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Effects of different selection strategies on subsequent breeder performance, slaughter, and carcass traits of Japanese quail

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Abstract: The present study evaluated the effect of different selection strategies in four closebred flocks (CBF) at three ages on subsequent breeder performance and carcass traits. A total of 540 Japanese quails already selected for higher body weight from four CBF (Major, Kaleem, Saadat, and Zahid) at three ages (10, 12, and 14 weeks) were subjected to 3 selection strategies (i.e. pedigree, mass selection, and randombred control). In pedigree selection, 108 birds with higher body weight were selected with full pedigree record whereas, in the mass selection, 324 birds with higher body weight were selected to be the parents of the next generation. However, in randombred control groups, 108 birds were selected without following any selection. The effect of selection strategies in parents of Japanese quails at 3 ages from 4 CBF was measured on subsequent breeder performance and carcass traits. Regarding productive performance, pedigree-based selected birds had the highest value for female body weight, average daily and fortnightly feed intake and average egg weight, whereas the mass selected birds revealed significantly higher production % and improved FCR (per dozen eggs and kg egg mass). Among different age groups, 14-week-old parents had the highest male and female body weight. However, no significant effect of different closebred flocks on production performance was observed in the present experiment. In conclusion, the pedigree-based and mass selection had a pronounced effect on productive performance and carcass traits, hence, can be an effective tool in the breeding of Japanese quails.

Key words: Selection, closebred flock, parental age, production performance, carcass traits

1. Introduction

The Japanese quail has created a significant impact in recent years because of its high resistance to diseases as compared to chicken. It can be used for meat production having a short market age (3–4 weeks) and matures at an early age of 6 weeks and the female birds usually begin to lay eggs by about 8 weeks [1]. The quail production is also attractive because of its high reproductive potential with a short incubation period of just 17 days. Quail farming was started in Pakistan in the seventies with the introduction of a breeding stock of Japanese quails [2]. However, quail farming has remained a neglected component of the poultry sector in the country. In this regard, research work to improve the productive potential of 4 closebred flocks (three local and one imported) of Japanese quails through selective breeding is being undertaken at Avian Research and Training Centre, University of Veterinary and Animal Sciences, Lahore, Pakistan [3].

It is generally reported that genetic differences have a major contribution (85%) of improving the productive potential of poultry; however, improved nutrition, health status, and environmental management has also created a considerable impact [4]. Selective breeding is found to improve the genetic potential of farm animals in a given set of environments. As the technology and understanding of the basic phenomenon are regarding animal breeding and genetics have improved, genetic selection criteria have also gone advanced enough, involving several traits (even up-to 40 traits) in a single breeding program, in comparison to the historical simple mass selection [5]. Due to genetic selection in the nucleus breeding flocks over the last 50 years, there has been achieved dramatic gains in terms of poultry meat and egg production from individual birds, and these gains are rapidly transferred to the commercial cross-bred progeny [6]. Selection

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experiments equip us with the tools to investigate the inheritance of complex traits. Application of classical techniques of quantitative genetic selection and use of the latest techniques of molecular biology are the major sources of performance improvement. Through selective breeding programs, a significant improvement in growth rate and carcass yield of indigenous breeds has also been observed by several scientists [7]. Presently main focus of the primary breeders regarding selection for economic traits in broiler chicken is especially on the increased growth rate, breast meat yield, improved body shape, and lowered abdominal fats [8]. The high heritability of breast meat and fat yield and body composition has been helpful regarding showing improvement through simple mass selection [9]. By such type of selection procedures, now it has even become possible to alter the processing quality and meat color as well [10]. Continuous selection for growth has led to relatively poor production performance with a decline in egg production [11]. For a single trait selection, the performance of unselected traits was lost and those losing traits may be very important from a breeder point of view. Selection experiments in Japanese quail for improving body weight at a fixed age have frequently resulted in changes other unselected traits due to genetic correlations between them [12]. Narinc et al. [13] reported the positive correlation between mass selection and age in the breeding of Japanese quail, the selection line achieved maximum carcass weight in 6 weeks of age as compared to control line that achieved the required weight at 8 weeks. There still exists a thirst to explore the relationship between selection for a particular trait and response of other traits with their advancing age and the present study is an effort in the same direction with the motives to study the response to selection for higher body weights with their advancing age among different genetic groups on overall productive performance as well as slaughter traits. Therefore, the present study was conducted to evaluate the effect of selection strategies for higher 4-week body weight in 4 closebred flocks at three ages of Japanese quail on subsequent breeder performance, carcass traits, and giblets weight.

