been found to have a profound effect on the production and reproduction performance of quail breeding flock. Among these components are mating ratio, photoperiod and housing type (Narahari *et al*., 1988; Onasanya and Ikeobi, 2013). These are of considerable importance in Japanese quail in order to obtain body weight gain, high fertility, hatchability, egg production and higher feed utilization. However, there had been no studies to investigate the effect of the combination of those factors on the reproductive performance of Japanese quail.

In view of the growing importance of quail rearing, there is need for relevant information to be obtained for the benefits of farmers. The objective of this study is to determine the effect of mating ratio, housing type and photoperiod on the reproductive performance of Japanese quail

MATERIALS AND METHODS

Study Location

The experiment was carried out at the Quail Unit of the Teaching and Research Farm, Obafemi Awolowo University, Nigeria. The University is located on Latitude 7º31´06´´N and longitude 4º31´22´´E.

Experimental birds and Management

A total of five hundred and seventy Japanese quails (*Coturnix coturnix japonica*) at three weeks old were purchased from National Veterinary Research Institute (NVRI) Ikire substation in Osun State, Nigeria. The feeders and drinkers were put in place and the floor of the pen overlaid with wood shavings. On arrival, they were given gluco-vita stress for three days to ameliorate the stress of transportation. Feed and water were given *ad libitum.* The experimental diet contained 23.85% Crude protein and 2848 kcal/kg ME for growing phase from day of arrival until 6 weeks of age and 22.03% Crude protein with 2838 kcal/kg ME for the laying phase from 6 weeks of age. Furthermore, daily routine management practices and clean environment were maintained. At six weeks of age, the birds were transferred to the cages and deep litter for the commencement of the study. Three (3) rooms were used for this experiment with each room representing the photoperiod regime. Each room was partitioned to accommodate the deep litter and cage housing for the allocation of the birds into six mating ratios. Openings at the top roof of each room were sealed with thick black nylon to prevent cross reflection of light and each photoperiod regime was controlled by different switches.

Experimental procedure

A total of five hundred and fifty - two (552) Japanese quails (156 males, 396 females) at 6 weeks of age were randomly allocated using Completely Randomised Design (CRD) in a 2×3×6 factorial arrangement of housing at 2 levels (deep litter and cage), photoperiod at 3 levels (13L:11D, 15L:9D and 18L:6D) and mating ratio at 6 levels (1:1, 1:2, 1:3, 1:4, 1:5 and 1:6) as shown in Figure 1. In the cage, a total of 276 Japanese quails (78 males, 198 females) were allocated among six mating ratios (1:1, 1:2, 1:3, 1:4, 1:5 and 1:6). 1:1 mating group comprise of 20 quails (10 males and 10 females); 1:2 mating group comprise of 15 quails (5 males and 10 females); 1:3 mating group comprise of 16 quails (4 males and 12 females); 1:4 mating group comprise of 15 quails (3 males and 12 females); 1:5 mating group comprise of 12 quails (2 males and 10 females) and 1:6 mating group comprise of 14 quails (2 males and 12 females) within each photoperiod regime. In the deep litter system, a total of 276 Japanese quails (78 males, 198 females) were allocated the same way as that of the cage for each photoperiod regime. Lighting was supplied using ECOMIN energy saving 40W bulbs with luminous flux of 12. Electricity was supplied with a power generator throughout the course of the experiment.

Data Collection

Egg Number (EN): Egg laid in each group were recorded at 7, 10, 13, 16 and 18 weeks of age. Percentage egg production per day was taken as the number of females that produced eggs out of the total number of females in the group for the specific day.

Egg Weight (EW): Eggs collected were individually weighed at 7, 10, 13, 16 and 18 weeks of age. The eggs were weighed in the morning to minimize loss of moisture from the eggs.

Percentage Fertility: This was calculated as the ratio of the total number of fertile eggs to the total number of egg set.

Percentage Hatchability: This was calculated as the ratio of the total number of chicks hatched to the total number of fertile eggs.

Percentage Hatch: This was calculated as the ratio of the total number of chicks hatched to the total number of eggs set.

Percentage Embryonic Mortality: Eggs that failed to hatch were opened out and the contents macroscopically observed**.** This is calculated as the ratio of the number of dead embryo to the total number of fertile eggs.

