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RESEARCH ARTICLE

Diurnal Behavior of Three Varieties of *Coturnix japonica* Selected for High Body Weight and Egg

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ABSTRACT

In the current study, several behaviors of Japanese quail kept in battery cages, including eating, drinking, activating, sitting, laying, standing, pecking at feathers, and flapping of wings, were observed twice a day on different days of the week. The activities occurred during the day, from 9 am to 12 pm, and in the evening, from 5 pm to 8 pm. The behavioral inspections for 180 quails were tossed when the quails were 16-week-old and continued for 2 months. Birds were divided into 15 experimental units having 4 birds (3 females and 1 male). In this study, the time-sampling method was used to record the behavioral features that were noticed once every five minutes during the course of a four-hour observation. Temperature and humidity were observed respectively. The weight of the birds was checked before and after the experiment. The Japanese quails displayed feeding, drinking, activation and wing flapping behaviors most in the study. Sitting / lying, standing and pecking behaviors befell at rather low levels. Hematological parameters (hemoglobin, WBC, RBC, HCT, MCV, MCH, MCHC, platelets, neutrophils, lymphocytes, heterophils, H/L) were evaluated at the time of slaughtering. Regarding behavioral traits, the maximum feeding was found in body weight line. Drinking, wing flapping and activation were found highly significant in egg number line. Standing was non-significant in egg number line. Pecking and sitting was non-significant in body-weight line with ($P>0.05$). However, in hematological parameters hemoglobin, WBC, HCT / PCV were statistically least significant with ($P<0.05$). Total RBC, MCH and MCHC were statistically significant, whereas MCV, platelets, neutrophil, lymphocyte, heterophils, H/L were of no significance with ($P>0.05$). Diurnal behaviors did not show any differences. According to the results, birds were comfortable with the intensive system.

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INTRODUCTION

Avian species are considered one of the most important for fulfilling the dietary needs of every growing human population around the globe. Chicken, duck and Japanese quails are slaughtered in huge numbers on daily basis (Hussain *et al.*, 2019). Pakistan is a nutrient deficient country where according to an estimate of World Health

Organization, 45% of the children are facing stunted growth and mental retardation due to food security issues (Hamad *et al.,* 2016). Japanese quail is a bird that can play a central role to mitigate these issues because it has very short generation interval and can produce enough quantity of meat and eggs in a very short period of time (Ghayas *et al.,* 2017; Hussain *et al.,* 2019). To fulfill the dietary needs of country' population, efforts were made in the past to enhance its meat and egg production (Ahmad *et al.,* 2018).

Quail have some highly desirable traits as they are fairly smaller in size, short life cycle, and also, they have the competence to produce five to seven eggs per week (Ahmad *et al.,* 2018). Japanese quail (*Coturnix japonica*) belong to the family Phasianidae, and subfamily Perdicinae. These quail are considered as they are originated as sub-species of common quail (*Coturnix coturnix*), which can be scavenged in all over Asia, over Africa and Europe and these are copious (Chang *et al.,* 2005). Japanese quail reach at sexual maturity in 45 days (Wilson *et al.,* 1971).

Genetic selection for enhanced body weight has been earlier applied in the past and considerable improvement in body size was recorded. In particular, larger quails are capable to produce larger eggs (Nora *et al.,* 2024; N'Zue *et al.,* 2025). However, these two traits (body weight and egg production) are negatively correlated to each other (Vieira *et al.,* 2016). Additionally, selection for these traits has compromised several other related traits such as welfare and behavior. There is a great concern from the consumers that the food animals should be in stress free environment during rearing at farms. However, it is still unknown that how much impact the genetic selection for body weight has put on the welfare and behavior of the Japanese quail. It is need of hour to find out the impact of genetic selection for body weight and selection for egg production on welfare and behavior of Japanese quail.

MATERIALS AND METHODS

Site of experiment: Current survey was directed at Avian Research and Training (ART) Center, Department of Poultry Production, University of Veterinary and Animal Sciences (UVAS), Lahore with the main objective to assess the differences in the behavior of three breeds of Japanese quail. Total 16-week-old male and female commercially raised Japanese quail was used in this experiment.

