Production Performance and Estimation of Heritabilities Using Regression Method of Different Traits of Quail Under Intensive Conditions

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Table of contents

Content **Page NO**

List of tables

List of graphs

List of abbreviations

Abbreviation	Elaboration
BBS	Bangladesh Bureau of Statistics
GDP	Gross Domestic Product
DLS	Department of Livestock Services
TM	Trademark
Avg.	Average
BWt.	Body Weight
h^2	Heritability

Abstract

A study was conducted to know the production performance, regression parameters and heritability estimation of different traits of Japanese quail. A total of 72 quails were reared in intensive conditions at two generations. Number of egg produced by the quails were counted up to 10 weeks age and weekly body weight was measured up to 11 weeks of age. A total of 40 eggs from each generation was collected at 10 weeks of age to assess the external and internal characteristics of eggs. The heritability of traits of quail was estimated using regression method. The egg production per quail per day of parent and offspring generation from the age of 47 days to 70 days was 0.30±0.030 and 0.31±0.027 for parent and offspring generations, respectively. Average body weight in parent and offspring generation up to 11 weeks was 120.38±21.149g and 117.74±21.646g, respectively. Both the external and internal characteristics of eggs of quail were higher in parent generation than the offspring generation except egg production, yolk height, thick albumen height and Haugh unit. The regression co-efficient of different values of offspring generation was positive except shell weight and albumen weight but in parent generation the regression co-efficient of different values was negative except egg production and body weight. The fit statistics R^2 values of egg production and live weight was higher than other traits in both generation. The heritability value of egg production, body weight, egg width, shell weight, thin albumen height and shape index were positive and rest of the traits showed negative values. The results indicate that egg production, body weight and shape index can be used for selection index to improve quail production.

Key words: Heritability, regression, quail, parent, offspring

Chapter 1: Introduction

Bangladesh is an agricultural based developing country with a population of 149.77 million (BBS, 2019). In fiscal year 2017-18, the total contribution of livestock sub-sector to Gross Domestic Product (GDP) in Bangladesh is approximately 1.54% and livestock in agricultural production 13.62% (DLS, 2018). The total population of ruminant and poultry were 55.13 million and 337.99 million, respectively (DLS, 2018). The production of meat and egg were 72.60 lakh metric ton and 1552 crore against the demand of 72.14 lakh metric ton and 1712.88 crore, respectively (DLS, 2018). There was surplus in meat production but deficit in egg production. Per capita protein intake was only 63.80 g per day (BBS, 2020). The lack of adequate animal source food is a major factor responsible for poor dietary and nutrient adequacy and undernutrition, particularly among mothers and young children in Bangladesh (FAO and WHO, 2014). Among the animal protein sources, quail meat and egg can be a good option to fulfill the demand of the mothers and young children in Bangladesh as it is cheap. Moreover, quail meat and egg contain more protein than the chicken (Ali, 2019; Ioniţă et al., 2011). In addition, quail eggs are good sources of folate, vitamin B12, pantothenic acid, iron, phosphorus, riboflavin and selenium (Kalsum at al., 2012) and in regard to meat quality (pH, color, and texture), the quail meat is similar to broiler meat (Narinc et al., 2013).

Quail has marked advantages such as faster growth, early sexual maturity, high rate of egg production, short generation interval (3-4 generations a year), small floor space (200-250 and 150-200 cm^2, respectively in litter and cage system), less feed requirements (20-25 g/adult bird/day), short incubation period of hatching eggs, less feed cost, and less susceptibility to common chicken diseases (Aygun and Sert, 2013; Faitarone et al., 2005; Jatoi et al., 2013). With proper care, hens should lay 200 eggs in their first year of lay. Life expectancy is only 2 to 2½ years. Quail eggs are a mottled brown color and are often covered with a light blue, chalky material. Each hen appears to lay eggs with a characteristic shell pattern or color (Randall and Bolla, 2008). The egg weight, egg length, egg width, shell weight, shell thickness, shape index, yolk weight, albumen weight and Haugh unit of Japanese quail ranges from 11.90-13.11g, 33.22-34.06mm, 25.69-26.43mm, 0.69-0.70g, 0.23mm, 77.16-79.34%, 3.89-4.38g, 7.32-8.04g and 83.60-87.41%, respectively (Yılmaz et al., 2011).

