D-5683
[1-6]

RESEARCH ARTICLE Agricultural Science Digest

Effect of Non-genetic Factors on Growth and Production Traits in Two Strains of Japanese Quails

Shubhankar Sharma[1], Saroj Kumar Sahoo[1], Shakti Kant Dash[1], Prem Prakash Dubey[1]

10.18805/ag.D-5683

ABSTRACT

Background: The growth of birds is a function of both genetics and environment involving change leading into improvement in weight, shape, size, volume, etc. Study of important non-genetic factors is important in view of formulating future selection and breeding strategies in different poultry species.

Methods: The present study was done on 1246 numbers of Japanese Quails (*Coturnix coturnix japonica*) of two strains *i.e*., black and white distributed in three generations during 2020-21. The fixed effects of gender, season of hatch, strain and generations on various fortnightly body weights (FNBW), average daily weight gain (ADWG), relative growth rate (RGR) and some production traits were studied.

Result: Significant ($p \leq 0.01$) differences in black and white strain as well as male and female quails for hatch weights were observed. The maximum ADG was during 4th to 6th wk whereas the RGR was highest during first fortnight (hatch-2nd wk). Significantly ($p \leq 0.01$) higher average egg weights (AEW) were observed in white quails. Part egg production (PEP) and AEWs were higher during summer and winter hatches, respectively. The present investigation elucidates the significance of different non-genetic factors on important growth and production performances for further selection in quails.

Key words: Average daily weight gain, Average egg weights, Fortnightly body weights, Japanese quail, Part egg production, Relative growth rate.

INTRODUCTION

In poultry, Japanese quails are considered as the model organism for genetic studies which allow breeders for designing appropriate improvement programmes for other poultry species. Initial growth, age and weight at sexual maturity and egg production are major factors which draw particular attention in selection of the birds (Sezer *et al*. 2006). Several studies in past highlighted the importance of non-genetic factors on different performance traits in quails (Bagh *et al*. 2016, Chimezie *et al*. 2017, Taskin *et al*. 2017, Al-Kafajy *et al*. 2018, Haqani *et al*. 2021). However, these has to be reevaluated with time and place for making appropriate selection decisions pertaining to different environmental conditions. Accordingly, the present study was carried out for evaluating the effects on major growth and production traits in Japanese quails.

MATERIALS AND METHODS

The present study were conducted on 681 black (508 female and 173 male) and 565 white (424 female and 141 male) plumage Japanese quails maintained at Poultry breeding farm under Directorate of Livestock Farms of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana during 2020-21.

Three generations of quails were raised (base, 1st and 2nd) and the information was collected/generate on Body weight (BW) at fortnightly intervals (hatch, 2nd, 4th, …… upto 20th week), average daily gain (ADG), relative growth rate (RGR), age at first egg (AFE), part egg production upto 20 weeks (PEP20WK) and average egg weight upto 12 and 12-20weeks of age (AEW12WK, AEW20WK).

Average daily gains (ADG) for the periods 0-2nd, 2nd-4th, 4th - 6th,....., 18th-20th weeks were estimated using the formula:

$$ADG = \frac{W_2 - W_1}{N}$$

Where,

W_2= Body weight at the end of period.

W_1= Body weight at the beginning of period.

N= No. of days from previous weight to present weight.

Relative growth rate (RGR) for the periods 0-2nd, 2nd-4th, 4th-6th,....., 18th-20th weeks were estimated using the formula:

$$RGR = \frac{W_2 - W_1}{1/2\ (W_2 + W_1)} \times 100$$

[1]Department of Animal Genetics and Breeding, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana-141 004, Punjabi, India.

Corresponding Author: Saroj Kumar Sahoo, Department of Animal Genetics and Breeding, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana-141 004, Punjabi, India. Email: saroj6804@gmail.com

How to cite this article: Sharma, S., Sahoo, S.K., Dash, S.K. and Dubey, P.P. (2023). Effect of Non-genetic Factors on Growth and Production Traits in Two Strains of Japanese Quails. Agricultural Science Digest. doi: 10.18805/ag.D-5683.

Submitted: 21-09-2022 **Accepted:** 18-01-2023 **Online:** 03-03-2023

Where,
W_1= Body weight at the beginning of period.
W_2= Body weight at the end of period.

Classification of data

The season of hatch were classified as winter (base Generation) from December to February, summer (1st Generation) from March to May and rainy/monsoon (2nd Generation) from June to August. The sex wise classification was male and female whereas the strains were classified as black and white.

