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The effect of different body weight categories on plasma macromineral levels in four close-bred flocks of adult Japanese quails (*Coturnix coturnix japonica*)

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Abstract: The present study was conducted to investigate plasma macrominerals (Ca, P, Na, K, and Mg) in adult male and female quails according to different body weights in four close-bred flocks of Japanese quails (*Coturnix coturnix japonica*) maintained at the Avian Research and Training Center of the University of Veterinary and Animal Sciences, Lahore. The results showed that mean plasma Na concentration was significantly ($P < 0.05$) different in female quails with respect to body size categories. The interaction between flocks and body size for plasma Ca levels was significant ($P < 0.05$) in both sexes of quails, whereas plasma Na was significant ($P < 0.05$) in female quails. The mean plasma P and K levels in imported and local flocks of Japanese quails were significantly ($P < 0.05$) different in female quails, whereas plasma Mg was significantly ($P < 0.05$) different in male quails. However, with respect to body size categories, plasma P, K, and Mg were significantly ($P < 0.05$) different in female quails only. The interaction between flocks and body size was significant for K and P in female quails and for plasma Mg levels in both sexes of quails.

Key words: Calcium, phosphorus, sodium, potassium, magnesium, Japanese quail

1. Introduction

Growth and egg production in Japanese quails depends on numerous physiological and biochemical mechanisms. Certain biochemical parameters, like Ca, P, Na, K, and Mg, play a major role in the body as they are directly related to cell metabolism (growth). The monitoring of biochemical indicators in blood samples from poultry is now a routine part of experimental studies in the area of veterinary medicine and animal husbandry. The values of blood indicators are affected by many factors, such as genotype, age, body size, laying period, physiological condition, sex, diet, micro- and macroclimatic conditions, the method of rearing, season, and pathological factors (1–4). In addition, how samples of biological material are collected and the methods of laboratory analysis also play an important role. Partial results of biochemical screening have been reported in gallinaceous poultry (the order Galliformes), namely hens, broiler chickens, wild turkey, and in common pheasant (5–10). However, little information is available on plasma constituents in adult Japanese quail. Therefore, the present study aimed to determine how plasma macrominerals are affected by different body weights. Keeping the above in view, 4 different close-bred flocks of Japanese quails (one imported and 3 local) were maintained at the Avian Research and Training Center of the Department of Poultry Production, University of Veterinary and Animal Sciences, Lahore, Pakistan, with the objective of studying the possibility of improving their growth and productive performance. Little information is available on the blood serum chemistry values of these strains of Japanese quails. The present study was undertaken to investigate some plasma macrominerals in 4 close-bred flocks of Japanese quails having different body weight categories.

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2. Materials and methods

The present study, involving 432 adult (12 weeks old) quails comprising 108 males and 324 females, was conducted to examine plasma macrominerals in adult male and female quails and their interactions with different body weights in four close-bred flocks of Japanese quails maintained at the Avian Research and Training Center of the University of Veterinary and Animal Sciences, Lahore, Pakistan. The birds were randomly divided into 108 experimental units (replicates comprising one male and three females each), which were randomly assigned to 12 treatment groups having 4 close-bred flocks (imported, local 1, local 2, and local 3) × 3 body sizes (different ranges for each flock, i.e. heavy, medium, and small; illustrated in Table 1) with randomized complete block design (RCBD) in factorial arrangements having 9 replicates in each treatment.

The experimental birds were tagged for their proper identification and maintained in specially remodeled individual compartments each measuring 30 × 20 × 15 cm in French-made multideck cages (equipped with separate nipple drinkers) placed in one of the well-ventilated octagonal quail houses measuring 10.05 × 3.65 × 2.74 m. The maximum and minimum temperatures of the quail house were recorded daily and ranged from 24 °C to 32 °C. Natural daylight was provided to the birds at the start of the experiment and then light hours were increased by 30 min weekly to 16 h light per day. Fresh and clean drinking water was provided at all times through automatic nipple drinkers. The birds were fed ad libitum a balanced quail breeder ration, containing metabolizable energy of 2900 kcal/kg, crude protein of 20%, calcium of 3%, and available phosphorus of 0.4% (11).