In quail, Akbas et al. (2004) found heritability estimates of body weight 0.007, 0.39, 0.45, 0.58, 0.61, 0.55 and 0.44 at the age of 0, 1, 2, 3, 4, 5 and 6 weeks, respectively. The heritabilities of egg weight, egg length, egg width, egg shape index, shell thickness, albumen width, albumen height, Haugh unit, yolk width and yolk height were found 0.37±0.09, 0.15±0.03, 0.40±0.17, 0.46±0.03, 0.52±0.03, 0.23±0.02, 0.27±0.14, 0.30±0.08, 0.11±0.03 and 0.11±0.02, respectively by Daikwo et al. (2013).

Genetic studies on quail in Bangladesh will enable breeders to design suitable improvement program for the bird. Therefore, reliable estimates of genetic parameters like heritabilities are necessary to predict response to direct or indirect selection. Considering the necessity of such studies in quails, present research was conducted with following objectives:

1) To know the production performance of Japanese quail under intensive farming condition.
2) To estimate the regression parameters of different traits of quail.
3) To estimate the heritability value of different traits of quail.

Chapter 2: Materials and Methods

2.1 Study area:

The study was conducted at local quail farm known as Arif Hatchery and Poultry Farm, Dagonbhuiya, Feni from October 2019 to March 2020. The study area has a latitude of 23°01'N, longitude 91°39'E and elevation of 12 m. The average daily maximum temperature is between 24^o C and 27^o C. At night it cools down to temperatures between 12^o C and 15^o C.

2.2 Husbandry:

A total of 72 Japanese quails were reared at a ratio of 1: 4 (male: female) both in parent and offspring generation. Chicks were brooded up to five weeks of age. Then, the birds were shifted to the cages maintaining the 1: 4 sex ratio (male: female). Sex was determined either by plumage color or examination of the gonads. Lighting schedule of 24 hours lighting for the first three weeks, and then the lighting regime was 16 hours light and 8 hours darkness. Birds were allowed to access *ad libitum* feed and water. They were fed with commercial diet Golden Poultry Boiler Starter™ (2950 kcal ME/kg, 24.7% CP and 3% Ca) for 35 days and thereafter commercial feed Fresh Layer Layer (Mash) 1™ (2800 kcal ME/kg, 24.7% CP and 3.5% Ca) was given. To produce offspring from parent generation, eggs were collected at 10 weeks of age and the eggs were incubated in an electronic incubator.

2.3 Measurements:

A total of 40 eggs from each generation of quails were collected at 10 weeks of age for assessment of both external and internal characteristic. Deformed egg like soft-shelled, cracked and small eggs were not used in the study. To measure the weights (egg weight, shell weight, yolk weight, and albumen weight), a digital weighing balance (Digiscale™, Germany) with 0.01 g accuracy was used. A slide caliper (Tricle Brand™, China) sensitive to 0.01mm was used for measuring the length and width of egg. Shell thickness was measured at equatorial region of egg using a micrometer

(Tricle Brand™, China) sensitive to 0.01 mm. Yolk height, thick albumen height and thick albumen height were calculated using a tripod micrometer (Sunshine™, India) . The egg shape index was determined from these measurements according to Reddy et al. (1979) as given with the following formula,

Shape Index (%) = (Egg width (cm) / Egg length (cm)) × 100.

The Haugh unit values were calculated for individual eggs using the following formula given by Haugh (1937),

Haugh Unit (%) = 100 log (Albumen height (mm) + 7.57 – 1.7 × Egg weight $(g)^{0.37}$).

