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# Effect of different Sex Ratios on Laying Performance, Fertility and Hatchability in Japanese Quail

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**ABSTRACT**

The present study was conducted to evaluate the laying performance, fertility and hatching characteristics of Japanese quail maintained at different sex ratios under a deep litter system of rearing. A total of 437 nos of 4 week old Japanese quails, comprising 137 males and 300 females, were randomly selected and divided into five groups. Each group contained 60 females, while the number of males varied according to the sex ratios. The numbers of males were 60, 30, 20, 15 and 12 in the 1:1 ($T_1$), 1:2 ($T_2$), 1:3 ($T_3$), 1:4 ($T_4$) and 1:5 ($T_4$) groups respectively. Sex ratio did not significantly ($P$>0.05) affect age of first lay, average body weight and egg weight at first lay, average egg weight, hen day egg production, average daily feed intake of birds. However, the total feed intakes per group increased with an increase in the number of male birds. Fertility and hatchability were significantly (P< 0.05) lower in $T_4$ and $T_5$ groups than $T_1$, $T_2$ and $T_3$ groups. No significant differences were observed in incubation weight loss and chick hatch weight among the groups. It may be concluded that the male-to-female sex ratio of 1:3 in Japanese quail is more economical under an intensive system.

**HIGHLIGHTS:**

- Study was conducted to evaluate the effect of different sex ratios under a deep litter system of rearing.
- Male-to-female sex ratio of 1:3 in Japanese quail is more economical under an intensive system.

**Keywords:** Laying, Hatchability, Fertility, Japanese Quail

In India, Poultry industry is considered as the greatest emergent segment under Agriculture system. In human sustenance, poultry industry plays an imperative role, as the eggs and chicken meat are loaded source of proteins, vitamins and minerals. Japanese quails are extensively scattered throughout the world. They are expansively reared for both meat and egg production and regarded as one of the significant substitute sources of animal protein. Rapid growth rate, early sexual maturity, less feed intake and floor space requirement, short incubation period, high egg-laying capacity and low maintenance costs are the major advantages of quail farming compared to other poultry species (Mady *et al*., 1981; Padmakumar *et al*., 2000). Reproductive performance, including egg production, fertility and hatchability plays a fundamental responsibility in the effectiveness of quail farming. Maximising the production of chicks is one of the vital features in a breeding farm to get the high financial returns. In a breeding farm, fertility is measured an essential issue and is calculated as the percentage of eggs laid that are fertile. Both hereditary and ecological factors are accountable for determining fertility (Kulenkamp *et al*., 1973). The number of chicks produced from a breeding flock principally depends on reproductive attributes such as egg production, fertility, hatchability and embryonic mortality. Consequently, determining the optimum sex ratio in Japanese quails is vital for achieving most

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favourable productive and reproductive performance. In print information on the topic of the effects of sex ratio on laying performance, fertility and hatchability of Japanese quail is partial. Hence, this study was conducted to evaluate the laying performance and hatching characteristics of Japanese quail as affected by different sex ratios.

## MATERIALS AND METHODS

The study was conducted at Instructional Poultry farm, Department of Animal Husbandry & Dairying, Faculty of Agriculture, Assam Agricultural University, Jorhat -785 013. A total of 437 nos of 4 week old quails comprising 137 males and 300 females were randomly selected from a brooded flock at the farm itself and divided into five groups. Each group contained 60 females, while the number of males assorted according to the sex ratios. The numbers of males were 60, 30, 20, 15 and 12 males in the 1:1 ($T_1$), 1:2 ($T_2$), 1:3 ($T_3$), 1:4 ($T_4$) and 1:5 ($T_4$) groups respectively. The laying performance was studied for a period of 12 week. Completely Randomized Design (CRD) was followed for the experiment. Feed and water were provided *ad libitum* for the birds during the experimental periods. Birds were fed diet containing 23 % crude protein and 2950 kcal/kg metabolisable energy at the growing phase (4-6 wk) and 20% crude protein and 2850 kcal/kg metabolisable energy at the laying phase (> 6 wk). The birds were raised under a deep litter management system. Throughout the experimental period, all birds received identical treatment and medication and were maintained under indistinguishable managerial and climatic conditions. A total of 300 hatchable quail eggs were selected from the eggs laid by the birds during the 10$^{th}$ week of lay. For the study, collection of egg was done over 4 days and 60 eggs were randomly chosen from each sex-ratio group. The average body weight of birds at first lay, age and egg weight at first lay, and daily egg production were recorded. Record on daily feed consumption per bird was also maintained throughout the experimental period. In addition, the incubation weight loss and hatching characteristics were recorded during the experimental period. The statistical analysis was carried out according to the methods described by Snedecor and Cochran, 1994. The Hen-day Egg production was calculated using the following formula:

Hen- Day Egg Production (%) =

$$\frac{\text{Number of eggs produced on a day}}{\text{Number of female quails present on that day}} \times 100$$

### Incubation and Hatching of Eggs

The eggs were put in an electric automatic incubator (Karamsar) at a preset temperature of 99.5°C and a relative humidity between 55 and 60% during 1 to 14 days in the setter part. During the hatching period, the temperature was maintained at 99.0°C and the relative humidity at 65-70% in the hatcher part of the egg incubator. Turning of eggs was done at hourly intervals in the setter part only according to that the incubator was programmed. Candling of eggs with the help of candling machine was done on the 10$^{th}$ day of incubation to determine fertility based on the existence of a visible network of blood vessels and a dark embryo mark. At this phase, all infertile, cracked and abnormal eggs were taken out from the incubator and fertility (%) was projected. The fertile eggs were then transferred to hatching trays. Number of hatched chicks, pipped eggs and dead-in-shell embryos were recorded. Fertility and hatchability percentages were calculated using the following formulas.

Calculation of Fertility Percentage:

$$\text{Fertility (\%)} = \frac{\text{Number of fertile egg}}{\text{Total number of eggs set}} \times 100$$

Calculation of hatchability percentage of total egg set:

$$\text{Hatchability (\%)} = \frac{\text{Number of chicks hatched}}{\text{Total number of eggs set}} \times 100$$

## RESULTS AND DISCUSSION

### Sex ratio on laying performance

The laying performance of Japanese quails for different sex ratios is presented in Table 1. Sex ratio did not significantly ($P > 0.05$) affect age of bird at first lay, average bird weight and egg weight at first lay, average egg weight, hen day egg production and average daily feed intake/bird/day. Age at first lay (43.00 ± 1.0 to 44.23 ± 0.91 day) of the birds was good agreement with the results of previous worker (Owen and Dike 2013). The average egg weight recorded in this

**Table 1:** Effect of Sex ratios on the laying performance of Japanese quails

| Attributes | Sex ratio group | | | | | SEM | P-values |
|---|---|---|---|---|---|---|---|
| | $T_1$ (1:1) | $T_2$ (1:2) | $T_3$(1:3) | $T_4$(1:4) | $T_5$(1:5) | | |
| Age at first lay (day) | 43.52 ± 0.72 | 44.23 ± 0.91 | 43.00 ± 1.0 | 44.12 ± 0.98 | 43.34 ± 0.82 | 0.88 | 0.070 |
| Bird weight at first lay (g) | 163.10 ± 10.12 | 160.23 ± 8.25 | 162.28 ± 7.25 | 160.23 ± 8.25 | 164.10 ± 10.12 | 6.99 | 0.120 |
| Egg weight at first lay (g) | 7.30 ± 0.19 | 7.43 ± 0.10 | 7.28 ± 0.18 | 7.16 ± 0.20 | 7.20 ± 0.18 | 0.17 | 0.090 |
| Hen day production (%) | 81.35 ± 3.37 | 82.02 ± 2.87 | 82.32 ± 4.02 | 81.78 ± 4.81 | 81.50 ± 2.15 | 3.44 | 0.210 |
| Average egg weight (g) | 10.56 ± 0.82 | 10.87 ± 0.75 | 11.02 ± 0.70 | 10.58 ± 0.90 | 11.05 ± 0.69 | 0.77 | 0.080 |
| Av. Feed intake/bird/day (g) | 25.15 ± 0.06 | 26.10 ± 0.04 | 25.35 ± 0.06 | 25.75 ± 0.09 | 26.00 ± 0.05 | 0.06 | 0.150 |
| Total feed intake/group/day(g) | $3018^{a}$ ± 4.7 | $2349^{b}$ ± 6.5 | $2028^{c}$ ± 6.3 | $1931.25^{c}$ ± 5.3 | $1872^{c}$ ± 4.9 | 5.54 | 0.031 |