Experimental birds: In this contemporary trial, the quails were attained from a running project funded by HEC (Project No. HEC-NRPU 8352) lined up to develop four genetic lines.

Inclusion area: Three varieties of Japanese quail (body weight line, egg base line and random birds' line) were included in this study.

Exclusion area: Quails with any disability, mortality and more or less than 16 days old were excluded.

Bird's husbandry: The trial quail birds were housed in an octagonal quail breeding shed that measured 9.14 x 3.96 x 3.65 meters in length, breadth, and height, respectively. Throughout the house was a French-made battery cage system with five-tiered laying cages and sloping wire to facilitate egg harvesting. A conveyer belt system was installed to remove the waste material. Clean, automatic nipples were placed in front of the pens to provide fresh water, and detachable feeders were used to deliver food.

Experimental plan: In this experiment 180 birds (60 from each line) of 16-week-old Japanese quail were divided into 15 experimental units and each of them contains four birds.

Bird's management and housing: These birds were divided into three groups. Among these groups, one group was observed on the basis of body weight line in which the birds with higher weight were selected, second group was observed on the basis of egg base line in which the birds were selected on the basis of higher egg production and third group was the mixture of both qualities, it was of random birds.

First of all, birds were reared in the battery cages. During first week of the experiment the birds were provided with adaptation period so they can easily adjust in a given environment because when they get accustomed to the new environment the accurate readings come out. During this initial week no data was collected. The data was collected through observations, picture clicking and by video recording after a week. Each replicate from three breeds was weighted in the beginning of experiment. The birds were provided with standard recommended food (20% protein and 2600 Kcal/kg metabolizable energy) and water on daily basis. Behavioral parameters feeding, drinking, wing flapping, activation, feather pecking, standing and sitting/laying were observed in alternate days. Temperature and humidity also observed respectively. Data was collected twice a day, in the morning from 9 am to 12 pm and in the evening from 5 pm to 8 pm respectively. Experiment was designed for two to three months.

Blood hematology: At last step of the experiment birds were reweighted and then their blood sample was taken to check their stress level. Their stress level was checked by hematological parameters by CBC (complete blood count). Quails were randomly selected for hematological valuation from each replicate and from the bird's jugular vein; about 3 ml blood were taken and collected into vacutainers (BIO-VAC) (with anticoagulant for hematology). During blood collection of birds, the needles and syringes were changed to prevent contamination. Later, hematological inspections were carried out at Quality Lab, Specialized Laboratory Services, Jail Road, Lahore. Hematological valuation, Complete Blood Count (Hemoglobin, WBCs, total RBCs, HCT, MCV, MCH, MCHC and Platelets) and Differential leucocyte count (Neutrophils, Lymphocytes, Heterophils and H / L) was accomplished on SYSME KX-21 Hematology analyzer (Model XP100; Sysmex Suisse AG, Yverdon-les-Bains, Switzerland). L / E ratio is a good indicator to measure the stress level of birds reared in cages. To relate behavioral changes with stress or to negate if birds were in stress, we find their L / E ratio.

All data from diurnal behaviors were collected and analyzed through t-test and composed data in percentage was administered to statistical analysis via one-way analysis of variance (ANOVA) technique in Statistical Package for Social Sciences (SPSS) in SAS 9.1 version and significant means were associated through Fishers' Least Significant Difference test (LSD).

RESULTS

Behavioral traits: Behavioral traits were noted on weekly basis in the morning (9am-12pm) and evening (5pm-8pm), during diurnal periods of 3h each, using the focal animal sampling method. Temperature and humidity were checked accordingly to see the differences in the diurnal hours. The diurnal hours did not show any differences (Table 1). Frequencies of behaviors were calculated as a percentage of the total observed behavior for feeding, sitting, activation, standing, pecking, flapping and drinking.