Average body weight of quail was measured at weekly interval up to 11 weeks of age. Body weight was measured early in the morning before feeding using an electronic balance (0.1g least count). Egg was collected twice daily from first day of laying until 70 days of age, After collecting, number of egg production was recorded in data sheet and egg production per quail was calculated by dividing number of egg production by number of quail on that particular day.

2.4 Model parameters and fit statistic:

The linear regression equation (Y = a + bx), where, Y is the value of the traits, x is the ages of female quail, and a and b are the parameters that define the shape of the curve. The goodness-of-fit, and model performance were compared by the fit statistics: coefficient of determination (R^2). The values of R^2 was obtained by fitting linear regression with the actual values of the traits.

The following statistical model was used to obtain the least square means for each parameter, goodness of fit (R^2) the regression model parameters using PROC GLM of SAS (SAS, 2010). The model is given as:

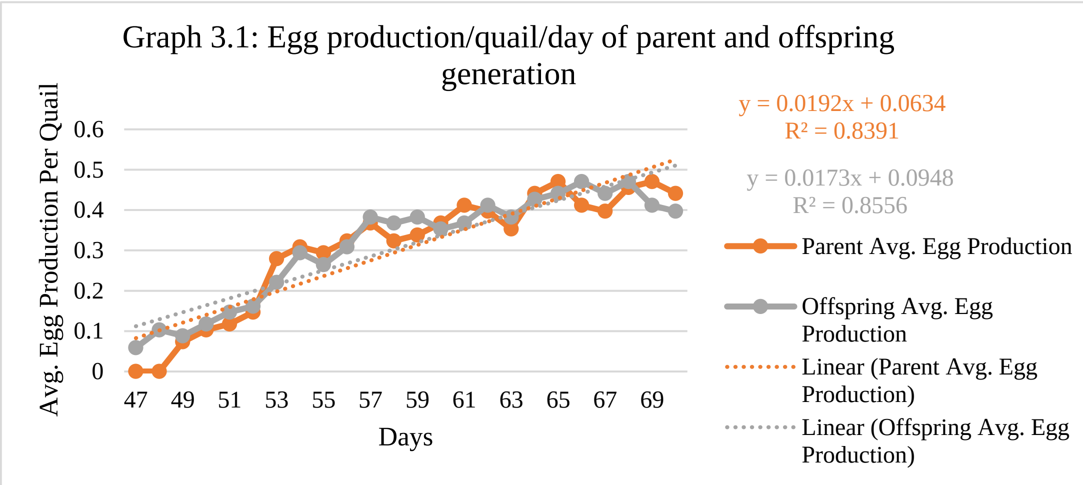
Yij = μ + Ai + eij

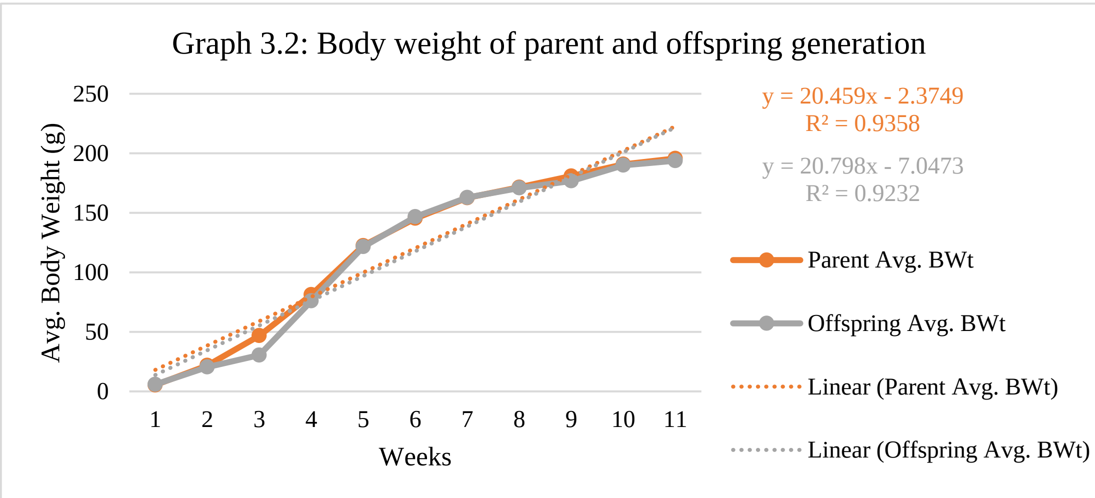
Where, Yij is the values of the trait, μ is the overall mean, Ai is the effect of age and eij is the residual effect, distributed as N (0 σ2).