Statistical analysis

Least squares analysis was done using SPSS software 22.0. Fixed effect model was used to study the effects of non-genetic factors on different fortnightly body weights (hatch, 2nd, 4th, ...20th week), ADG, RGR, AFE, PEP20WK, AEW12WK and AEW20WK records of Japanese Quails. The following model was used:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + e_{ijkl}$$

Where,
Y_{ijk}= BW/ADG/RGR/AFE/PEP20WK/AEW12WK/AEW20WK records of the l^{th}individual of k^{th} strain, j^{th} sex/gender and i^{th} season of hatch/generation.
m= Population mean.
A_i= Fixed effect of i^{th} season of hatch/generation (i=1 to 3).
B_j = Fixed effect of j^{th} sex/gender (j=1 to 2).
C_k= Fixed effect of k^{th} strain (k=1 to 2).
e_{ijk}= Random error, assumed to be normally and independently distributed with mean zero and constant variance *i.e.* NID(0, σ^2e).

The statistical significance of various fixed effects was determined by 'F' test. For significant effects, the differences between pairs of levels of effects were tested by Tukey's HSD (Honest significant difference) test.

RESULTS AND DISCUSSION

Fortnightly body weights

The least squares means for hatch weight of black and white plumage Japanese quails were 6.64±0.05 g and 7.39±0.06 g, whereas in male and female quails it was 7.01±0.07 g and 7.02±0.04 g, respectively (Table 1). The growth followed normal sigmoid pattern in both strains and sexes *i.e.*, inflection phase (maximum growth) followed by almost steady (zero) growth rate after 18 wks of age. Our findings are supported by various researchers (Sezer *et al*., 2006; Devi *et al*., 2010; Bagh *et al*., 2016) who also observed gradual increase in body weight for both sexes and males were lighter as compared to female Japanese quails. Similarly, consistent increase in the mean body weights from hatch to 10th weeks was observed by Dash *et al*. (2018) in white and black Japanese quails. Previous studies have also reported significant effect of different color varieties (Rahman *et al*., 2010) and gender (Akbarnejad *et al*., 2015) on body weight in Japanese quails.

ADG and RGR

The maximum ADG was observed from 4th-6th wk of age *i.e.*, 4.03±0.07g in black; 4.41±0.08 g in white; 4.34±0.06 g in female and 4.10±0.09 g in male quails. Similarly, the relative growth rate (RGR) was highest during the first fortnight (hatch-2nd wk) *i.e.*, 141.14±0.65 g in black; 135.90± 0.72 g in white; 139.57±0.53 g in female and 137.48±0.88 g in male Japanese quails. Similar finding for highest growth rate i.e., 3.02±0.11 g during 4th to 5th weeks was observed by Dauda *et al*. (2014). Devi *et al*. (2010) reported consistent increase in ADG of Japanese quails from 0 d to 4 wks of age. These results are supported by the findings of Narinc *et al*. (2014) at 5 weeks of age in 948 Japanese quails and RGR and ADG are reported as 1.90±0.63% SD and 3.56±0.84% SD, respectively. Elkomy *et al*. (2019) also reported RGR of 1060 quail chicks from 0 to 5 weeks of age ranged from 182.48 to 184.50% under different light colors.

Production traits

The values for the production traits *i.e*. age at first egg (AFE), part egg production upto 20 weeks (PEP20WK), average egg weight upto 12 weeks (AEW12WK) and average egg weight from 12-20 weeks of age (AEW20WK) were 57.68±0.78 and 57.40±0.87 days; 37.37±0.38 and 37.40±0.42 numbers; 10.13±0.07 and 10.85±0.08g; 10.55±0.05 and 11.10±0.05g; in black and white quails respectively (Table 2). Age at sexual maturity (ASM) of 45.82±0.22 days and 32.96±0.18 days in female and male Japanese quails, respectively were reported by Sezer *et al*. (2006). As per Devi *et al*. (2010) least squares means (LSM) of AFE, PEP upto 16th and 30th week were 56.26±0.51 days, 30.85±0.69 numbers and 73.02±1.44 numbers, respectively. Momoh *et al*. (2014) reported the LSM of AFE, avg. egg wt. and part egg production. (3 months) as 54.49±0.20 days, 8.43±0.06 g and 23.19±0.11 numbers, respectively in Japanese quails. Dauda *et al*. (2014) reported AFE as 54.49±0.20 days while WFE and BWFE were 7.83±0.08 g and 138.91±0.64 g, respectively.