Table 1: Comparison of diurnal behaviors of three varieties of Japanese quail

Parameters	Morning	Evening	P- value
Feeding	40.79 ± 1.55	29.95 ± 1.52	0.908
Drinking	24.34 ± 0.69	25.36 ± 0.69	0.998
Wing flapping	2.73 ± 0.26	2.98 ± 0.27	0.778
Activation	12.48 ± 0.73	18.05 ± 0.74	0.986
Standing	8.49 ± 0.53	6.23 ± 0.49	0.866
Feather pecking	1.26 ± 0.08	1.16 ± 0.06	0.079
Sitting	9.91 ± 0.52	15.94 ± 0.51	0.757

Expression of data is by mean ± standard error of mean. The results for t-test are shown as p-value. P>0.05 = non-significant.

Feeding: The feeding rate of body weight line was 41.43 + 1.702 %, whereas the feeding rate of egg number line of Japanese quail was 29.32+1.241 % and of random bred type Japanese quail 35.94 +0.476 %. The maximum feeding was found in body weight line quail with(P<0.001) which is highly significant (Table 2; Fig. 1).

Drinking: The drinking of bodyweight line was 23.21 ± 1.008 %, whereas of egg number line was 26.49 ± 0.754 % and of random bred type Japanese quail 21.24 ± 0.592 %. The maximum drinking was found in egg number line quail with (P<0.001) which is highly significant (Table 2; Fig. 2).

Wing flapping: The wing flapping rate of body weight line was 1.71 ± 0.187 %, whereas wing flapping rate of egg number line was 3.99 ± 0.283 % and of random bred type Japanese quail 3.09 ± 0.075 %. The maximum wing flapping was found in egg number line quail with (P<0.001) which is highly significant (Table 2; Fig. 3).

Activation: The activation of body weight line was 12.27 ± 0.311 %, whereas activation rate of egg number line was 18.26 ± 0.924 % and of random bred type Japanese quail 16.48 ± 0.281 %. The maximum activation rate was found in egg number line with (P<0.001) which is highly significant (Table 2; Fig. 4).

Standing: The standing rate of body weight line was 7.33 ± 0.527 %, whereas standing rate of egg number line was 7.42 ± 0.887 % and of random bred type Japanese quail 6.94 ± 0.221 %. The maximum standing rate was found in egg number line with (P>0.05) which is statistically non-significant (Table 2; Fig. 5).

Pecking: The pecking rate of body weight line was 1.23 ± 0.077 %, whereas of egg number line 1.188 ± 0.118 % and of random bred type Japanese quail 1.09 ± 0.034 %. The maximum pecking rate was found in body weight line with (P>0.05) which is statistically non-significant (Table 2; Fig. 6).

Sitting: The sitting rate of body weight line was 12.62 ± 0.782 %, whereas of egg number line 13.24 ± 0.678 % and sitting rate of random bred type Japanese quail was 11.24 ± 0.321 %. The maximum sitting rate was found in body weight line with (P>0.05) which is statistically non-significant (Table 2; Fig. 7).

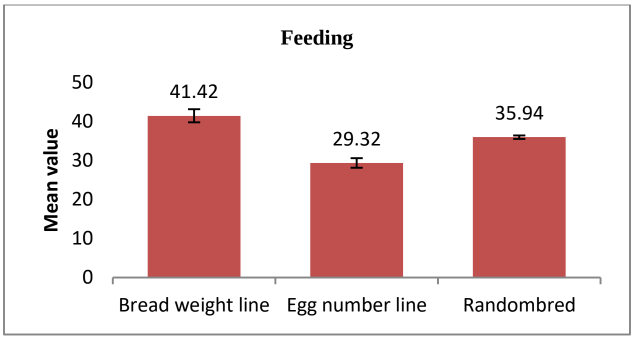

Fig. 1: Comparison of feeding behavior of three varieties of Japanese quail. Standard error of mean ± mean is used to present the data. The p-value represents the one-way ANOVA results. P<0.001 = highly significant (***)

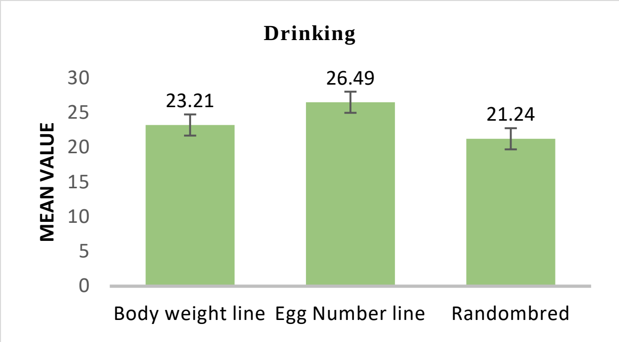

Fig. 2: Comparison of drinking behavior of three varieties of Japanese quail. The information is presented as mean ± standard error of mean. p-values are the results of a one-way ANOVA. P<0.001 = highly significant (***).