The mean differences were compared using least significant difference (lsd) (Steel et al., 1997) at 5% level of significance.

Chapter 3: Results

The average egg production (no) per quail per day in parent and offspring generation up to 10 weeks of age is presented in Table 3.1. Graph 3.1 showed the egg production per quail per day of parent and offspring generation from the age of 47 days to 70 days was 0.30±0.030 and 0.31±0.027 for parent and offspring generations, respectively. The age of first lay of parent generation and offspring was 47 days and 49 days, respectively. The average body weight in parent and offspring generation up to 11 weeks was 120.38g ± 21.149 and 117.74g ± 21.646, respectively. Graph 3.2 showed the average body weight of quail from first to eleventh weeks of age. The average body weight of quail showed an increasing trend with age both in parent and offspring generation.





The mean with standard error of different traits of parent and offspring generation of quail were showed in Table 3.1. The results showed that body weight, egg weight, egg length, egg width, shell weight, yolk weight, albumen weight, thin albumen height and shape index were higher in parent generation than the offspring generation (Table 3.1). Whereas, egg production (No) /quail/day, shell thickness, yolk height, thick albumen height and Haugh unit were found higher in offspring generation than the parent generation (Table 3.1). Significant difference ($P < 0.05$) was observed in egg length and yolk weight between parent and offspring generation.

Table 3.1: Mean with standard error of different traits of parent and offspring generation of quail

Traits	Parent generation	Offspring generation	SEM
Egg Production (No) /quail/day	0.30 ± 0.030	0.31 ± 0.027	0.086
Body Weight (g)	120.38 ± 21.149	117.74 ± 21.646	24.294
Egg Weight (g)	10.91 ± 0.294	9.69 ± 0.181	5.047
Egg Length (cm)	3.25^{a} ± 0.065	3.18^{b} ± 0.076	1.456
Egg Width (cm)	2.59 ± 0.063	2.48 ± 0.055	1.170
Shell Weight (g)	1.46 ± 0.063	1.35 ± 0.054	0.609
Shell Thickness (mm)	0.31 ± 0.008	0.31 ± 0.019	0.109
Yolk Weight (g)	4.04^{a} ± 0.129	3.30^{b} ± 0.096	1.806
Albumen Weight (g)	5.11 ± 0.218	4.85 ± 0.130	2.265
Yolk Height (mm)	10.14 ± 0.100	10.46 ± 0.143	4.753
Thick Albumen Height (mm)	4.58 ± 0.112	4.64 ± 0.168	1.917
Thin Albumen Height (mm)	3.16 ± 0.143	3.04 ± 0.104	1.346
Haugh Unit (%)	90.08 ± 0.646	91.27 ± 0.841	43.158
Shape Index (%)	79.94 ± 2.140	79.00 ± 2.721	33.883

SEM= Standard error of mean; $^{a\,b}$ Means with different superscript are differed at 5% level of significance

The regression parameters of different traits of parent and offspring generation of quail were showed in Table 3.2. In case of parent generation, all regression co-efficient were negative except egg production and body weight. Whereas in offspring generation, all regression co-efficient were positive except egg shell weight, albumen weight and shape index. Intercept of all traits were positive except body weight both in parent and offspring generation. Body weight (R^2= 0.935) and egg production (R^2= 0.839) showed strong relation with dependent and independent variable both in parent and offspring generation. In case of parent generation, shell membrane thickness (R^2= 0.340) and yolk height (R^2= 0.257) showed lower relationship with dependent and independent variable. On the other hand, shell thickness (R^2= 0.54) showed moderate relationship with dependent and independent variable in offspring generation.