Statistical Analysis

Data obtained were subjected to statistical analysis using Generalised Linear Model (GLM) procedure and the mean separation was done using Least Square Means (LSMEANS)

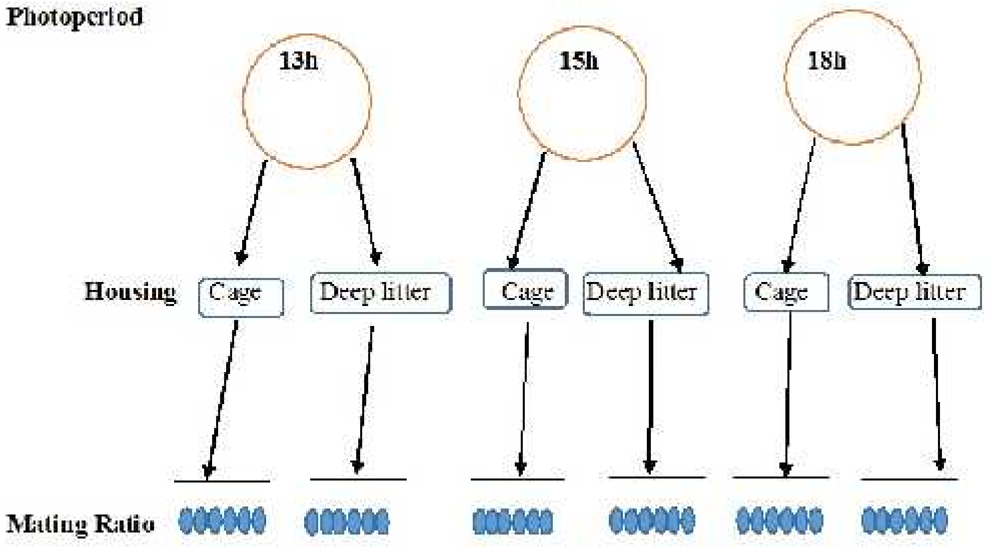

Figure 1: Experimental Layout

RESULTS AND DISCUSSION

Table 1 showed the interaction effect of mating ratio, housing type and photoperiod on percentage egg number. Mating ratio had significant (p<0.01) effect on percentage egg number. Peak egg number was observed at the 13th week for all the mating ratios. The highest percentage egg number was recorded at the 1:5 mating ratio. The result agreed with the report of Karousa *et al.*, (2015) that mating ratio 1:3 (57.01±1.68%) produced more eggs than quails housed with mating ratio 1:2 (53.21±1.68%). Housing type had significant (p<0.01) effect on percentage egg number. The result obtained agreed with Roshdy *et al*., (2010) who recorded that quails kept on floor pens had significantly higher values in egg number than those kept in battery cages.

On the other hand, the obtained results disagreed with the reports of Arumugam *et al*., (2014) and Gandhimathi *et al*., (2014) who found that egg production of Japanese quail were about 80% in cage system and 70 % in deep litter system. However, the higher percentage egg number in deep litter could be attributed to body weight of the quail birds and the ambient temperature as the cages were at a higher elevation than the deep litter. Photoperiod had significant (p<0.01) effect on percentage egg number. Quail under the 15L: 9D regime recorded the highest percentage egg number at the 13th, 16th and 18th week but the lowest at the 7th and 10th week. Lewis *et al.*, (1997) found that longer photoperiods increase egg production, but also increase mortality rate in laying hens. There were significant interactions (p<0.05) among photoperiod, housing and mating ratio at 13th, 16th and 18th week. At 13th week, Japanese quail reared on a deep litter with 1:5 mating ratio, subjected to both 15L:9D and 18L:6D photoperiod regimes gave the best results (97.14% ±7.56). At 16th week, Japanese quail reared on a deep litter with 1:2 mating ratio, subjected to 13L:11D photoperiod regime gave the best result (92.86%±6.68) followed by 1:5 mating ratio (91.43% ±10.69) under the same housing type and photoperiod regime. Also, quail reared on deep litter with 1:5 mating ratio, subjected to 15L:9D photoperiod regime gave the best result (91.43% ±10.69) at 18th week.