2. Materials and methods

This study was conducted at Avian Research and Training (ART) Centre, University of Veterinary and Animal Sciences, Lahore, Pakistan. ART Centre is located at 31.410230°N and 74.375369°E with an altitude of 210.62 m (691 ft).

2.1. Housing and management

All the experimental birds were maintained in well ventilated octagonal quail house (10.05 × 3.65 × 2.74 m) equipped with French-made multideck cages (dimension for each cage = 30 × 20 × 15 cm) specially designed for separate rearing and breeding of quails [83.61 cm^2/quail during brooding (1–14 days) and 150 cm^2/quail during growing (15–28 days)] and breeding of quail (220 cm^2/bird) [14]. During the brooding of two weeks, 25 lux was provided to the birds, however, light intensity was decreased up to 5–10 lux in the growing period. During the breeding phase, 16 h of light (40 lux) was provided to the bird. The birds were fed quail ration recommended by NRC standards [15], separately for quail breeder (CP 20% and ME 2900 kcal/kg) and quail broiler (CP 24% and ME 2900 kcal/kg). A completely randomized design in a 3 × 4 × 3 factorial arrangement was applied. The 36 treatments consisted of 3 selection strategies (pedigree-based, mass selected, and random bred control), 4 closebred flocks (Major, Kaleem, Saadat, and Zahid), and 3 parental age groups (10, 12, and 14 weeks), with 9 replicates. Through the nipple drinker system availability of clean drinking water was ensured. In the case of pedigreed and random bred control, an individual female was kept in replicate in order to maintain information of each and every bird whereas in mass selected birds three females were kept in each replicate (for the information of family record). Stud mating system was performed in pedigreed and random bred control groups whereas the pen mating system was practiced in mass selected groups; all the experimental birds were maintained in the same shed.

2.2. Selection procedure

At Avian Research and Training Centre, four different closebred flocks (1 imported and 3 locals) of Japanese quails were maintained for the last 13 years. These four closebred flocks (CBF) were separately maintained and inbred lines were developed based on selection for higher 4-week body weight. These inbred lines were named Major, Kaleem, Saadat, and Zahid. A total of 540 quail breeders were picked from four CBF and in each flock 3 age groups were selected i.e. 10, 12, and 14 weeks in order to evaluate the effect of parental age group on subsequent progeny. Four CBF at three ages were subjected to three selection strategies and their confounding effect was evaluated on subsequent progeny performance. Based on selection strategies; birds were divided into three main groups, i.e. pedigree-based, mass selected, and random bred control with 108, 324, and 108 birds, respectively. In the first group, all quails (4 CBF × 3 age groups × 9 replicates × 1 bird each) were selected having higher body weight with a full pedigree record to draw a comparison with birds subjected to mass selection and random bred group. In the second group, 324 quails (4 CBF × 3 age groups × 9 replicates × 3 bird each) were subjected to mass selection in which birds having the highest body weight were selected to be the parent of the next generation. In the third group, 108 quails (4 CBF × 3 age groups × 9 replicates × 1 bird each) were selected randomly without following any selection procedures and considered as a control group. In the next generation, their progeny was maintained for four weeks of age and their growth performance and carcass traits were evaluated [16]. The remaining birds were maintained for the current experiment in which quail breeder performance was evaluated for 12 weeks (8–20 weeks) and after 20 weeks of age birds were slaughtered and their carcass traits were evaluated.

2.3. Parameter evaluated

Bodyweight: the individual weight of males and females was recorded at the start (8 weeks) and end of experimentation (20 weeks) with the help of an electric weighing balance (Wei Heng, China).

Feed intake: feed intake was recorded on daily basis by subtracting the feed residue from the total feed intake offered (50 g/bird/day).