The experimental birds were tagged for their proper identification. At the termination of the experiment about 2 mL of blood samples were collected from the jugular veins of 72 male and female breeder quails during slaughter and kept in heparin-coated Vacutainer tubes (Becton Dickinson, USA). The blood samples were refrigerated during transportation to the laboratory and then were centrifuged at 3000 rpm for 10 min, and plasma was harvested and frozen (–20 °C) until assay (12). Digestion of the blood samples was done using 10% trichloroacetic acid. After digestion and dilution, samples were analyzed for Ca, P, Na, K, and Mg using a spectrophotometer and an atomic absorption spectrophotometer, respectively (13,14), in the nutrition laboratory of the Department of Food and Nutrition at the University of Veterinary and Animal Sciences, Lahore, Pakistan.

Table 1. Different body weight categories.

Bod weights	♂	♀
Heavy	270–315 g	300–350 g
Medium	225–270 g	250– 300 g
Small	180–225 g	200– 250 g

The data collected were analyzed using ANOVA techniques with RCBD, with more than one observation for further interpretation using general linear model procedures, assuming the following mathematical model:

$$Y_{ijkl} = \mu + F_i + S_j + W_k + Sj \times W_k + e_{ijkl},$$

where:

Y_{ijkl} = the l*th* observation of the k*th* category of females of the j*th* category of males of the i*th* flock;

μ = population mean;

F_i = effect of the i*th* flock (i = 4), treated as blocks;

S_j = effect of the j*th* category of male (k = 3);

W_k = effect of the k*th* category of female (j = 3);

e_{ijk} = random error associated with the i*th* flock and j*th* body weight category.

The comparison of means was made using Duncan's multiple range test (15–17).

3. Results

3.1. Plasma Ca

The difference in mean plasma Ca concentration (mg/dL) in male and female quails of imported and local flocks of Japanese quails was not significant ($P > 0.05$). Body size categories had no significant ($P > 0.05$) effect on mean plasma Ca levels in either sex. The interaction between flocks and body size was also not significant ($P > 0.05$) (Table 2).

3.2. Plasma P

The difference in mean plasma P concentration (mg/dL) in imported and local flocks was significant ($P < 0.05$) in female quails, whereas it was found to be nonsignificant in male quails. The maximum mean plasma P (5.66 ± 0.10 mg/dL) was recorded in female birds of the local 2 flock and the minimum (5.24 ± 0.13 mg/dL) was recorded in the local 1 flock. However, with respect to body size categories, a significant ($P < 0.05$) difference was observed in female quails, whereas a nonsignificant difference was noted in male quails. The maximum mean plasma P (5.66 ± 0.08 mg/dL) in female quails was recorded in the heavy weight category and the minimum (5.34 ± 0.07 mg/dL) in the small category. The interaction between flock and body size was significant ($P < 0.05$) in female quails and it was not significant in male quails. The maximum mean plasma P (5.96 ± 0.14 mg/dL) was observed in heavy females in the local 2 flock, while the minimum (4.85 ± 0.24 mg/dL) was observed in medium females in the local 1 flock (Table 2).

Table 2. Plasma Ca and P levels (mg/dL) in 4 close-bred flocks of Japanese quails with different body weight categories at 31 weeks.

Category \ *CBF	Sex	Imported	Local 1	Local 2	Local 3	Mean
		---------- (Mean ± **SE; †Ca, mg/dL) ----------				
Heavy	Male	13.73 ± 0.73	12.30 ± 0.25	13.18 ± 0.30	12.58 ± 0.21	12.94 ± 0.24
	Female	13.29 ± 0.48	12.68 ± 0.45	13.09 ± 0.60	12.88 ± 0.23	12.98 ± 0.20
Medium	Male	12.63 ± 0.97	12.22 ± 0.67	12.88 ± 0.10	12.22 ± 0.13	12.49 ± 0.27
	Female	13.29 ± 0.03	12.50 ± 0.25	12.45 ± 0.06	13.21 ± 0.55	12.86 ± 0.17
Small	Male	12.41 ± 0.54	13.29 ± 0.38	12.81 ± 0.18	12.06 ± 0.44	12.64 ± 0.22
	Female	12.70 ± 0.37	12.82 ± 0.56	12.37 ± 0.08	13.40 ± 0.60	12.82 ± 0.22
Mean	Male	12.92 ± 0.43	12.60 ± 0.29	12.96 ± 0.12	12.28 ± 0.16	
	Female	13.09 ± 0.20	12.66 ± 0.22	12.64 ± 0.21	13.16 ± 0.25	
		---------- (Mean ± **SE; ††P, mg/dL) ----------				
Heavy	Male	5.74 ± 0.54	5.37 ± 0.03	5.39 ± 0.06	5.74 ± 0.29	5.56 ± 0.14
	Female	5.66 ± 0.18^{ab}	5.45 ± 0.13^{abc}	5.96 ± 0.14^{a}	5.57 ± 0.16^{abc}	5.66 ± 0.08^{E}
Medium	Male	5.59 ± 0.07	5.82 ± 0.15	5.65 ± 0.22	5.56 ± 0.10	5.65 ± 0.07
	Female	5.32 ± 0.00^{bcd}	4.85 ± 0.24^{d}	5.45 ± 0.16^{abc}	5.73 ± 0.25^{ab}	5.34 ± 0.12^{F}
Small	Male	5.32 ± 0.29	5.50 ± 0.23	5.26 ± 0.07	5.68 ± 0.22	5.44 ± 0.10
	Female	5.11 ± 0.19^{cd}	5.43 ± 0.11^{abc}	5.58 ± 0.06^{abc}	5.26 ± 0.09^{bcd}	5.34 ± 0.07^{F}
Mean	Male	5.55 ± 0.19	5.56 ± 0.10	5.43 ± 0.09	5.66 ± 0.11	
	Female	5.36 ± 0.11B	5.24 ± 0.13^{B}	5.66 ± 0.10^{A}	5.52 ± 0.11^{AB}	