Table 2 showed the interaction effect of mating ratio, housing type and photoperiod on egg weight of Japanese quail. Mating ratio had significant (p <0.01) effect on egg weight. Egg weight ranged between 8.46 – 10.03 g which can be classified as medium sized eggs (Othman *et al.,* 2014). The lowest egg weights for all the mating ratios were recorded at the 18th week while the highest egg weights were recorded at the 10th week except for 1:6 mating ratio. The result is in consonance with Seker *et al.* (2004) who reported that mating ratio was significant statistically (p<0.01) on egg weight. This result was different from the findings of Asasi and Jaafar, (2000) who did not report any significant egg weight differences between mating ratio. Also, the result did not agree with the findings of Abdel-Magied Sayed, (1994) who reported that 1:5 mating ratio showed significant (p≤0.05) highest egg weight. Housing type had significant (p<0.05) effect on egg weight. Quail raised on deep litter system gave higher egg weight than those on the cage system for the weeks under consideration. This could be attributed to the body weight difference of female quail and ambient temperature as the cage had higher elevation than the deep litter. Another reason could be the degree of ventilation afforded the two housing type. This finding agreed with that of Roshdy *et al.* (2010) who reported that there is significant difference on egg weight between ($p<0.05$) housing system.

Table 1: Interaction among Mating Ratio, Housing and Photoperiod on % Egg Number

Treatment	7^{th} week (%)	10^{th} week (%)	13^{th} week(%)	16^{th} week(%)	18^{th} week(%)
AX_1	26.67±20.82	65.00±24.66	79.59±7.63	61.22±24.35	44.90±19.22
AX_2	16.67±15.28	43.57±23.22	96.43±6.10	92.86±6.68	75.00±17.68
AX_3	27.78±4.81	56.75±18.69	73.81±13.11	52.38±32.53	57.14±25.20
AX_4	25.00±8.33	44.05±26.22	91.67±6.81	66.67±11.79	76.19±12.20
AX_5	20.00±0.00	34.29±22.99	94.29±9.76	85.71±22.25	85.71±22.25
AX_6	8.33±0.00	39.28±29.94	92.86±8.91	90.47±8.91	90.47±8.91
BX_1	20.00±0.00	35.71±29.36	46.94±15.89	8.16±11.24	16.33±9.86
BX_2	6.67±5.77	12.86±17.04	19.64±17.47	5.36±14.17	25.00±25.00
BX_3	22.22±4.81	16.43±16.26	47.62±17.82	44.38±24.32	75.71±12.87
BX_4	5.55±4.81	10.12±12.70	2.38±4.06	8.33±15.96	5.95±6.30
BX_5	6.67±11.55	22.86±24.30	42.86±26.90	77.14±29.28	71.43±15.74
BX_6	5.56±9.62	7.14±8.91	71.43±15.85	54.76±18.55	78.57±28.41
AY_1	13.33±5.77	27.50±11.99	73.47±22.48	71.43±14.28	53.06±19.72
AY_2	13.33±5.77	43.21±32.75	83.93±9.45	78.57±11.89	78.57±11.89
AY_3	5.55±4.81	33.73±28.35	95.24±8.13	78.57±28.40	78.57±28.40
AY_4	16.67±0.00	45.24±27.99	53.57±23.00	61.90±26.29	61.90±26.29
AY_5	23.33±15.28	41.43±12.15	97.14±7.56	91.43±10.69	91.43±10.69
AY_6	8.89±0.96	45.24±22.49	90.47±8.91	73.81±23.29	73.81±23.29
BY_1	6.67±5.77	5.24±6.90	32.65±21.37	0.00±0.00	14.29±14.29
BY_2	8.89±8.39	8.21±13.75	44.64±33.74	32.14±30.50	58.93±23.62
BY_3	5.55±4.81	2.38±4.06	78.57±20.89	45.24±18.55	66.67±34.69
BY_4	4.17±7.22	1.79±4.72	22.62±20.81	19.05±24.87	22.62±20.81
BY_5	6.67±11.55	2.86±7.56	77.14±26.90	51.43±15.74	54.29±19.02
BY_6	16.67±28.87	7.14±18.90	59.52±21.21	57.14±18.90	71.43±12.60
AZ_1	16.67±15.28	67.86±27.67	87.75±12.85	89.80±13.59	79.59±13.94
AZ_2	10.00±0.00	41.43±36.25	51.79±8.63	55.36±18.90	57.14±12.20
AZ_3	27.78±9.62	57.54±23.17	90.47±8.91	85.71±17.82	70.48±21.29
AZ_4	36.11±20.97	76.19±18.90	66.67±16.67	57.14±16.96	28.57±9.45
AZ_5	40.00±0.00	62.86±17.99	97.14±7.56	71.90±11.20	65.71±15.12
AZ_6	27.78±25.46	53.57±20.89	78.57±18.54	83.33±9.62	76.19±8.91
BZ_1	5.56±9.62	2.38±6.30	7.14±18.90	10.20±21.37	12.25±17.36
BZ_2	12.50±21.65	5.36±14.17	28.57±17.25	7.14±9.83	8.93±13.91
BZ_3	12.50±21.65	5.36±14.17	64.29±31.07	64.29±17.82	45.24±15.86
BZ_4	12.50±21.65	5.36±14.17	25.00±16.67	19.05±14.99	7.14±10.13
BZ_5	6.67±11.55	2.86±7.56	48.57±19.52	48.57±25.45	71.43±15.74
BZ_6	11.11±19.24	4.76±12.60	30.95±17.82	54.76±23.00	42.86±25.20
PP	0.0481	0.0009	0.0003	0.9112	< .0001
HT	<.0001	<.0001	< .0001	< .0001	< .0001
MR	0.6842	0.4461	< .0001	< .0001	< .0001
PP*HT	0.2043	<.0001	0.0008	0.9309	0.4559
PP*MR	0.2158	0.0288	< .0001	< .0001	< .0001
HT*MR	0.1908	0.6034	0.0004	<. 0001	< .0001
PP*HT*MR	0.9399	0.4800	< .0001	0.0075	< .0001