Table 3.2: Regression parameters of different traits of quail in parent and offspring generation

Traits	Parent Generation			Offspring Generation		
	Intercept	Regression Co-efficient	R^2	Intercept	Regression Co-efficient	R^2
Egg Production	0.0634	0.0192	0.8391	0.0948	0.0173	0.855
Body Weight	-2.375	20.459	0.9358	-7.043	20.798	0.923
Egg Weight	11.466	-0.0535	0.0577	9.1097	0.0557	0.165
Egg Length	3.2579	-0.0008	0.0002	3.046	0.0124	0.047
Egg Width	2.705	-0.0114	0.0585	2.4597	0.0019	0.002
Egg Shell Weight	1.6463	-0.0177	0.0138	1.3701	-0.0021	0.002
Shell Thickness	0.3216	-0.0016	0.0677	0.195	0.0107	0.54
Yolk Weight	4.1395	-0.0095	0.0095	3.073	0.0219	0.091
Albumen Weight	5.4368	-0.0311	0.0356	4.9121	-0.0064	0.004
Yolk Height	10.547	-0.0383	0.2579	10.369	0.0089	0.006
Thick Albumen Height	4.6931	-0.0105	0.0154	4.2014	0.0422	0.111
Thin Albumen Height	3.3816	-0.0214	0.0388	2.9771	0.0055	0.005
Haugh Unit	90.232	-0.0146	0.0009	89.302	0.1877	0.087
Shape Index	83.118	-0.3029	0.0351	80.648	-0.1572	0.005

R^2 = Co-efficient of determination

Table 3.3 presents the heritability estimates of different traits of quail. High heritability of 2.043 and 1.963 were recorded for average body weight and egg production (no/quail/day) respectively up to 10 weeks of age. Moderate heritability of 0.216 was recorded for egg shape index at 60 to 70 days of age. However, low heritability ranged from -1.508 to 0.078 was recorded for remaining egg traits (egg weight, egg length, egg width, egg shell weight, shell thickness, yolk weight, albumen weight, thick albumen height, thin albumen height and Haugh unit) at 60 to 70 days of age.

Table 3.3: Heritability value (h^2) of different traits of quail

Traits	h^2
Egg Production	1.963
Body Weight	2.043
Egg Weight	-0.523
Egg Length	-0.194
Egg Width	0.078
Egg Shell Weight	0.058
Shell Thickness	-0.265
Yolk Weight	-0.622
Albumen Weight	-0.317
Yolk Height	-0.425
Thick Albumen Height	-1.508
Thin Albumen Height	0.004
Haugh Unit	-1.030
Shape Index	0.216

Chapter 4: Discussion

The production egg up to 10 weeks of age was higher than the result of Dauda et al. (2014) which may be attributed to ambient temperature, relative humidity and photoperiod provided to the quail hens. Average body weight up to 11 weeks was similar with result of Rahman et al. (2016). In contrast, Jatoi et al. (2015) found lower average body weight than the present result.