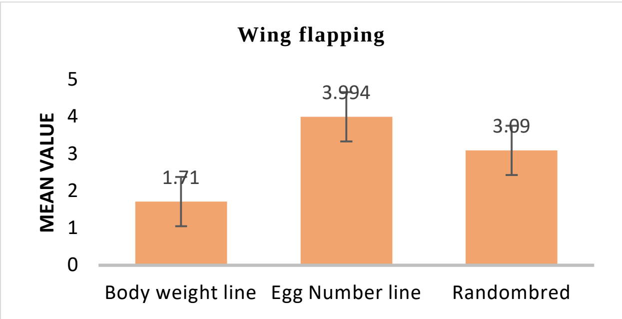

Fig. 3: Comparison of Wing flapping behavior of three varieties of Japanese quail. The information is presented as mean ± standard error of mean. p-values are the results of a one-way ANOVA. P<0.001 = highly significant (***).

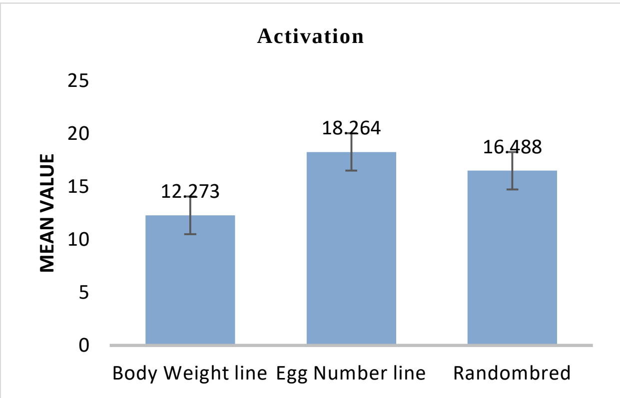

Fig. 4: Comparison of Activation behavior of three varieties of Japanese quail. The information is presented as mean ± standard error of mean. p-values are the results of a one-way ANOVA. P<0.001 = highly significant (***).

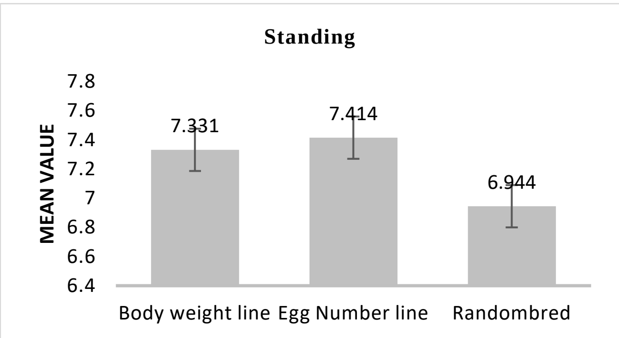

Fig. 5: Comparison of Standing behavior of three varieties of Japanese quail. Metrics are shown as mean ± standard error of mean. p-value is the expression for the one-way ANOVA results. P>0.05 = non-significant.

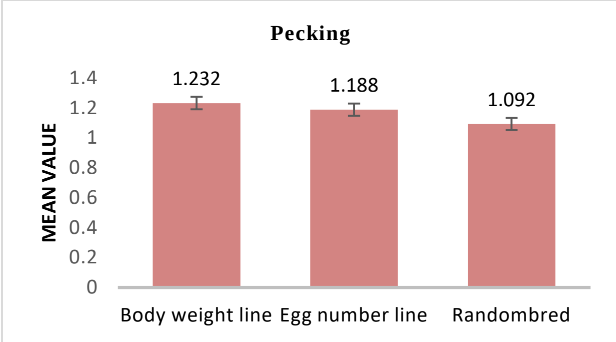

Fig. 6: Comparison of Feather Pecking behavior of three varieties of Japanese quail. Metrics are shown as mean ± standard error of mean. p-value is the expression for the one-way ANOVA results. P> 0.05 = non-significant.