Keys

A, B (Housing) – Deep litter, Cage respectively; X,Y,Z (Photoperiod) – 13L:11D, 15L:9D and 18L:6D respectively; 1,2,…6 (Mating ratio) – 1:1, 1:2, … 1:6 respectively; PP – Photoperiod; MR - Mating ratio; HT – Housing type, Means ± Standard Error

Table 2: Interaction among Mating Ratio, Housing and Photoperiod on Egg Weight

Treatment	7th week (g)	10th week (g)	13th week(g)	16th week(g)	18th week(g)
AX_1	9.44 ± 0.80	10.40 ± 0.84	9.94 ± 1.17	9.35 ± 1.33	9.79 ± 1.35
AX_2	9.48 ± 0.97	10.17 ± 0.62	9.81 ± 0.78	8.75 ± 0.82	8.88 ± 0.98
AX_3	9.31 ± 1.08	9.90 ± 0.64	9.64 ± 0.67	8.57 ± 0.93	8.36 ± 1.24
AX_4	9.79 ± 0.83	9.43 ± 0.95	9.11 ± 1.26	8.26 ± 1.14	8.73 ± 1.15
AX_5	9.03 ± 1.00	9.45 ± 0.57	9.02 ± 0.49	8.17 ± 1.06	8.17 ± 1.06
AX_6	9.05 ± 0.90	9.41 ± 0.92	9.76 ± 0.69	8.78 ± 0.58	8.78 ± 0.58
BX_1	9.08 ± 0.90	9.69 ± 0.81	8.78 ± 0.87	8.23 ± 0.72	8.57 ± 0.94
BX_2	8.03 ± 0.55	9.09 ± 0.82	9.17 ± 0.98	8.27 ± 1.30	8.65 ± 1.00
BX_3	8.80 ± 0.46	8.83 ± 0.71	8.94 ± 0.75	9.01 ± 0.93	9.00 ± 0.72
BX_4	8.20 ± 0.72	8.89 ± 0.59	8.96 ± 1.67	9.93 ± 1.42	9.17 ± 1.36
BX_5	8.85 ± 0.55	9.37 ± 0.38	8.72 ± 0.79	8.44 ± 0.90	8.54 ± 0.46
BX_6	8.77 ± 0.70	8.95 ± 1.03	8.99 ± 0.89	8.40 ± 1.01	8.72 ± 0.65
AY_1	10.46 ± 0.62	10.88 ± 0.81	10.09 ± 1.44	9.22 ± 0.94	9.52 ± 1.36
AY_2	9.76 ± 0.65	9.68 ± 0.59	8.91 ± 0.79	8.36 ± 0.84	8.36 ± 0.84
AY_3	9.40 ± 1.17	9.94 ± 0.89	9.49 ± 1.03	8.58 ± 1.45	8.58 ± 1.45
AY_4	9.69 ± 0.65	9.48 ± 0.97	8.94 ± 0.72	8.15 ± 1.07	8.15 ± 1.07
AY_5	9.50 ± 1.27	9.49 ± 0.83	9.45 ± 0.69	8.60 ± 1.14	8.60 ± 1.14
AY_6	9.20 ± 0.84	9.07 ± 0.88	9.71 ± 0.74	9.00 ± 0.54	9.00 ± 0.54
BY_1	8.86 ± 1.38	9.58 ± 1.06	8.46 ± 0.99	8.77 ± 0.78	7.94 ± 0.66
BY_2	8.30 ± 0.79	9.35 ± 0.81	8.80 ± 0.94	8.63 ± 0.82	8.98 ± 0.82