Egg weight: eggs were weighed by using a weight balance capable of measuring up to 0.1g (Sartorius Entris 224-1S Balance, USA).

Hen day production %: It was calculated by using the following formula.

Hen day egg production % = number of egg produced / number of females present on that day

FCR per dozen eggs: Feed/dozen eggs were calculated by using the following formula.

Feed / dozen eggs = (total feed consumed (kg) / number of eggs produced) × 12

FCR per kg egg mass: Feed/Kg egg mass was determined by dividing the total feed consumed (kg) by the total egg mass-produced (kg) during the experimental period.

Slaughter parameters: All the breeder parents used in this experiment were slaughtered at the age of 20 weeks and the following parameters were evaluated.

Live body weight: Before slaughtering, live body weight was noted by using an electrical weighing balance (Wei Heng, China).

Carcass weight: Dressed weight was considered as eviscerated carcass weight without skin

carcass yield, liver, gizzard, and heart rate were calculated as the weight of the respective parameter divided by live body weight in grams (g) and multiplied by 100.

2.4. Statistical analysis

Collected data were analyzed through factorial ANOVA using PROC MIXED model with the help of the Statistical Analysis System (SAS 9.1 for windows) [17]. The comparison of means was worked out using Tukey's HSD test assuming the following mathematical model:

$Y_{ijk} = \mu + F_i + C_j + F_i \times C_j + \epsilon_{ijk}$,

where

Y_{ijk} = dependent variable

μ = overall population mean

F_i = fixed effects (i = 2; selection strategies, age groups)

C_j = closebred flocks assumed as random effect (j = 4)

$F_i \times C_j$ = overall interaction effect

ϵ_{ijk} = residual effect

3. Results and discussion

3.1. Productive performance

In the present study, significant differences were observed in female body weight among different selection strategies and age groups ($p \leq 0.05$) (Tables 1–6). Selected birds (pedigree as well as mass selected) remained higher in terms of the initial (298.53, 297.63 vs. 285.17 g) and final body weight (314.07, 314.67 vs. 301.57 g) as compared to random bred control. Higher female body weight is the typical trait in Japanese quail contrary to other avian species [18]. Similarly, higher body weight in the female Japanese quail when selected for higher 4-week body weight has also been reported [19]. Among different age groups, 14-week-old birds showed maximum value for initial (307.56 vs. 291.7, 281.98 g) and final body weight (323.59 vs. 308.23, 298.49 g) followed by the birds having 12- and 10-weeks age, respectively. However, closebred flocks alone did not show any significant difference. Significant differences among different age groups indicated that body weight in Japanese quail is significantly influenced by age that is why selection for higher body weight can be effective by using birds at different ages. Moreover, 14-week-old quails achieved maximum egg size (12–14 g) and ultimately yield better chick quality. Therefore, while planning breeding programs 14 to 20 weeks age in Japanese quail should be considered for ideal progeny growth. Similarly, another study reported better progeny growth performance especially bodyweight of 17 weeks old Pharaoh quails [20]. While comparing different closebred flocks' nonsignificant differences were observed throughout the experimental period. In the present experiment, significant differences were observed in male body weight among different age groups ($p \leq 0.05$). Male birds at 14 weeks of age showed the highest initial (298.67 vs. 285.03, 275 g) and final (311.28 vs. 299.56, 291.33 g) body weight followed by the birds having 12 and 10 weeks of age, respectively. Similarly, in another study, significant differences in male body weight were observed in Japanese quail at different ages [13]. Nonsignificant differences were observed in male Japanese quails among different selection strategies and closebred flocks throughout the experimental period. However, another study reported significant differences in male body weight among different closebred flocks of Japanese quail [21]. Moreover, all the interactions were significant regarding the initial and final body weight of male Japanese quail ($p \leq 0.05$). However, in the case of females, the interactions between selection strategies and parental age groups and closebred flock and parental age group were significant ($p \leq 0.05$).

Table 1. Bodyweight of Japanese quail (means ± S.E) from four closebred flocks and 3 parental age groups subjected to 3 selection strategies.