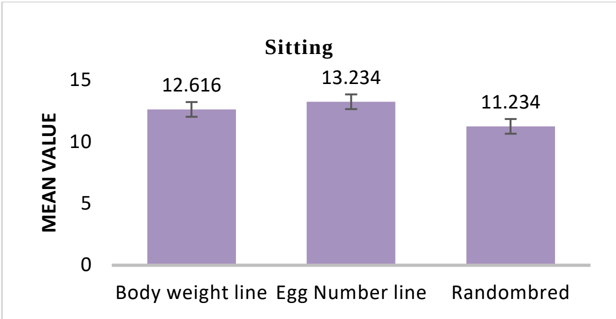

Fig. 7: Comparison of Sitting behavior of three varieties of Japanese quail. Metrics are shown as mean ± standard error of mean. p-value is the expression for the one-way ANOVA results. P>0.05 = non-significant.

Hematological parameters: Hematological parameters are often used clinical indications of health and disease, such as hemoglobin concentration and the counts of red and white blood cells (Table 3). The hemoglobin level in body weight line was 14.45 ± 0.556, whereas hemoglobin level in egg production line was 17.32 ± 0.396 and of random bred type Japanese quail was 16.29 ± 0.962. The maximum level was found in egg production line with (P<0.05) which is statistically least significant. The WBC or total leukocyte count in body weight line was 113.50 ± 5.293 whereas WBC level in egg production line was 89.98 ± 5.679 and of random bred type Japanese quail was 91.18 ± 8. 237. The maximum WBC level was found in body weight line with (P<0.05) which is statistically least significant. Total red blood cells count in body weight line was 1.80 ± 0.036, whereas total RBC level in egg production line was 2.20 ± 0.102 and of random bred type Japanese quail was 2.24 ± 0.146. The maximum RBC level was found in random bred line with (P<0.01) which is statistically significant. The HCT/PCV level in body weight line was 31.40 ± 1.066, whereas HCT/PCV level in egg production line was 41.21 ± 1.804 and of random bred type Japanese quail was 40.81 ± 3.051. The maximum level was found in egg production line with (P<0.05) which is least significant. The MCV level in body weight line was 183.80 ± 1.768, whereas MCV level in egg production line was 185.60 ± 2.468 and of random bred type Japanese quail was 179.30 ± 2.155. The maximum MCV level was found in egg production line with (P>0.05) which is statistically non-significant. The MCH level in body weight line was 85.30 ± 1.292, whereas MCH level in egg production line was 82.85 ± 2.441 and of random bred type Japanese quail was 73.64 ± 3.767. The maximum level was found in body weight line with (P<0.01) which is statistically significant. The MCHC level in body weight line was 45.70 ± 0.700, whereas MCHC level in egg production line was 44.03 ± 0.868 and of random bred type Japanese quail was 41.20 ± 1.459. The maximum level was found in body weight line with (P<0.01) which is statistically significant. The platelets level in body weight line was 32.10 ± 5.174, whereas platelets level in egg production line was 41.60 ± 4.828 and of random bred type Japanese quail was 32.10 ± 4.843. The maximum level was found in egg production line with (P>0.05) which is statistically non-significant. The neutrophils level in body weight line was 1.60 ± 0.305, whereas neutrophils level in egg production line was 1.30 ± 0.153 and of random bred type Japanese quail was1.70 ± 0.153. The maximum level was found in random bred line with (P>0.05) which is statistically non-significant. The lymphocytes level in body weight line was 0.97 ± 0.004, whereas lymphocytes level in egg production line was 0.98 ± 0.003 and of random bred type Japanese quail was 0.97 ± 0.004. The maximum level was found in egg production line with (P>0.05) which is statistically non-significant. The heterophils level in body weight line was 1.058 ± 0.021, whereas heterophils level in egg production line was 1.059 ±0.01888 and of random bred type Japanese quail was 1.066 ± 0.019. The maximum level was found in random bred line with (P>0.05) which is statistically non-significant. The H/L level in body weight line was 1.08 ± 0.022 whereas H/L level in egg production line was 1.079 ± 0.018 and of random bred type Japanese quail was 1.09 ± 0.023. The maximum level was found in random bred line with (P>0.05) which is statistically non-significant.