BY_3	8.68 ± 0.22	8.92 ± 0.94	8.75 ± 0.89	8.53 ± 0.93	8.80 ± 1.28
BY_4	9.27 ± 0.57	9.17 ± 0.86	8.42 ± 0.80	8.52 ± 0.72	8.31 ± 0.71
BY_5	8.93 ± 0.64	9.04 ± 1.02	9.22 ± 1.03	8.67 ± 1.22	9.12 ± 1.15
BY_6	8.50 ± 0.78	8.85 ± 0.83	8.85 ± 1.53	9.04 ± 0.68	9.24 ± 0.64
AZ_1	9.57 ± 0.85	10.15 ± 0.58	10.06 ± 0.49	9.12 ± 0.50	9.39 ± 0.98
AZ_2	9.18 ± 1.23	9.28 ± 0.96	9.43 ± 1.05	8.68 ± 1.42	9.06 ± 1.16
AZ_3	9.38 ± 0.68	9.23 ± 0.61	9.09 ± 0.80	8.58 ± 1.49	8.86 ± 0.63
AZ_4	9.40 ± 1.02	9.78 ± 0.92	9.10 ± 0.85	9.20 ± 1.15	9.80 ± 1.93
AZ_5	9.55 ± 0.74	9.46 ± 0.65	9.46 ± 0.60	8.52 ± 0.85	8.57 ± 0.99
AZ_6	9.29 ± 0.77	9.05 ± 0.57	8.78 ± 0.84	8.31 ± 1.17	8.56 ± 0.99
BZ_1	8.43 ± 0.40	9.36 ± 1.22	8.50 ± 0.00	7.73 ± 0.47	8.33 ± 1.00
BZ_2	9.00 ± 0.96	8.98 ± 0.75	8.64 ± 0.78	7.70 ± 0.43	9.04 ± 1.05
BZ_3	8.90 ± 0.20	9.23 ± 0.63	9.07 ± 1.23	8.56 ± 1.30	9.26 ± 0.88
BZ_4	9.37 ± 0.76	9.40 ± 0.96	8.23 ± 1.62	8.70 ± 0.47	8.13 ± 0.73
BZ_5	9.83 ± 0.42	9.41 ± 0.74	8.48 ± 1.29	8.18 ± 0.91	8.11 ± 0.91
BZ_6	9.67 ± 0.21	8.91 ± 0.87	9.15 ± 0.86	7.83 ± 0.81	8.64 ± 1.06
PP	0.1797	0.0004	0.0161	0.8254	0.1172
HT	<.0001	< .0001	<.0001	0.0237	0.3299
MR	0.2429	< .0001	<.0001	< . 0001	0.0001
PP*HT	0.1383	0.4329	1.0000	0.0019	0.0056
PP*MR	0.7343	0.0053	<.0001	0.2980	< .0001
HT*MR	0.4988	< .0001	<.0001	< . 0001	< .0001
PP*HT*MR	0.3198	0.0016	0.0984	0.5479	0.2183

Keys

A, B (Housing) – Deep litter, Cage respectively; X,Y,Z (Photoperiod) – 13L:11D, 15L:9D and 18L:6D respectively; 1,2,…6 (Mating ratio) – 1:1, 1:2, … 1:6 respectively; PP – Photoperiod; MR - Mating ratio; HT – Housing type, Means ± Standard Error

Table 3: Interaction among Mating ratio, Housing and Photoperiod on Fertility, Hatchability and Embryonic mortality