Non-genetic factors affecting different growth and production performances

Effect of strains

The effect of strain on 2 wks body weight was non-significant whereas for all other fortnightly BWs it was highly significant (P≤0.01). Effect on ADGs was highly significant (P≤0.01) from 2nd to 6th, 8th to 12th and 14th to 20th wks of age. Similarly, highly significant (P≤0.01) effects of strains on RGRs were observed from hatch-2nd, 8th-10th and 14th to 20th wks of age. Non-significant effects on RGRs from 2nd to 8th and 10th to 14th wks of age were observed. For production traits, highly significant (P≤0.01) effect of strain on AEW12WK and AEW20WK was observed. Non-significant effect was observed on PEP20WK and AFE.

Devi *et al*. (2010) reported significant (p<0.01) influence of strain in Japanese quails. Varkoohi *et al*. (2010) also observed significant strain differences for BWs. Tarhyel *et al*.

Table 1: Least squares means along with their standard errors for non-genetic factors affecting body weight at different ages in Japanese quails (0 d to 8 wk).

	0D			2 wk			4 wk			6 wk			8wk		
	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.
Overall	1246	7.01	0.04	1232	40.36	0.30	1221	91.91	0.74	1217	150.77	0.90	1204	183.14	0.86
Strains															
Black	681	6.64**	0.05	676	40.09NS	0.38	670	89.25**	0.92	668	145.73**	1.14	664	177.15**	1.07
White	565	7.39**	0.06	556	40.64NS	0.42	551	94.56**	1.01	549	155.80**	1.24	540	189.14**	1.18
Gender															
Male	314	7.01^{NS}	0.07	311	39.80^{NS}	0.51	310	92.37^{NS}	1.24	310	149.52^{NS}	1.52	307	176.92**	1.45
Female	932	7.02^{NS}	0.04	921	40.92^{NS}	0.30	911	91.45^{NS}	0.75	907	152.01^{NS}	0.92	897	189.36**	0.87
Season of Hatch/Generation															
Winter (Base Gen.)	392	7.08^{NS}	0.06	392	41.55^{a}	0.48	390	111.64^{a}	1.15	390	177.71^{a}	1.41	379	208.61^{a}	1.36
Summer (1st Gen.)	270	7.04^{NS}	0.08	270	42.87^{a}	0.56	265	89.26^{b}	1.39	265	153.76^{b}	1.70	263	178.31^{b}	1.60
Monsoon (2nd Gen.)	584	6.92^{NS}	0.05	570	36.66^{b}	0.40	566	74.82^{c}	0.97	562	120.83^{c}	1.19	562	162.51^{c}	1.13

(10wk to 20wk).

	10wk			12wk			14wk			16wk			18wk			20wk		
	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.
Overall	812	194.34	0.99	809	198.95	0.96	807	198.40	0.91	807	201.72	0.98	801	204.22	1.04	780	201.79	1.05
Strains																		
Black	423	185.52**	1.26	422	188.68**	1.23	420	186.77**	1.16	420	192.67**	1.24	417	198.76**	1.32	401	193.66**	1.36
White	389	203.15**	1.31	387	209.22**	1.28	387	210.04**	1.21	387	210.76**	1.29	384	209.67**	1.39	379	209.92**	1.33
Gender																		
Male	210	185.21**	1.64	209	188.88**	1.60	208	186.42**	1.51	208	186.89**	1.62	204	191.12**	1.74	187	193.38**	1.82
Female	602	203.46**	1.01	600	209.02**	0.98	599	210.38**	0.93	599	216.54**	0.99	597	217.31**	1.05	593	210.21**	1.00
Season of Hatch/Generation																		
Winter (Base Gen.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Summer (1st Gen.)	260	205.60**	1.53	257	207.65**	1.49	256	204.19**	1.40	256	203.13NS	1.50	255	204.18NS	1.60	255	207.29**	1.54
Monsoon (2nd Gen.)	552	183.07**	1.08	552	190.25**	1.06	551	192.62**	1.00	551	200.30NS	1.08	546	204.26NS	1.15	525	196.30**	1.20

*****Significant at P≤0.05; ** Significant at P≤0.01; NS-Non significant.

(2012) reported higher means (132.66±2.27 g) for albino than normal colored quails (121.33±4.77g) and the difference was significant (p<0.05) for 5wk live weight. Significantly heavier body weights at 21, 28 and 35 days of age for brown strains and at hatch for white Japanese quails were reported by Mahmoud *et al*. (2014). Chimezie *et al*. (2017) reported significantly higher (P<0.05) egg weight in brown (10.53 g) as compared to black (9.95 g) and white (9.82 g) varieties of Japanese quails. Non-significant difference among varieties (grey, brown and white) for BWs during early ages was reported by Bagh *et al*. (2016). Monika *et al*. (2021) observed significant (p<0.01) effect of varieties and hatches on age at sexual maturity.