Table 2. Comparison of behavioral parameters of three varieties of Japanese quail

Parameters	Body weight line	Egg production line	Random bred line	P- value
Feeding	41.43 ± 1.702	29.32 +1.241	35.94 ±0.476	0.000***
Drinking	23.21 ± 1.008	26.49 ± 0.753	21.24 ± 0.592	0.000***
Wing flapping	1.71 ± 0.187	3.99 ± 0.282	3.09 ± 0.075	0.000***
Activation	12.27 ± 0.310	18.26 ± 0.923	16.48 ± 0.281	0.000***
Standing	7.33 ± 0.527	7.41 ± 0.887	6.94 ± 0.220	0.845
Pecking	1.23 ± 0.077	1.18 ± 0.118	1.09 ± 0.033	0.491
Sitting	12.61 ± 0.781	13.23 ± 0.678	11.23 ± 0.320	0.080

The information is presented as Mean ± Standard Error of Mean. P-value is the one-way ANOVA outcome. P>0.05 designates non-significant. Very significant (***) if P<0.001 is met.

Table 3. Comparison of hematological parameters of three varieties of Japanese quail.

Parameters	Body weight line	Egg production line	Random bred line	P- value
Hemoglobin	14.45 ± 0.556	17.32 ± 0.396	16.29 ± 0.962	0.020*
WBC	113.5 ± 5.293	89.98 ± 5.679	91.18 ± 8. 237	0.028*
RBC	1.80 ± 0.036	2.20 ± 0.102	2.24 ± 0.146	0.011**
HCT	31.40 ± 1.066	41.21 ± 1.804	40.81 ± 3.051	0.004*
MCV	183.8 ± 1.768	185.60 ± 2.468	179.30 ± 2.155	0.122
MCH	85.30 ± 1.292	82.85 ± 2.441	73.64 ± 3.767	0.012**
MCHC	45.70 ± 0.700	44.03 ± 0.868	41.20 ± 1.459	0.019**
Platelets	32.10 ± 5.174	41.60 ± 4.828	32.10 ± 4.843	0.309
Neutrophils	1.60 ± 0.305	1.30 ± 0.153	1.70 ± 0.153	0.407
Lymphocytes	0.97 ± 0.004	0.98 ± 0.003	0.97 ± 0.004	0.247
Heterophils	1.058 ± 0.021	1.059 ± 0.018	1.066 ± 0.019	0.952
H/L	1.08 ± 0.021	1.07 ± 0.018	1.09 ± 0.023	0.835

Standard error of mean ± mean is used to present the data. The p-value represents the one-way ANOVA results. P>0.05 = non-significant; P<0.05 = least significant (*) P<0.01 = significant (**).

DISCUSSION

The current study shows that quail's behavioral repertoire is significantly impacted by genetic selection for certain production traits (body weight vs. egg number). The non-significant behaviors and the lack of substantial diurnal change in temperature and humidity indicate that genetic lineage, rather than fleeting environmental fluctuations throughout the observation periods, is the primary cause of the observed variances.

The most salient finding is the clear behavioral divergence between the two genetic lines. The feeding rate was substantially higher for quail from the body weight line (P<0.001). According to (Boon *et al.*, 1999), this is consistent with the metabolic regulation principle, which states that feed intake is directly adjusted to satisfy the significant energy requirements connected to fast growth and high metabolic turnover. However, the results of (Schmid and Wechsler, 1997), who noted that instinctual behaviors were reduced in surroundings with restrictive cages, seem to be at odds with this outcome. At least in terms of food desire, this disparity implies that the strong genetic drive for development in the body weight line may outweigh some environmental constraints.