Treatment	Fertility (%)	Hatchability (%)	Hatch (%)	E.mortality (%)
AX_1	90.73 ± 9.70	85.03 ± 8.16	77.20 ± 11.36	14.97 ±8.16
AX_2	96.34 ±1.20	93.26 ±7.99	89.89 ±8.50	6.74 ±7.99
AX_3	93.19 ±2.80	88.15 ±6.39	82.16 ±6.77	11.85 ±6.39
AX_4	86.44 ±6.31	84.70 ±9.94	72.90 ±5.98	15.30 ±9.94
AX_5	86.92 ±10.51	89.35 ±2.59	80.74 ±7.14	10.65 ±2.59
AX_6	86.47 ±7.80	89.19 ±5.22	79.06 ±10.14	10.81 ±5.22
BX_1	78.13 ±25.58	55.31 ±48.56	50.49 ±43.79	44.69 ±48.86
BX_2	75.00 ±21.65	92.86 ±7.15	68.75 ±16.54	7.14 ±7.15
BX_3	91.27 ±9.11	83.77 ±6.64	76.85 ±13.65	16.23 ±6.64
BX_4	93.33 ±11.55	80.56 ±17.35	82.22 ±16.78	19.44 ±17.35
BX_5	94.19 ±5.04	81.39 ±16.13	76.34 ±12.84	18.61 ±16.13
BX_6	93.51 ±4.01	89.20 ±3.98	83.31 ±0.70	10.80 ±3.98
AY_1	81.80 ±10.14	90.11 ±4.76	73.92 ±11.99	9.89 ±4.76
AY_2	91.58 ±3.23	85.33 ±8.32	71.60 ±13.75	14.67 ±8.32
AY_3	86.15 ±3.45	86.39 ±5.29	74.39 ±4.67	13.61 ±5.29
AY_4	74.18 ±16.27	72.86 ±12.53	53.19 ±8.57	27.14 ±12.53
AY_5	93.22 ±7.66	87.37 ±7.97	81.77 ±13.59	12.63 ±7.97
AY_6	85.26 ±4.63	78.23 ±7.82	66.87 ±9.42	21.77 ±7.82
BY_1	93.10 ±11.95	63.21 ±4.82	59.01 ±10.27	36.79 ±4.82
BY_2	77.82 ±11.52	60.35 ±23.43	48.20 ±22.98	39.65 ±23.43
BY_3	83.33 ±16.67	65.33 ±11.39	72.74 ±26.82	34.67 ±11.39
BY_4	81.22 ±11.72	73.20 ±24.20	61.29 ±29.47	26.80 ±24.20
BY_5	87.06 ±13.17	78.18 ±15.72	68.57 ±18.82	21.82 ±15.72
BY_6	86.46 ±13.13	73.53 ±12.11	64.56 ±18.86	26.47 ±12.11
AZ_1	87.47 ±8.13	80.97 ±6.36	70.53 ±3.52	19.03 ±6.36
AZ_2	91.11 ±8.01	92.47 ±9.66	84.69 ±15.56	7.53 ±9.66
AZ_3	90.38 ±6.37	92.59 ±4.28	83.86 ±9.83	7.41 ±4.28
AZ_4	85.83 ±13.41	83.52 ±10.71	72.49 ±19.89	16.48 ±10.71
AZ_5	90.23 ±14.04	85.09 ±9.15	75.93 ±4.60	14.91 ±9.15
AZ_6	78.58 ±7.62	83.52 ±11.73	65.99 ±14.53	16.48 ±11.73
BZ_1	83.33 ±16.67	80.00 ±34.64	66.67 ±33.34	20.00 ±34.64
BZ_2	79.45 ±13.03	64.58 ±30.26	53.13 ±32.19	35.42 ±30.26
BZ_3	94.10 ±3.55	76.21 ±11.44	71.46 ±8.06	23.79 ±11.44
BZ_4	88.33 ±12.58	78.84 ±12.90	68.93 ±9.63	21.16 ±12.90
BZ_5	87.13 ±6.59	88.52 ±14.50	76.51 ±7.54	11.48 ±14.50
BZ_6	64.10 ±32.03	80.16 ±21.61	50.85 ±28.39	19.84 ±21.61
PP	0.3066	0.0810	0.0465	0.0810
HT	0.2760	0.0013	0.0115	0.0013
MR	0.4559	0.6072	0.3071	0.6073
PP*HT	0.7900	0.6151	0.8925	0.6152
PP*MR	0.3948	0.7813	0.6788	0.7813
HT*MR	0.2220	0.3911	0.1840	0.3910
PP*HT*MR	0.7767	0.7764	0.9613	0.7763

