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Full Length Research Paper

Genetic parameters and consequences of selection for short-term egg production traits in Japanese quail in a tropical environment

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The current study was conducted to investigate the effect of selection for short-term (30 days) egg production trait in Japanese quail (*Coturnix coturnix japonica)* over three generations (G_o, G_1 and G_2). Heritabilities were estimated using the mixed model least squares and maximum likelihood computer programme. Fertility percentages of 76.29, 70.06, and 65.98% and hatchability percentage of 57.89, 63.75 and 69.12% were obtained for G_o, G_1 and G_2 generations, respectively. The average egg weight for G_0, G_1 and G_2 generations were 11.41, 10.84 and 9.33 g, respectively. Body weight at first egg (BWTFE) was 135.61, 150.02 and 154.64 g for the G_o, G_1 and G_2 generations respectively. Egg number differed significant ($p < 0.05$) between generations. Heritability estimates for egg number, egg weight and BWTFE studied were low to moderate and ranged from 0.11 to 0.48. Realized genetic gains of 1.60 and 2.86 eggs were obtained for egg number while realized correlated responses of -0.18 and -1.17 g for egg weight and -6.03 and -15.14 g for BWTFE were obtained respectively in G_0 and G_1 generations. The experiment indicates that mass selection improved egg number in Japanese quail.

Key words: Fertility, hatchability, heritability, realized genetic gain.

INTRODUCTION

Over the years, there has been a significant gap between the production and supply of animal protein to feed the ever-growing population in Nigeria. To halt this negative trend, efforts have been directed towards boosting the livestock industry with micro-livestock having prolific tendency, short gestation period, short generation interval and rapid growth (Owen and Amakiri, 2010). Among the micro-livestock, is the Japanese quail, which is farmed for meat and egg production (Panda and Singh, 1990). Japanese quail breeding programs rely on knowledge of genetic relationships and variation among individuals. Breeders aim to exploit these forms of variation by taking into account additive, non-additive, and environmental factors. Variation and co-variation within and among populations provide the basis for development of selection strategies. Selection for productive traits (egg number) could affect the performance of reproductive traits and might directly affect commercial production (Buis et al., 1994).

Fertility and hatchability (reproductive traits) is one of the most important attributes of parent stock performance (Hunton, 1971). Fertility is defined as the interaction between maternal and paternal gametes to produce a viable zygote and can be expressed as the number of fertile eggs per bird. Hatchability on the other hand is the ratio between fertile eggs that produce viable birds and unfertilized eggs. Hatchability is the composite of the embryos' ability to survive and the maternal contribution towards embryo survival (Savegnago et al., 2011). The relationships between productive traits (body weight at first egg and egg production) and reproductive traits (fertility and hatchability) are of interest in Japanese quail breeding because if the relationships are strong, they may affect

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progress of selection. Selection for productive traits could affect the performance of reproductive traits and might directly affect commercial performance, as in the case of meat poultry, for which hatchability is one of the most important attributes of parent stock performance (Savegnago et al., 2011).

Establishment of breeding and selection programs necessitates estimation of genetic parameters for different productive and reproductive traits. Poultry, especially Japanese quail, have received less attention relative to other livestock species; although some work, have been reported on Japanese quail (Aggrey et al., 2003; Megeed and Younis, 2006; Kumari et al., 2009; Alkan et al., 2010). Bahie El-Dean et al. (2008) reported age at sexual maturity in Japanese quail females to range between 42.98 to 61.89 days. Abdel-Fattah et al. (2006) found that heritability for growth rate ranged from 0.01 to 0.71, while, Bahie El-Dean et al. (2008) recorded heritability estimates 0.76, 0.08 and 0.06 for early, medium and late age at sexual maturity groups; respectively.

Maurice and Gerry (2005) indicated that Japanese quail subjected under proper management weighs about 100 to 140 g (male), while the females are heavier, weighing from 120 to 160 g. The average egg weight is about 10 g while the average egg number is about 100 to 200 eggs per bird per year (Onyimonyi and Okeke, 2000). It is quite possible that when these birds are subjected to selection and improved management, production will be better. Therefore, the aim of the current study was to estimate heritability and selection response of egg production traits (egg number and egg weight), and BWTFE over three generations of selection.