Quail chosen for their high egg production, on the other hand, showed noticeably higher levels of active behaviors, such as drinking, flapping their wings, and overall stimulation (scratching, wandering). The elevated metabolic demands of egg production, which necessitates significant water for yolk synthesis and general physiological processes, may be directly responsible for the increased drinking (P<0.001) (Takei, 1977). This line's conclusion that drinking took up more time, however, is different from that of (Whelton *et al.*, 2002), who observed shorter water consumption times. This suggests that the physiological necessity or behavioral strategy of the egg number line may be essentially different.

Of special attention is the significantly increased frequency of wing activation and flapping in the egg number line. These actions are commonly acknowledged as manifestations of natural inclinations and good welfare (Gordon, 2012; Hughes and Black, 1977). Our findings corroborate those of (Moesta *et al.,* 2008), who found that birds with access to more complex habitats exhibited more energetic behaviors. This implies that a greater drive for energetic and inquisitive behaviors may be a feature of the egg number line's genetic phenotype. This could be regarded as a better adaption to captive settings that permit such expression.

There was no significant difference between the lines in behaviors including standing, pecking, and sitting (P>0.05), suggesting that they are more general maintenance activities shared by both genotypes. While the higher sitting in the heavier body weight line is a well-documented consequence of greater mass, as observed in broiler chickens (Weeks *et al.,* 2000), the high standing rate is consistent with the activity patterns of poultry in restricted settings (May *et al.,* 1987).

Hematological parameters are essential biomarkers for evaluating the health, adaptation, and physiological state of birds under various genetic selection pressures. The hematological profiles of quail lines chosen for body weight, egg production, and a randomly-bred control line were assessed in this study. The findings show that some hematological indices, which represent underlying physiological adaptations, are considerably influenced by genetic selection for production qualities.

The results pertaining to the erythrocytic series are the most noteworthy. Intensive selection for production qualities may have changed erythropoiesis or RBC turnover, as evidenced by the significantly increased RBC count (P<0.01) in the random-bred control line. The body weight line, on the other hand, revealed significantly higher mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) (both P<0.01). According to this, these birds may have fewer erythrocytes, but each one has more hemoglobin, which could improve their ability to carry oxygen and satisfy the high metabolic needs of rapid growth. According to (Unigwe *et al*., 2016), this supports rapid muscle development by pointing to a compensating mechanism.

Hemoglobin (Hb) and packed cell volume (PCV) were highest in the egg production line, while the differences were not statistically significant (P<0.05). This pattern might be an adaptation to sustain the high oxygen consumption and metabolic rate required for long-term egg production. Erythrocyte size remained constant in spite of selection pressures, as evidenced by the non-significant mean corpuscular volume (MCV) values across lines, which are within generally reported ranges (Coenen, 1994).

The body weight line's noticeably higher white blood cell (WBC) count (P<0.05) needs to be interpreted with caution. An activated immune system may be indicated by elevated WBCs, which may be brought on by the metabolic stress of rapid growth, as noted by (Kumar *et al*., 2013). The high-growth characteristic may be associated with an immunological challenge or an elevated inflammatory state.

Crucially, most of the measures such as the heterophil-to-lymphocyte (H/L) ratio, platelets, neutrophils, lymphocytes, and heterophils, did not significantly alter between lines and stayed within normal physiological ranges (Sturkie and Griminger, 1976; Clark, 2015). Strong evidence that the birds in all genetic lines were healthy and did not suffer from severe stress under the given housing conditions is supplied by the non-significant H/L ratio, a well-known measure of chronic stress in poultry.

Conclusion

The present study concluded that diurnal period did not show any differences. Diurnal hours were non-significant which means that Japanese quail's behavior was same in the morning and evening time. Birds were comfortable with battery cages they were not under any stress. According to hematological parameters birds were showing normal behaviors which shows that the birds were in good health and were not under any pressure.

Conflict of Interest: The authors have no competing interests.

Authors' contribution: KF, IB, MS, and MJ executed the experiments. PS, and WS Analyzed the data, write up and revised the manuscript.

REFERENCES

Ahmad S, Mehmood S, Javed K, *et al.*, 2018. Different selection strategies for the improvement of the growth performance and carcass traits of Japanese quails. Braz J Poult Sci 20:497-506.