Effect of gender

The gender/sex effect for hatch, 2nd, 4thand 6th week of age were non-significant whereas from 8th to 20th wks was highly significant (P≤0.01). For ADGs from hatch up to 4th week and 10th-12th wks non-significant effect of gender was observed. For rest of the period during the study ADGs, significant (P≤0.05) and highly significant (P≤0.01) effect was noted. For RGRs, non-significant effect was observed from 10th-12th and 16th-18th wks, significant (P≤0.05) from hatch up to 6th and 12th-14th wks and highly significant (P≤0.01) from 6th up to 10th, 14th-16th and 18th-20th wks of age. The present findings for significant differential growth between two sexes of Japanese quail supports the earlier findings (Seizai *et al*., 2010; Devi *et al*., 2010). Tarhyel *et al*. (2012) reported significantly (p<0.05) higher 5wk body weight in females (134.73±2.93 g) than males (126.41±2.48 g). Similar findings of significant (p<0.01) sex effect on 5 week body weight was reported by Pourtorabi *et al*. (2017) where males (206.73±1.23 g) had comparatively lower body weights than females (215.03±1.39 g). Recently Haqani *et al*., (2021) reported non- significant effect of sex on hatch weight across generations. However, significant differences were observed at 1wk in different generations with the exception of F1 (NS ♀ × LS♂) generation.

Effect of season of hatch/generation

In the present study, hatches were taken in winter (base generation), summer (1st gen.) and monsoon (2nd gen.) seasons. Winter hatched chicks were heavier as compared to summer and monsoon hatches. Overall, in exception to hatch, 16th and 18th wk weights, season effect for rest of fortnightly body weights were highly significant (P≤0.01). The effect of season was highly significant (P≤0.01) for most of the ADGs. Similarly, with the exception of 12th-14th and 16th-18th wks, season effect was significant (P≤0.05) or highly significant (P≤0.01) on the RGRs. Season effect for AFE and AEW12WK were non-significant whereas significantly higher AEW12-20WK for winter hatches were observed. Higher body weight gain in winter months may be attributable due to less stress, higher body metabolism leading to higher feed intake.

Significant (p<0.05) hatch effect on mean body weights were observed by Devi *et al*. 2010. Gopinathan *et al*. (2013) reported highly significant (p<0.01) effect of season of hatch on average daily gain (ADG) which was lowest in the summer and highest during monsoon season and in agreement with our study. Significant effect of line on both egg number and ASM was reported by Farrag (2011) which preferred the selected line for egg production but for egg weight, no effect was found. Nath *et al*. (2011) reported significantly lower ASM (46.2 vs 52.4 day) and higher 16wk egg weight (13.78vs12.66 g) and higher egg production for selected over control population.

Ashok and Prabakran (2012) reported significant (P<0.01) effect of generation on body weights at different ages barring 2nd week in Japanese quail. Manaa *et al*. (2015) reported the highest ADG value of 5.22 g for 3rd to 4th week in 1st generation, whereas for 2nd generation the value was highest from 2nd to 3rd weeks (5.13 g). Significant generation effects for body weight as well as egg production traits were also observed by Mahmoud *et al*. (2014). Significant (P<0.05) differences in egg weight and birth weight through generations has been reported by El-Deen *et al*., 2015. As per Taskin *et al*. (2017) body weight through different generations varied significantly (P<0.01) barring the parental generations. In divergent selected lines significant generation difference were found by Yamani *et al*. (2020) for weekly body weights up to three generations of Japanese quail.

Table 2: Least squares means along with their standard errors for non-genetic factors affecting AFE, PEP20 wk, AEW12 wk, AEW12-20 wk in Japanese quails.