MATERIALS AND METHODS

The experiment was carried out in a curtained quail coop located at the Research and Teaching Unit in Department of Animal Science, Faculty of Agriculture, University of Nigeria, Nsukka. Nsukka town is located on latitude 05º 22' North and longitude 07º 24' East with annual rainfall ranging from 986-2098mm (Ndofor-Foleng et al., 2010). The farm is situated within the equatorial rainforest belt of the tropics and falls specifically within the derived savanna vegetation zone. It has well-defined rainy season (April - October) and dry season (November - March) (Ohagenyi et al., 2011). The base population of Japanese quail was obtained as two-week old chicks from National Veterinary Research Institute (NVRI), Vom, Plateau State, Nigeria and transferred to Animal Science Departmental Farm, University of Nigeria, Nsukka in furtherance of the breeding programme.

Breeding programme

In other to generate enough birds for the experiments, mating was carried out within the base population in a ratio of one male to two females. This ratio was chosen to ensure the highest fertility as suggested by El-Fiky (2002). Eggs were collected, pedigreed (identified according to sire) and hatched to obtain the G_o generation. Hatched chicks were wing banded and raised. Feed and water were provided *ad-libitum*. The experimental diet con-tained 28% protein and 2920k cal-ME/Kg until two weeks of age and 25% protein with 2850 k cal-ME/Kg during 3 to 6 weeks of age.

From the foundation population (280 females and 100 males), two randomly sampled sub populations namely: the population under selection (200 females and 50 males) and a random breeding control population (40 females and 40 males) were established. The random breeding control was maintained as non-selected pedigreed population to correct for environmental trends and/or fluctuations brought about by random genetic drift (Havenstein et al., 1988). Quail chicks in the control were reared intermingled with the population under selection throughout generations of selection to also minimize environmental variation. At six weeks of age, female quails were moved into individual laying cages for egg production study. During egg production, the birds were fed with a layer ration containing 20% crude protein with 2820 kcal-ME/Kg. At all stages and across the generations of selection, the same diets were provided to all the birds.

Selection in the Go generation

After two weeks of stabilization of lay, females were mass selected based on their individual laying performance (egg number) over a period of 30 days, while males were selected based on their individual body weight. Sixty percent (60% or 120 females) were selected from the G_o population to become the parents of G_1 generation, which is turn, yielded the parents of G_2 generation.

Variables measured

Fertility

Fertility was tested at the 11th day of incubation by directing candle light across an egg in the dark. Fertile eggs showed a dark spot at the center with radiating streaks of blood vessels, mimicking the structure of spider. Infertile eggs were removed. Fertility percentage was recorded for each sire family and calculated as:

$$\text{Fertility percentage} \quad \frac{\text{Total number of fertile eggs}}{\text{Total number of}} \times \frac{100}{1}$$

Hatchability Percentages (Scientific) was recorded for each sire family by the following formula:

$$\text{Hatchability percentage} = \frac{\text{Total number of chicken hatched}}{\text{Total number of fertile egg}} \times \frac{100}{1}$$

Production traits

The body weight of each quail on the day of first egg was recorded as the body weight at first egg (BWTFE). During egg production, eggs were collected twice daily, recorded in an egg chart and weighed to obtain the egg weight.

Statistical analysis

Data on Body weight at first lay, egg number and egg weight were analyzed using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 2002) in a completely randomized design (CRD). The means were separated using Duncan's New multiple range test (Duncan, 1955).

Table 1. Fertility and Hatchability percent of Japanese quail eggs by generations of selection.

Parameter	Generation		
	G_0	G_1	G_2
Fertility percentage	76.29[a]	70.06[b]	65.98[c]
Hatchability percentage	57.89	63.75	69.12

[a],[b],[c],Row means with different superscripts are significant at 5 % (P < 0.05).

Model: $X_{ijk} = \mu + S_i + G_j + e_{ijk}$

Where, $X_{ij\ k}$= the record of the j^{th} progeny of the i^{th} generation, μ = the overall mean; S_i= effect of sire; G_j = effect of generation; e_{ijk} = error.

Analysis variance component and heritability estimates

Components of variance were estimated using the mixed model least squares and maximum likelihood computer programme of Harvey (1990).

Genetic response (ΔG) was calculated as the difference between the mean of the progeny of the selected parents and the mean of the contemporary reared control population (Falconer, 1989).

$$\Delta G = XS - XC$$

Where, ΔG = Genetic response; XS = mean phenotypic value of the progeny of the selected individual; XP = the mean of the control population.