Boon P, Visser GH and Visser GH, 1999. Feeding and growth of Japanese quail (*Coturnix c. japonica*) chicks with unpredictable food access. NJZ 49:233-250.

Chang GB, Chang H, Liu XP, *et al.*, 2005. Developmental research on the origin and phylogeny of quails. World's Poult Sci J 61:105-112.

Clark P, 2015. Observed variation in the heterophil to lymphocyte ratio values of birds undergoing investigation of health status. Comp Clin Patho 24:1151-1157.

Coenen TMM, Enninga IC, Cave DA, *et al.*, 1994. Hematology and serum biochemistry of Japanese quail fed dietary tri-n-butyltin oxide during reproduction. Arch Environ Contam Toxicol 26:227-233.

Ghayas A, Hussain J, Mahmud K, *et al.*, 2017. Productive performance, egg quality, and hatching traits of Japanese quail reared under different levels of glycerin. Poult Sci 96:2226-2232.

Gordon CJ, 2012. Thermal physiology of laboratory mice: defining thermoneutrality. J therm biol 37:654-685.

Hamad N, Sarwar Z, Ranjha MK, *et al.*, 2016. Food utilization as anti-stunting intervention in Pakistan. Med Chan 22:80-87.

Hughes BO and Black AJ, 1977. Diurnal patterns of feeding and activity in laying hens in relation to dietary restriction and cage shape. Brit Poult Sci 18:353-360.

Hussain J, Mehmood S, Ullah I, *et al.*, 2019. Post hatch performance of meat type Japanese quail influenced by time of offering feed and ambient environment. J Anim Plant Sci 29:365-369.

Kumar KY, Muralidhara HB, Nayaka YA, *et al.*, 2013. Low-cost synthesis of metal oxide nanoparticles and their application in adsorption of commercial dye and heavy metal ion in aqueous solution. Pow Tech 246:125-136.

May JD, Deaton JW and Branton SL, 1987. Body temperature of acclimated broilers during exposure to high temperature. J Poult Sci 66:378-380.

Moesta A, Briese A, Knierim U, *et al.*, 2008. Behaviour of laying hens in aviaries--review. Part 2: Feeding behaviour, reproductive and dust bathing behaviour of chickens. DTW 115:4-14.

Nora A, Ismael, Usama M, *et al.,* 2024. The relationship between eggshell color, hatching traits, fertility, mortality, and some qualitative aspects of Japanese quail (*Coturnix japonica*) eggs, Poult Sci 103:103298

N'Zue, Samuel k, N'DRI AL, *et al.,* 2025. Effects of egg weight variation on growth and reproductive performance of Japanese quail (Coturnix japonica) raised in Côte d'Ivoire. J Appl Biosci 214;22689–22697.

Schmid I and Wechsler B, 1997. Behaviour of Japanese quail (Coturnix japonica) kept in semi-natural aviaries. App Anim Behav Sci 55:103-112.

Sturkie MJ and Griminger AS, 1976. Thick-billed parrot (*Rhynchopsitta pachyrhyncha*). Birds of NA 4:24-27.

Takei Y, 1977. The role of the subfornical organ in drinking induced by angiotensin in the Japanese quail, Coturnix coturnix japonica. Cell Tissue Res 185:175-181.

Unigwe AE, Gerrano AS, Adebola P, *et al.*, 2016. Morphological variation in selected accessions of Bambara groundnut (Vigna subterranea L. Verdc) in South Africa. J Agri Sci 8:69-80.

Vieira Filho JA, Garcia EA, Molino ADB, *et al.*, 2016. Productivity of japanese quails in relation to body weight at the end of the rearing phase. Acta Scientiarum. J Anim Sci 38:213-217.

Weeks CA, Danbury TD, Davies HC, *et al.*, 2000. The behaviour of broiler chickens and its modification by lameness. J App Anim Sci 67:111-125.

Whelton SP, Chin A, Xin X, *et al.*, 2002. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. Ann Int Med 136:493-503.

Wilson W, Anderson B and Siopes T, 1971. Importation of wild strain Japanese quail (wild coturnix) offers new game bird possibility. Califor Agri 25:5-6.