Different letters of means in a row show significant differences at $P < 0.05$.
*CBF = Close-bred flocks, **SE = standard error, †Ca = calcium, ††P = phosphorus.

3.3. Plasma Na

The difference in mean plasma Na concentration (mg/dL) of imported and local flocks was not significant in both male and female quails. However, body size categories were significantly ($P < 0.05$) different in plasma Na in female quails, whereas no significant differences were found in male quails. The maximum mean plasma Na (177.04 ± 0.85 mg/dL) was recorded in medium female quails and the minimum (173.61 ± 0.52 mg/dL) was recorded in small females. The interaction between flock and body size was significant ($P < 0.05$) in females, whereas no significant difference was found in the plasma Na levels of males. The maximum mean plasma Na (178.37 ± 1.68 mg/dL) was observed in medium females in the local 1 flock and the minimum (172.14 ± 1.67 mg/dL) was observed in small females in the local 2 flock (Table 3).

3.4. Plasma K

The difference in mean plasma K concentration (mg/dL) in imported and local flocks of Japanese quails was significantly ($P < 0.05$) different in females, whereas no significant difference was found in male quails. The maximum mean plasma K (4.58 ± 0.11 mg/dL) level was recorded in female quails from the local 2 flock and the minimum (4.01 ± 0.20 mg/dL) was recorded in the local 1 flock. However, body size categories were significantly ($P < 0.05$) different in plasma K in females, whereas no significant difference was found in male quails. The maximum mean plasma K (4.49 ± 0.10 mg/dL) was recorded in medium female quails and the minimum (3.80 ± 0.16 mg/dL) was recorded in small females. The interaction between flocks and body size was significant ($P < 0.05$) in females, whereas a nonsignificant difference

Table 3. Plasma Na and K levels (mg/dL) in 4 close-bred flocks of Japanese quails with different body weight categories at 31 weeks.

*CBF / category	Sex	Imported	Local 1	Local 2	Local 3	Mean
		---------- (Mean ± **SE; †Na, mg/dL) ----------				
Heavy	Male	171.92 ± 1.19	173.89 ± 2.23	174.44 ± 1.22	173.36 ± 1.12	173.40 ± 0.70
	Female	176.80 ± 0.93^{ab}	176.15 ± 1.81^{ab}	175.88 ± 0.61^{ab}	174.54 ± 1.86^{ab}	175.84 ± 0.65^{E}
Medium	Male	172.59 ± 1.88	174.80 ± 0.71	174.14 ± 0.74	172.33 ± 1.57	173.46 ± 0.64
	Female	175.63 ± 2.18^{ab}	178.37 ± 1.68^{a}	175.83 ± 1.69^{ab}	178.33 ± 1.45^{a}	177.04 ± 0.85^{E}
Small	Male	173.96 ± 2.58	174.15 ± 3.04	171.10 ± 1.61	176.70 ± 1.61	173.98 ± 1.14
	Female	173.69 ± 0.80^{ab}	174.75 ± 0.54^{ab}	172.14 ± 1.67^{b}	173.85 ± 0.71^{ab}	173.61 ± 0.52^{F}
Mean	Male	172.82 ± 1.02	174.28 ± 1.11	173.22 ± 0.82	174.13 ± 0.98	
	Female	175.37 ± 0.85	176.42 ± 0.90	174.61 ± 0.94	175.57 ± 0.99	
		---------- (Mean ± **SE; ††K, mg/dl) ----------				
Heavy	Male	3.73 ± 0.32	3.71 ± 0.30	3.73±0.20	3.70 ± 0.15	3.71 ± 0.10
	Female	4.26 ± 0.16^{a}	4.25 ± 0.03^{a}	4.81 ± 0.12^{a}	4.26 ± 0.16^{a}	4.39 ± 0.09^{E}
Medium	Male	3.35 ± 0.28	3.43 ± 0.13	3.91 ± 0.29	3.81 ± 0.24	3.63 ± 0.12
	Female	4.33 ± 0.22^{a}	4.44 ± 0.27^{a}	4.62 ± 0.12^{a}	4.57 ± 0.29^{a}	4.49 ± 0.10^{E}
Small	Male	3.24 ± 0.33	3.39 ± 0.22	3.36 ± 0.31	3.73 ± 0.26	3.43 ± 0.13
	Female	3.48 ± 0.37^{bc}	3.35 ± 0.30^{c}	4.32 ± 0.27^{a}	4.06 ± 0.07^{ab}	3.80 ± 0.16^{F}
Mean	Male	3.44 ± 0.17	3.51 ± 0.12	3.67 ± 0.15	3.74 ± 0.11	
	Female	4.02 ± 0.19^{B}	4.01 ± 0.20^{B}	4.58 ± 0.11^{A}	4.30 ± 0.12^{AB}	