RESULTS AND DISCUSSION

The various results obtained for the variables (mean egg number, average egg weight, body weight at first egg as well as fertility and hatchability percentages over three generations) are shown. Table 1 shows the fertility of 76.29% for G_o, 70.06% for G_1 and 65.98% for G_2 of selection. A significant difference ($p < 0.05$) was observed in fertility percentage between the generations of selection. There was a decrease in fertility percentage as the number of generations increased. These results agree with those of El-Hammady et al. (2001) and Magda et al. (2010) who found significant differences for fertility percentages among generations. The decrease in fertility in this study could be the result of the negative correlated response observed during selection for increase egg production in females and body weight in males. It was expected that lower estimates would be found for fertility, because, reproductive traits have a low heritability estimate (Savegnago et al., 2011), and are highly influenced by environmental factors (Austic and Neshim, 1990). For instance, Khaldari et al. (2010) reported estimates of 67.00 and 72.90% for fertility percentages during 5 and 3 consecutive generations of selection for increasing six and four weeks body weight respectively. Similarly, El–Fiky et al. (1996) reported a wide range (66.70 to 85.80%) for the same trait. Higher estimates of 80.60 and 81.70% were however reported for these traits by El–Fiky (2002) respectively for young quail flock. It seem generally that these birds are highly fertile, a characteristics, which should be utilized efficiently for quail meat production.

Hatchability percentage of 57.89, 63.75 and 69.12% were obtained for G_0, G_1 and G_2 generations respectively. Significant differences among generations were recorded for hatchability percentages. Unlike fertility, hatchability increased with generation. The third generation represented the highest significant percentage (69.12 %), while the lowest was recorded for the first generation (57.89 %) (Table 1). Different pattern of results was recorded by El-Hammady et al. (2001) and Magda et al. (2010) who reported the lowest hatchability percentage in the second generation (69.70%) and the highest (82.30%), in the third generation.

The increase in hatchability could be attributed to improved incubating conditions over generations. The values reported for the two traits are below the range reported in the literature. Narahari et al. (1988) and Bunaciu et al. (1994) reported 72.20% and 73.20% respectively for hatchability percentage in Japanese quail. Furthermore, El-Fiky et al. (1996) and Adeogun and Adeoye (2004) reported a wide range for this trait (68.20 to 78.50%) during three consecutive generations while lower ranges of 45.50 and 50.80% were reported by Marks (1979). The wide differences in reported values for fertility and hatchability could be attributed to water loss during incubation and other environmental differences. Water loss is a normal process during incubation; usually 11.32% of water is lost in quail eggs. However, too low or too high water loss influences embryo development, and, consequently, egg hatchability (Vasconcelos et al., 2008).

Egg number, average egg weight and body weight at first egg

The means for egg number, average egg weight and BWTFE are shown in Table 2. The mean egg production in the G_0, G_1 and G_2 were 25.34, 27.60 and 29.46, respectively. The corresponding generational means for egg weight were 11.41 g, 10.84 g and 9.33 g respectively.

Table 2. Descriptive statistics of egg number for 30 days (short egg production) egg weight and BWTFE of Japanese quail over three generations.

Statistic	Generation		
	G_0	G_1	G_2
Mean egg number	25.34 ± 0.60 [a]	27.60 ± 0.71 [b]	29.46 ± 0.52 [c]
BWTFE (g)	154.64 ± 2.06 [a]	150.02 ± 1.66 [b]	135.61 ±1.32 [c]
Average egg weight	11.41 ± 0.10[a]	10.84 ± 0.11[b]	9.33 ± 0.11[c]

[a], [b], Row means with different superscripts are significant at 5 % ($P < 0.05$).

Table 3. Heritability estimates of egg production traits.

Trait	Generation		
	G_0	G_1	G_2
BWTFE (g)	0.46±0.54	0.32±0.47	0.30±0.30
Egg Number	0.12±0.36	0.33±0.47	0.48±0.54
Egg weight (g)	0.19±0.34	0.11±0.34	0.12±0.30

There were significant differences ($p < 0.05$) in egg number and egg weight between the generations. While egg number increased progressively with generations, egg weight decreased. The upper trend in egg number over generations of selection was expected because egg number was the trait considered during selection and the gain in this trait indicates a positive response. The decreasing trend observed for egg weight over generation reflects a negative correlated response in egg weight due to selection for increased egg production.

Mean body weight at first egg of 154.64, 150.02 and 135.61 g of G_0, G1 and G_2 generations respectively were obtained (Table 2). There were significant differences ($p < 0.05$) in the body weights at first egg among the three generations with a decreasing trend over generations. This result indicates a negative correlated response in BWTFE following selection for improve egg production.