[ab] Means with different superscripts within a row differ significantly.

**Table 2:** Effect of Sex ratio on incubation weight loss of Japanese quail eggs

| Attributes | Mating ratio | | | | | SEM | P-values |
|---|---|---|---|---|---|---|---|
| | $T_1$ (1:1) | $T_2$ (1:2) | $T_3$(1:3) | $T_4$(1:4) | $T_5$(1:5) | | |
| Initial weight (g) | 10.56 ± 0.82 | 10.87 ± 0.75 | 11.02 ± 0.70 | 10.58 ± 0.90 | 11.05 ± 0.69 | 0.77 | 0.082 |
| Final weight (g) | 9.20 ± 0.95 | 9.50 ± 1.20 | 9.62 ± 0.90 | 9.21 ± 1.37 | 9.65 ± 1.07 | 1.09 | 0.064 |
| Weight loss (g) | 1.36 ± 0.80 | 1.37 ± 0.71 | 1.40 ± 0.67 | 1.37 ± 0.95 | 1.40 ± 0.78 | 0.78 | 0.060 |
| Weight loss (%) | 12.87 ± 1.05 | 12.60 ± 1.54 | 12.70 ± 1.23 | 12.94 ± 1.10 | 12.66 ± 1.25 | 6.17 | 0.080 |

present study was also comparable to the values reported by other researchers (Garcia *et al*., 2000; Oliveira *et al*., 2007). The results of the study were consistent with those obtained by previous worker who (Ayoola *et al.*, 2017) reported that mating ratio did not significantly affect age of bird at first lay, average bird weight of first lay, average egg weight at first lay, average egg weight, hen day egg production. Similar findings were also revealed by other researcher, who observed no significant differences ($P \geq 0.05$) in total egg production due to variations in sex ratio (Karosa *et al.,* 2015). The total feed intake/group/day in group $T_1$ was highest and lowest in $T_5$ group. In this study, the daily feed consumption was within the recommended daily feed requirement for adult birds (Ani *et al*., 2009). The feed cost was highest in the $T_1$ group followed by $T_2$, $T_3$, $T_4$ and $T_5$ groups. The increase in feed intake per group with changes in sex ratio was attributed to variations in the number of birds in each group. The study revealed that feed cost increased with increasing sex ratio. This may be due to the different numbers of male birds present in the groups. The observed increase in feed cost with increasing sex ratio is in agreement with the findings of previous work (Dogan *et al.*, 2013) who reported that maintaining excessive number of males could result in financial losses.

**Sex ratio on incubation weight loss**

The incubation weight loss in different groups is presented in table 2. In this study, incubation weight loss was not significantly ($P > 0.05$) influenced by the sex ratio. The observed range of incubation weight loss was comparable to the values reported by other workers (Ayoola *et al.,* 2017; Soliman *et al.,* 1994).