Keys: A, B (Housing) – Deep litter, Cage respectively; X,Y,Z (Photoperiod) – 13L:11D, 15L:9D and 18L:6D respectively; 1,2,…6 (Mating ratio) – 1:1, 1:2, … 1:6 respectively; PP – Photoperiod; MR - Mating Ratio; HT – Housing Type, Means ± Standard Error

Egg weight of those raised under deep litter (13.51±0.24) is higher than those raised on cage (12.75±0.24). Also, Pistekova *et al.*, (2006) reported that the egg weight was significantly ($P<0.05$) higher in the deep litter system of housing than cages. The result showed that there were significant differences ($p<0.05$) in photoperiod for egg weight at the 10th and 13th week. The overall highest egg weight was recorded for those raised under 13L:11D photoperiod regime at the 10th week of age while the lowest was found for those raised under 13L:11D at 16th week of age. Lewis *et al.,* (1997) reported increased egg weights for laying hens exposed to shorter photoperiods compared to those exposed to longer photoperiods. Significant interaction ($p<0.01$) among photoperiod, housing and mating ratio only existed at 10th week which showed that Japanese quail reared on a deep litter with 1:1 mating ratio, subjected to 15L:9D photoperiod regime gave the best result for egg weight (10.88g±0.81).

Table 3 showed the interaction effect of mating ratio, housing type and photoperiod on percentage fertility, hatchability, hatch and embryonic mortality. Photoperiod had significant ($p<0.05$) effect on percentage hatch. Housing type had significant ($p<0.01$) effect on percentage hatchability, hatch and embryonic mortality. Deep litter had a higher hatchability (86.01% ± 8.42) and lower embryonic mortality (13.99 ± 8.42). The result did not agree with the findings of Karousa *et al*., (2015) who reported that percentage hatchability of fertile eggs was significantly higher ($p<0.01$) in battery cages (70.40±0.90) than those on floor pens (64.45±0.90). The result also contradicts that of Raji *et al*., (2014) who reported that Japanese quail reared on battery cages did better in terms of hatchability and hatch percentages than those on deep litter. The result on percentage embryonic mortality agreed with that of Arumugam *et al*., (2014) who reported that significant higher ($p<0.01$) embryonic mortality was recorded for cage rearing (16.75±1.25) compared to deep litter (11.85±0.65). Unnoticed minor cracks possible under cage rearing before setting would have led to this difference. Birds reared on cages had lower values than those on deep litter. Decrease in percentage hatchability and increase in embryonic mortality might be attributed to non-specific stress, fertile eggs produced from battery cages had significantly lower yolk index and shell thickness than those floor pens and plumage damage in males (Roshdy *et al*., 2010).

CONCLUSION

The study showed that 1:5 mating ratio gave the best performance on percentage egg production, fertility, hatchability and embryonic mortality while 1:1 mating ratio gave the highest egg weight and 1:3 gave the best percentage hatch performance. Japanese quail raised on deep litter system gave the best performance for all the reproductive traits considered. Quail raised at 13L:11D photoperiod regime gave the best performance on percentage fertility, 10th week egg weight while those raised at 15L:9D gave the best performance for percentage egg production, 16th week egg weight.

However, the interaction effect showed that Japanese quail raised on deep litter with 1:5 mating ratio, subjected to 15L:9D photoperiod regime gave the best result for percentage egg production at weeks 13 and 18 while those raised on deep litter with 1:1 mating ratio, subjected to 15L:9D photoperiod regime gave the best result for egg weight at week 10.

It was concluded that 1:5 mating ratio in combination with 15L:9D photoperiod regime on a deep litter system can give a good (optimum) reproductive performance.

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CONFLICT OF INTEREST

Authors declare that no conflict of interest exist concerning this manuscript

REFERENCES

Abdel-Magied Sayed, S. M. 1994. Studies on some factors affecting productive performance and fertility of Japanese quail (*Coturnix coturnix japonica*). M.Sc. Thesis in Agricultural Sciences. Al-Azhar University, Egypt.