Egg number and egg weight are negatively correlated genetically thus, increase egg number will on the average lead to reduced egg weight (Nwosu, 1990). Panda and Singh (1990) determined an egg weight in quails either subjected to selection for meat or egg traits as 10.58 and 9.76 g, respectively. Asasi and Jaafar (2000) reported a range of 9.76 to 11.63 g while Khaldari et al. (2010) reported that, egg weight was 13.40 and 12.80 g in the selected and control populations respectively, during selection for increased body weight at four weeks. Also, Inal et al. (1996) using selection for body weight at 5 weeks of age reported higher estimates for egg weight that ranged from 10.94 to 13.23 g over 5 generations. These higher values reflect positive correlated responses in egg weight due to selection for improved body weight, which agrees with the positive genetic correlation between body weight and egg weight.

Age at sexual maturity influences BWTFE, egg number to a particular age and egg weight. Selection for increased laying potential encourages early sexual maturity (lower age at sexual maturity) which means lower body weight at sexual maturity (lower BWTFE). Thus, BWTFE and egg number are negatively correlated **(**Saatci et al., 2006).

Heritability

Heritability estimates for egg number and egg weight and BWTFE derived from sire components of variance are shown in Table 3. Heritability estimates for egg number, egg weight and BWTFE were 0.12 ± 0.36, 0.33 ± 0.47 and 0.48 ± 0.54; 0.19 ± 0.34, 0.11 ± 0.34 and 0.12 ± 0.30; 0.46 ± 0.54, 0.32 ± 0.47, and 0.30 ± 0.30, respectively, were obtained for G_0, G_1 and G_2 generation respectively. Thus, heritability values were low to high for egg number and BWTFE but low for egg weight across the generations. Heritability values for egg number show an upward trend across generations while those of egg weight and BWTFE show a downward trend. The increase in heritability estimates for egg number across generations indicates increasing additive genetic variance across generations (Falcorner, 1989). The estimate of heritability reported in the present study is however within the range normally reported for the respective traits in this species (Adeogun and Adeoye, 2004).

Genetic response to selection

The genetic response to selection (realized genetic gain) for short-term egg production over three generations of

Table 4. Realized genetic response of egg production traits and BWTFE over generations of selection.

Trait	Generation		
	G_0	G_1	G_2
BWTFE (g)	-6.03	-15.14	-
Egg Number	1.60	2.86	-
Egg weight (g)	-0.18	-1.17	-

selection is shown in Table 4. A realized genetic gain of 1.60 and 2.86 eggs were obtained for egg number in G_0 and G_1 generations respectively. The realized genetic response for body weight at first egg and average egg weight were -6.03, -15.14 g and -0.18 g, -1.17 g for G_0 and G_1 generations respectively. The results reflect positive responses to selection, for egg number and negative correlated responses for BWTFE and egg weight. Clearly, the realized genetic gains from this experiment did not measure up to expectations. This could be attributed to the question of refractory response to continued selection for egg number. Abdullah and Aktan (2011) reported that the most likely causes of this might be genetic "slippage" due to fluctuation of environmental trends and negative genetic correlations between components of performance. By "genetic slippage", Abdullah and Aktan (2011) implied that selection is mainly directed towards non additive genetic effects of over dominance, epistasis, and genotype X environment interactions, which dissipate in the next generation; this could well account for the "non-response" in egg weight and BWTFE.

Aboul-Seoud (2008) using selection based on high egg weight found an irregular selection response averaging 12.24 g, 11.59 g and 10.06 g in the first second and the third generation. This irregularity of the selection response has been observed in many selection experiments reported in literature. However, Abdel-Tawab (2006) reported that the actual response to selection for high egg weight was 1.22 g after the first generation of selection and fluctuated to be 0.68 g after the third generation of selection. Falconer (1954) has shown that the irregularity in response to selection might have been due to many genetic or environmental factors. Differences in natural selection differential, fertility and/or genetic environment interaction might be because of such irregularities in selection response (Aboul-Seoud, 2008) especially in such small numbers of generations as it was the case in the present study.

Conclusion

Egg production traits (egg number and egg weight) in the Japanese quail are lowly to moderately heritable while BWTFE is moderately to highly heritable. Values obtained in heritability estimate of egg number, egg weight and BWTFE indicate that direct selection for these traits could lead to genetic improvement as was observed for egg number in the present study. However, where simultaneous improvement is required for traits, a multiple trait selection index could be used with appropriate weighting factor for each trait. It could be concluded that mass selection improved egg number in Japanese quail on the other hand, improving fertility and hatchability could be done through adjusting the environmental factors.

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