**Sex ratio on fertility and hatchability**

The hatching characteristics of quail eggs of different groups are presented in table 3. Significant differences ($P < 0.05$) were observed in fertility percentages between the $T_1$, $T_2$, $T_3$ groups and the $T_4$, $T_5$ groups. However, no significant differences ($P > 0.05$) were recorded among the $T_1$, $T_2$ and $T_3$ groups. Similarly no significant difference ($P > 0.05$) was observed between the $T_4$ and $T_5$ group. Hatchability percentage was similar ($P > 0.05$) in the $T_1$, $T_2$ and $T_3$ groups, although the value were significantly ($P < 0.05$) higher than those recorded in the $T_4$ and $T_5$ groups. No significant differences ($P > 0.05$) in chick hatch weight were observed among the groups. The improvement in fertility rate at lower sex ratios could be

**Table 3:** Effect of Sex ratios on hatching characteristics of quails

| Attributes | Mating ratio | | | | | SEM | P-values |
|---|---|---|---|---|---|---|---|
| | $T_1$ (1:1) | $T_2$ (1:2) | $T_3$ (1:3) | $T_4$ (1:4) | $T_5$ (1:5) | | |
| Average egg weight (g) | 10.56 ± 0.82 | 10.87 ± 0.75 | 11.02 ± 0.70 | 10.58 ± 0.90 | 11.05 ± 0.69 | 0.77 | 0.085 |
| Fertility (%) | 90.54$^{a}$ ± 0.22 | 90.21$^{a}$ ± 0.31 | 89.76$^{a}$ ± 0.28 | 73.53$^{b}$ ± 0.25 | 72.82$^{b}$ ± 0.20 | 0.26 | 0.030 |
| Hatchability of total egg set (%) | 67.42 $^{a}$ ± 0.15 | 68.14$^{a}$ ± 0.18 | 67.82 $^{a}$ ± 0.24 | 59.25$^{b}$ ± 0.19 | 58.60$^{b}$ ± 0.23 | 0.20 | 0.023 |
| Chick weight (g) | 6.70 ± 0.25 | 6.79 ± 0.20 | 6.83 ± 0.18 | 6.75 ± 0.22 | 6.85 ± 0.18 | 0.21 | 0.092 |

$^{ab}$ Means with different superscripts within a row differ significantly $P<0.05$).

attributed to the females in these groups receiving more mating opportunities than those in other groups (Karousa *et al*., 2015). The findings of the present study are good agreement with those of other researchers (Sheikh *et al.,* 2016; Dogan *et al.*, 2013; Walker 1990) who reported that sex ratios of 1:1, 1:2 and 1:3 male to females resulted in higher ($P \leq 0.05$) fertility and hatchability rates compared with sex ratios of 1:4 and 1:5. These results are also consistent with reports from several authors (Farooq *et al.,* 2001; Ipek *et al.,* 2004; Ali *et al.,* 2013; Baser *et al.* 2002) who found no significant differences in hatchability of fertile quail eggs between the 1:2 and 1:3 sex ratios and observed that hatchability increased with an increasing number of males in the sex ratio. In contrast, (Raji *et al.*, 2014) reported a significantly higher hatchability of fertile eggs at a sex ratio of 1:3 (71.48%) compared with a sex ratio of 1:2 (26.32%). From the study, it was observed that the chick weight was not influenced by the different mating ratios group. This finding is agreed with the finding of previous works (El- Sheikh *et al*., 2016; Ayoola *et al.,* 2017).

## CONCLUSION

From the study, it was observed that sex ratio did not significantly affect age and average body weight of birds at sexual maturity, average egg weight, hen – day egg production, average daily feed intake, incubation weight loss or chick weight in Japanese quail. The sex ratios of 1:1, 1:2 and 1:3 were found to be more appropriate for rearing Japanese quail, resulting in superior fertility and hatchability rates compared with the 1:4 and 1:5 sex ratios. Increased fertility and hatchability of quail eggs was observed with an increase in the number of males, as well as the feed cost per group also augmented in increased number of males. Therefore, it can be concluded that the sex ratio of 1:3 is the most cost-effective and competent ratio for Japanese quail reared under an intensive production system.

## GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

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