Adene, D. F. and Oguntade, A. E. 2006. Poultry Sector country review for Nigeria. FAO Animal Production and Health division. 95pp

Arumugam, R., Prabakaran, R and Sivakumar, T. 2014. Hatching performance of pure Japanese quail breeders under cage and deep litter systems of rearing. *Journal of Global Biosciences*, 3(7):1105-1110.

Asasi, K. and Jaafar, A. J. 2000. The effect of sex ratio on egg production, fertility and hatchability of Japanese quail. *Pajouhesh-va-Sazandegi*, 45: 128-131.

Egbeyale, L. T., Fatoki, H. O and Adeyemi, O. A. 2013. Effect of egg weight and oviposition time on hatchability and post hatch performance of Japanese quail (*Coturnix*

coturnix japonica). *Nigerian Journal of Animal Production*, 40: 102-110.

Gandhimathi, A., Babu, M., Asha rajini, R., Sujatha, S. and Lurthu Reetha, T. 2014. Effect of nest box on the reproductive performance of Japanese quail. *Journal of International Academic Research for Multidisciplinary*, 2:(5).

Jadhav, N. V. and Siddiqui, M. F. 2007. Handbook of poultry production and management. 2nd ed., Jaypee Brothers Medical Publishers Ltd. New Delhi, India. 383pp.

Karousa, M. M., Souad, A. A., Elaithy, S. M. and Elgazar, E. A. 2015. Effect of housing system and sex ratio of quails on egg production, fertility and hatchability. *Benha Veterinary Medical Journal*, 28(2): 241-247.

Lewis, P. D., Perry, G. C. and Morris, T. R. 1997. Effect of size and timing of photoperiod increase on age at first egg and subsequent performance of two breeds of laying hen. *British Poultry Science*, 38(2): 142-150.

Narahari, D., Mujeer, A. K., Thangavel, A., Ramamurthy, N., Viswanathan, S., Mohan, B., Muruganandan, B. and Sundararasu, V. 1988. Traits influencing the hatching performance of Japanese quail eggs. *British Poultry Science*, 29: 101-112.

NVRI, 1994. Farmer training on quail production and health management. National Veterinary Research Institute, Vom, Nigeria, pp: 44.

Odunsi, A. A., Rotimi, E. A. and Aina, O. 2007. Effect of different vegetable protein sources on growth and laying performance of Japanese quails (*Coturnix coturnix japonica*) in a derived savannah zone of Nigeria. *World Applied Science Journal*, 3(5), 567-571

Onasanya, G. O. and Ikeobi, C. O. N. 2013. Egg physical traits, performance, fertility and hatchability in exotic and Nigerian indigenous chickens. *Standard Research Journal of Agricultural Sciences*, 1(1):1 – 8.

Ojo, V., Ayorinde, K. L. and Fatoki, H. O. 2011. Relationship between body weight and some egg production traits in the Japanese quail. *NISER*, 11:1.

Othman, R.A., Amin, M. R. and Rahman, S. 2014. Effect of egg size, age of hen and storage period on fertility, hatchability, embryo mortality and chick malformations in eggs of Japanese quail (*Coturnix coturnix japonica*). *ISOR Journal of Agriculture and Veterinary Science*, 7(1): 101-106

Pistekova, V., Hovorka, M., Vecerek, V., Strakova, E. and Suchy, P. 2006. The quality comparison of eggs laid by laying hens kept in battery cages and a deep litter system. *Czech Journal of Animal Science*, 51(7): 318-325.

Raji, A., Mbap, S., Mohammed, G. and Kwari, I. 2014. Fertility and hatchability of Japanese quail eggs under semi-arid conditions in Nigeria. *Agricultural Science and Technology*, 6(4):455 - 459.

Roshdy, M., Khalil, H.A., Hanafy, A.M. and Mady, M.E. 2010. Productive and reproductive traits of Japanese quail as affected by two housing system. *Egypt Poultry Science*, 30:55-67.

Seker, I., Ekmen, F., Bayraktar, M. and Krul, S. 2004. The effects of parental age and mating ratio on egg weight, hatchability and chick weight in Japanese quail. *Journal of Animal Veterinary Advances*, 3:424-430.