Different letters of means in a row show significant differences at $P < 0.05$.
*CBF = Close-bred flocks, **SE = standard error, †Na = sodium, ††K = potassium.

was found in male birds. The maximum mean plasma K (4.81 ± 0.12 mg/dL) was found in heavy females from the local 2 flock, while the minimum (3.35 ± 0.30 mg/dL) was observed in small females in the local 1 flock (Table 3).

3.5. Plasma Mg

The difference in mean plasma Mg concentration (mg/dL) among imported and local flocks of Japanese quails was significant ($P < 0.05$) in male quails, whereas it was not significantly different in female quails. The maximum plasma Mg (22.77 ± 0.79 mg/dL) was recorded in male birds from the imported flock and the minimum (19.88 ± 0.77 mg/dL) was recorded in the local 1 flock. However, body size categories were significantly ($P < 0.05$) different in plasma Mg in female, whereas male birds were not significantly different. The maximum plasma Mg (22.50 ± 0.67 mg/dL) in female birds was observed in the heavy quails and the minimum (19.83 ± 0.92 mg/dL) was observed in small quails. The interaction between flock and body size was significant ($P < 0.05$) in both sexes for plasma Mg. The maximum mean plasma Mg (25.00 ± 1.00 mg/dL) level in male quails was observed in heavy quails in the imported flock and the minimum (19.33 ± 0.66 mg/dL) was observed in small quails in the local 1, whereas in females, the maximum plasma Mg (23.33 ± 2.96 mg/dL) was observed in heavy quails in the imported flock and the minimum (18.00 ± 0.57 mg/dL) was observed in small quails in the local 3 flock (Table 4).

4. Discussion

During the present study, the mean plasma Ca and Na (mg/dL) in imported and local flocks of Japanese quails differed nonsignificantly ($P > 0.05$) from each other in both sexes. The mean plasma P and K in imported and local flocks varied significantly ($P < 0.05$) only in female flocks. The plasma Mg in imported and local flocks of Japanese

Table 4. Plasma magnesium level (mg/dL) in 4 close-bred flocks of Japanese quails with different body weight categories at 31 weeks.

*CBF / category	Sex	Imported	Local 1	Local 2	Local 3	Mean
		---------- (Mean ± **SE; †Mg, mg/dL) ----------				
Heavy	Male	25.00 ± 1.00^{a}	20.33 ± 1.45^{b}	21.00 ± 0.57^{b}	22.66 ± 0.88^{ab}	22.25 ± 0.69
	Female	23.33 ± 2.96^{a}	22.33 ± 0.66^{ab}	22.33 ± 0.33^{ab}	22.00 ± 0.57^{ab}	22.50 ± 0.67^{E}
Medium	Male	21.00 ± 1.52^{b}	20.00 ± 2.08^{b}	21.66 ± 1.85^{ab}	19.33 ± 0.88^{b}	20.50 ± 0.75
	Female	23.33 ± 0.33^{a}	20.33 ± 1.20^{ab}	21.66 ± 0.66^{ab}	20.66 ± 0.33^{ab}	21.50 ± 0.46^{EF}
Small	Male	22.33 ± 0.33^{ab}	19.33 ± 0.66^{b}	22.00 ± 1.00^{ab}	20.33 ± 0.33^{b}	21.00 ± 0.46
	Female	22.00 ± 3.60^{ab}	20.00 ± 1.15^{ab}	19.33 ± 0.33^{ab}	18.00 ± 0.57^{b}	19.83 ± 0.92^{F}
Mean	Male	22.77 ± 0.79^{A}	19.88 ± 0.77^{B}	21.55 ± 0.64^{AB}	20.77 ± 0.61^{AB}	
	Female	22.88 ± 1.36	20.88 ± 0.63	21.11 ± 0.51	20.22 ± 0.64	