	AFE			PEP 20 wk			AEW 12 wk			AEW 12-20 wk		
	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.	N	Mean	S.E.
Overall	904	57.54	0.60	904	37.38	0.29	904	10.49	0.05	904	10.82	0.04
Strain												
Black	496	57.68^{NS}	0.78	496	37.37^{NS}	0.38	496	10.13**	0.07	496	10.55**	0.05
White	408	57.40^{NS}	0.87	408	37.40^{NS}	0.42	408	10.85**	0.08	408	11.10**	0.05
Season of hatch/Generation												
Winter (Base Gen.)	278	56.84^{NS}	1.03	278	35.92^{b}	0.46	278	10.61^{NS}	0.09	278	10.99^{a}	0.06
Summer (1st Gen.)	203	58.61^{NS}	1.20	203	38.87^{a}	0.56	203	10.51^{NS}	0.11	203	10.59^{b}	0.07
Monsoon (2nd Gen.)	423	57.17^{NS}	0.83	423	37.36^{ab}	0.43	423	10.34^{NS}	0.08	423	10.89^{a}	0.05

*****Significant at P≤0.05; **Significant at P≤0.01; NS- Non significant.

CONCLUSION

There was significant difference ($p \leq 0.01$) in the hatch weight of black and white plumage Japanese quails and white plumage quails have a better growth as compared to the black ones in different fortnightly weeks. The females have a higher body weight as compared to the males which was significant ($p \leq 0.01$) for most of the fortnightly weeks. For the early fortnightly weeks the growth was higher in the winter hatches as compared to summer and monsoon hatches. The maximum ADG was observed from 4^{th} -6^{th} wk of age (3.69 to 4.25 g) in both black and white as well as male and female quails and a gradual and steady decline was observed afterwards. The RGR in both females and male as well as black and white quails was highest during the first fortnight (hatch-2^{nd} wk) (132 to 141 g) and a gradual and steady decline was observed afterwards. The white quails had significant higher ($p \leq 0.01$) AEW12WK and AEW12-20WK than the black quails. PEP20WK was higher for summer hatches, whereas AEW12-20WK was higher for winter and monsoon hatches than the summer hatches.

Conflict of interest: None.

REFERENCES

Akbarnejad, S., Zerehdaran, S., Hassani, S., Samadi, F. and Lotfi, E. (2015). Genetic evaluation of carcass traits in Japanese quail using ultrasonic and morphological measurements. British Poultry Science. 56: 293-298. DOI: 10.1080/00071668.2015.1041453

Al-Kafajy, F.R., Al-Shuhaib, M.B.S., Al-Jashami, G.S. and Al-Thuwaini, T.M. (2018). Comparison of three lines of Japanese quails revealed a remarkable role of plumage color in the productivity performance determination. Journal of World's Poultry Research. 8(4): 111-119.

Ashok, A. and Prabakaran, R. (2012). Effect of non genetic factors on growth traits in short term selection for different ages in Japanese quail. Journal of World's Poultry Research. 2(2): 28-32.

Bagh, J., Panigrahi, B., Panda, N., Pradhan, C.R., Mallik, B.K., Majhi, B. and Rout, S.S. (2016). Body weight, egg production and egg quality traits of gray, brown and white varieties of Japanese quail (*Coturnix coturnix japonica*) in coastal climatic condition of Odisha. Veterinary World. 9(8): 832-836.

Chimezie, V.O., Fayeye, T.R., Ayorinde, K.L. and Adebunmi, A. (2017). Phenotypic correlations between egg weight and some egg quality traits in three varieties of Japanese quail (Coturnix coturnix japonica). Agrosearch. 17(1): 44-53.

Dash, S.K., Naik, S., Dubey, P.P., Malhotra, P. and Bansal, B.K. (2018). Effect of plumage colour and estimation of variance components of bi-weekly growth traits in Japanese quail (*Coturnix coturnix japonica*). Indian Journal of Animal Sciences. 88(10): 1193-1196.

Dauda, G., Momoh, O.M., Dim, N.I. and Ogah, D.M. (2014). Growth, production and reproductive performance of Japanese quails (*Coturnix coturnix japonica*) in humid environment. Egyptian Poultry Science Journal. 34(II): 381-395.

Devi, K.S., Gupta, B.R., Prakash, M.G., Qudratullah, S. and Reddy, A.R. (2010). Genetic studies on growth and production traits in two strains of Japanese quails. Tamil Nadu Journal Veterinary and Animal Sciences. 6(5): 223-230.

El-Deen, M.B., Nour, A.A., El-Tahawy, W.S. and Fouad, H.A. (2015). Effect of Selection for Weight of Early Eggs on Egg Production Traits in Japanese quail. Asian Journal of Poultry Science. 9(4): 179-190.