Egg weight is the most important trait than other traits for the consumer (Genchev, 2012). The egg weight of parent and offspring generation was similar with the finding of Islam et al. (2015). However, Abd Salman Abu Tabeekh (2011) and Daikwo et al. (2013) found lower egg weight than the current study and Narinc et al. (2015) observed higher egg weight than the current study. Egg length and egg width of parent and offspring generation was similar with Hrnčár et al. (2014) and Kul and Seker (2004). Whereas, unlike the present study, Abd Salman Abu Tabeekh (2011) and Chimezie et al. (2017) observed the lower egg length and egg width. Egg shell weight of parent and offspring generation was close to the observation of Khan and Akter (2019). In consistent with this result, Abd Salman Abu Tabeekh (2011) who found lower egg shell weight. But, result of shell thickness of current study was similar with the findings of Abd Salman Abu Tabeekh (2011). Shape index of parent and offspring generation was similar with the findings of Abd Salman Abu Tabeekh (2011) and Chimezie et al. (2017). However, Kul and Seker (2004) observed slightly lower shape index value than the current study. Yolk weight and albumen weight of parent and offspring generation were close to results of Chimezie et al. (2017). However, lower yolk and albumen weight than the current study was observed by Abd Salman Abu Tabeekh (2011). Yolk height of parent and offspring generation was close to the result of Kul and Seker (2004). The average albumen height of Abd Salman Abu Tabeekh (2011) and Hrnčár et al. (2014) which ranges from 3.30-4.82 mm was close to the result of current study. In contrast, Chimezie et al. (2017) found lower yolk and albumen height than the current study. Haugh unit of parent and offspring generation was similar with Ayorinde (1987). However, Chimezie et al. (2017) found 79.81% Haugh unit in quail which was lower than the current study.

The causes of difference of external and internal egg quality traits with above mentioned researchers may be due to number of sample size, age, plumage color, breed, environment and management practices. Sarı et al. (2012) reported that layer age and plumage color had effect on external and internal qualities of egg.

The higher R values indicated close agreement between dependent and independent variable. If a model achieves R above 90%, it indicates close agreement Karmakar and Ray (2011) hence R values of body weight in the present study showed close agreement. In case of non-linear models considered R values above 0.89 as superior (Khan and Ahmed, 2010).

The egg shape index showed moderate heritability and this result was lower to the result of Sezer (2007). Low heritability estimates for egg width, egg shell weight, thin albumen height indicates that those traits at this age are to a very large extent a function of environmental factors. The low heritability at this age also indicates less genetic variability relative to phenotypic variability among the quails. The implication of this is that selection for trait of interest may not result in any appreciable improvement. This findings were lower than the results of Daikwo et al. (2013) and Sezer (2007). The causes of variation might be due to sample size, breed, management procedure and environmental factors. Heritability estimates for egg production and body weight were higher than the normal value and heritability estimates for egg weight, egg length, egg shell thickness, yolk weight, albumen weight, yolk height, thick albumen height and Haugh unit were lower than the normal value. This may be due to uncontrolled effects of lines, sex and generation (Michalska, 1992) in addition to method of analysis and sample size.

Limitations

Seasonal variation could not be observed due to shortage of time. Only one flock of offspring generation was reared for this study due to shortage of money and time. External and internal qualities of egg was observed only at 10 weeks of age. Among the different varieties of quail only Japanese quail was considered for the study.

Conclusion

From this research it reveals that the values of the production traits of offspring generation was higher than the parent generation. The regression co-efficient of different values of offspring generation indicated that selection of subsequent generation could have positive impact. The heritability value of different traits could be include in different breeding program.

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Biography

I am Mrinmoy Bhowmik, son of Mr. Narayan Chandra Bhowmik and Mrs. Jharna Rani Bhowmik. I passed my Secondary School Certificate (SSC) examination from Ataturk Model High School, Feni in 2012 (GPA 5.00) and Higher Secondary Certificate (HSC) examination from Dhaka City College, Dhaka in 2014 (GPA 5.00). I enrolled for Doctor of Veterinary Medicine (DVM) degree in Chattogram Veterinary and Animal Sciences University (CVASU), Bangladesh. I have immense interest to work in the field of Microbiology.