Different letters of means in a row show significant differences at $P < 0.05$.
*CBF = Close-bred flocks, **SE = standard error, †Mg = magnesium.

quails were significantly different ($P < 0.05$) only in male quails. With respect to body size categories, a significant difference ($P < 0.05$) was observed for plasma P, Na, K, and Mg levels only in female quails, whereas a nonsignificant difference ($P > 0.05$) was found in mean plasma Ca levels in both sexes. The interaction between flocks and body size was nonsignificant ($P > 0.05$) for plasma Ca level in both the sexes. However, it was found to be significant ($P < 0.05$) for plasma P, Na, and K in female quails and for Mg in both sexes of quails.

The level of several blood plasma constituents has been reported to vary in female birds during different reproductive stages. Therefore, plasma mineral concentrations during the laying period can be influenced by many factors, such as laying rate, body weight, and age of hens (1–4,18). The results of the present study indicating nonsignificant differences in plasma Ca and Na concentration in imported and local flocks of quails are in quite agreement with those of Abdelrahim Ahmed (19), who observed nonsignificant differences in plasma Ca and Na levels among three breeds of Sudanese indigenous chickens. However, the results of this study are not in line with those of El-Kaiaty and Hassan (20), who reported significant differences between local strains of chickens for serum Ca. Plasma Ca level increases significantly with the advancement of age (21,22). The exact reasons for variation in the findings of the present study and other studies with respect to plasma Ca levels could not be precisely explained; however, it seems that similar blood plasma levels in different close-bred flocks of quails in this study might be due to an identical genetic mechanism controlling Ca metabolism in these birds. The concentration of various plasma blood components may vary in female birds during different productive stages. Different studies were undertaken to associate performance with some physical and chemical constituents of blood in chickens. The results of these investigations, however, are conflicting. Increase in Ca level with an increase in egg production is due to the release of steroid hormones in laying hens through several modes of action involving deposition of Ca within the medullar portion of long bones (18,23–25). A considerable increase in plasma Ca levels at the beginning of the laying period of hens and its subsequent gradual increase has been observed (2–4).

The results of the present study showed nonsignificant differences in plasma P concentration between male quails and plasma Na levels in both the sexes of imported and local flocks. These results are in agreement with those of Hassan et al. (26), who observed nonsignificant differences in serum P levels between different strains of chickens. El-Anwer et al. (21) could not detect an appreciable difference in plasma P levels between two different strains of chickens. Na levels in young Nigerian ducks (*Anas platyrhynchos*) were not significantly different from those of the adult ducks. The variation in plasma P concentration between male and female quails recorded during this study agree with the findings of Nazifi et al. (28), who reported significant ($P < 0.05$) differences in blood P concentration between both sexes of Iranian chukar partridges (*Alectoris chukar*). Serum P concentration ($P < 0.05$) increased during laying. Plasma P increased significantly with advancement of age, with the lowest values at 18 weeks; plasma P

concentrations decreased from 22 to 75 weeks of age in laying hens (4,22,27,29).

In the present study, mean plasma K concentration in imported and local flocks varied significantly ($P < 0.05$) only in female quails. Similar findings indicating breed variation in plasma K concentration in Sudanese indigenous chickens have been reported by Abdelrahim Ahmed (19). K is essential for many important functions, such as osmotic, acid–base, and water balance, and is also involved in different enzymatic actions; a balance is necessary between K, Na, Ca, and Mg. With an increase in the pH of the body fluids, K concentration and alkalinity in the cells increase, resulting in more alkalinity in the urine (30,31).

Plasma P and K concentrations were not significantly different in male quails, whereas plasma Mg concentration was not significantly different in female quails. Plasma Ca was not significantly ($P > 0.05$) different in both sexes due to the effect of close-bred flocks, whereas the effect of body size showed that the plasma macrominerals studied were not significantly different in male quails and plasma calcium (Ca) was not significantly different in both the sexes.

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