Elkomy, H.E., Taha, A.E., Basha, H.A., Abo-Samaha, M.I. and Sharaf, M.M. (2019). Growth and reproduction performance of Japanese quails (*Coturnix coturnix japonica*) under various environments of light colors. Slovenian Veterinary Research. 56(Suppl 22): 119-27.

Farrag, S.A. (2011). Genetic variations within and between quail lines selected for high body weight at four weeks of age and egg production using DNA fingerprinting. Ph.D. Thesis Fac. Farm Technology and Food Safety Kazakh National Agrarian Univ. Kazakhstan.

Gopinathan, A., Ramesh, J., Devendran, P., Shivkumar, T., Sivaselvam, S.N. and Kumarasamy, P. (2013). Effect of Non-genetic factors on growth and ready to cook yield of japanese quails. International Journal of Livestock Research. 3(3): 57-59.

Haqani, M.I., Kawamura, K., Takenouchi, A., Kabir, M.H., Nakamura, Y., Ishikawa, A. and Tsudzuki, M. (2021). A growth performance and nonlinear growth curve functions of large- and normal -sized Japanese Quail (*Coturnix japonica*). Journal of Poultry Science. 58(2): 88-96. doi:10.2141/ jpsa.0200020.

Mahmoud, B., Farahat, G. and El-Full, E. (2014). Genetic and phenotypic correlations of body weight and shank length with some egg production-related traits in two Japanese quail genotypes differing in plumage colour. Egyptian Poultry Science Journal. 34: 133-149. 10.21608/epsj.2014.5309.

Manaa, E.A., El-Bayomi, K.M. and Sosa, G.A. (2015). Genetic evaluation for growth traits in Japanese quail. Benha Veterinary Medical Journal. 28(1): 8-16.

Monika, M., Rokadae, J.J., Narayan, R., Verma, M.R., Panda, S. and Saharia J. (2021). Genetic evaluation of egg production and egg quality attributes in Japanese quails through Partial Periods. Indian Journal of Animal Research. 55: 1393-1400.

Narinc, D., Karaman, E., Aksoy, T. and Firat, Z.M. (2014). Genetic parameter estimates of growth curve and reproduction traits in Japanese quail. Poultry Science. 93: 24-30.

Nath, N.D., Sheriff, F.R., Prabakaran, R. and Rajini, A. (2011). Response to short term index selection for economic traits in meat type Japanese quail. Journal of Indian Veterinary Science. 9: 10-14.

Pourtorabi, E., Farzin, N. and Seraj, A. (2017). Effects of genetic and non-genetic factors on body weight and carcass related traits in two strains of japanese quails. Poultry Science Journal. 5(1): 17-24.

Rahman, M.S., Rasul, K.M.G. and Islam, M.N. (2010). Comparison of the productive and reproductive performance of different colour mutants of Japanese quails (*Coturnix japonica*). Proceedings of the Annual Research Review Workshop-2010, BLRI, Savar, Dhaka, Bangladesh. pp. 50-56.

Seizai, A., Kemal, K., Askin, G., Taki, K. and Murat, S.B. (2010). Determination of body weight and some carcass trait in Japanese quail (*Coturnix coturnix Japonica*) of different lines. Kafkas Universitesi Veteriner Fakultesi dergisi. 16(2): 277-280.

Sezer, M., Berberoglu, E. and Ulutas, Z. (2006). Genetic association between sexual maturity and weekly live weights in laying-type Japanese quail. South African Journal of Animal Science. 36(2): 142-148.

Tarhyel, R., Tanimomob, B.K. and Henac, S.A. (2012). Effect of sex, colour and weight group on carcass characteristics of Japanese quail. Scientific Journal of Animal Science. 1(1): 22-27.

Taskin, A., Karadavut, U., Tunca, R.I., Genc, S. and Cayan, H. (2017). Effect of selection for body weight in Japanese quails (*Coturnix coturnix* Japonica) on some production traits. Indian Journal of Animal Research. 51(2): 358-364. DOI:10. 18805/ijar.11466.

Varkoohi, S., Babak, M.M.S., Pakdel, A., Javaremi, A.N., Zaghari, M. and Kause, A. (2010). Response to selection for feed conversion ratio in Japanese quail. Poultry Science. 72: 1005-1011.

Yamani, H.A.L., Koluman, N. and Hembade, A.S. (2020). Investigating the effects of divergence selection parameter and Japanese quail differences (low-high) according to body weight. International Journal of Veterinary Sciences and Animal Husbandry. 5(1): 97-103.