Selection strategies	Female		Male	
	Initial[1]	Final[2]	Initial[1]	Final[2]
Pedigree	298.53 ± 1.28[a]	314.07 ± 1.31[a]	285.92 ± 1.68	299.36 ± 1.48
Mass selection	297.63 ± 1.20[a]	314.67 ± 1.19[a]	286.03 ± 1.76	299.11 ± 1.69
Random bred	285.17 ± 0.82[b]	301.57 ± 0.78[b]	286.75 ± 1.80	303.69 ± 1.68
Closebred flocks				
Major	293.56 ± 1.42	309.95 ± 1.45	285.67 ± 1.82	298.44 ± 1.82
Kaleem	294.02 ± 1.50	310.72 ± 1.44	285.33 ± 1.84	300.85 ± 1.88
Sadaat	293.68 ± 1.48	309.35 ± 1.43	286.96 ± 2.08	301.78 ± 1.78
Zahid	293.84 ± 1.44	310.41 ± 1.49	286.96 ± 2.32	301.81 ± 2.12
Parental age groups				
10 weeks	281.98 ± 0.52[c]	298.49 ± 0.55[c]	275.00 ± 0.47[c]	291.33 ± 0.94[c]
12 weeks	291.79 ± 0.58[b]	308.23 ± 0.60[b]	285.03 ± 0.54[b]	299.56 ± 0.87[b]
14 weeks	307.56 ± 1.04[a]	323.59 ± 1.05[a]	298.67 ± 0.78[a]	311.28 ± 0.94[a]
Selection strategies × closebred flocks				
Pedigree × Major	298.41 ± 2.57[a]	314.04 ± 2.66[a]	285.89 ± 3.12	298.33 ± 2.79
Pedigree × Kaleem	300.48 ± 2.80[a]	316.11 ± 2.64[a]	284.11 ± 3.18	299.22 ± 3.18
Pedigree × Sadaat	297.11 ± 2.46[a]	311.63 ± 2.52[a]	287.56 ± 3.90	301.78 ± 2.36
Pedigree × Zahid	298.11 ± 2.52[a]	314.52 ± 2.74[a]	286.11 ± 3.71	298.11 ± 3.72
Mass selection × Major	297.22 ± 2.22[a]	314.33 ± 2.27[a]	284.44 ± 2.98	295.44 ± 2.93
Mass selection × Kaleem	297.11 ± 2.23[a]	314.19 ± 2.24[a]	286.89 ± 3.68	302.78 ± 4.20
Mass selection × Sadaat	298.44 ± 2.71[a]	315.04 ± 2.53[a]	285.11 ± 3.05	298.67 ± 3.32
Mass selection × Zahid	297.74 ± 2.53[a]	315.11 ± 2.60[a]	287.67 ± 4.65	299.56 ± 3.02
Random bred × Major	285.04 ± 1.73[b]	301.48 ± 1.75[b]	286.67 ± 3.67	301.56 ± 3.66
Random bred × Kaleem	284.48 ± 1.61[b]	301.85 ± 1.63[b]	285.00 ± 2.95	300.56 ± 2.46
Random bred × Sadaat	285.48 ± 1.71[b]	301.37 ± 1.54[b]	288.22 ± 4.14	304.89 ± 3.44
Random bred × Zahid	285.67 ± 1.55[b]	301.59 ± 1.35[b]	287.11 ± 4.11	307.78 ± 3.77
Selection strategies × parental age groups				
Pedigree × 10 weeks	285.22 ± 0.51[c]	300.58 ± 0.69[c]	274.92 ± 0.92[c]	289.83 ± 1.42[e]
Pedigree × 12 weeks	295.61 ± 0.67[b]	311.36 ± 0.79[b]	285.00 ± 0.98[b]	299.17 ± 1.04[cd]
Pedigree × 14 weeks	314.75 ± 1.24[a]	330.28 ± 1.32[a]	297.83 ± 1.09[a]	309.08 ± 1.00[b]
Mass selection × 10 weeks	285.08 ± 0.50[c]	302.36 ± 0.74[c]	274.67 ± 0.81[c]	288.92 ± 1.36[e]
Mass selection × 12 weeks	295.00 ± 0.47[b]	312.22 ± 0.53[b]	285.00 ± 0.97[b]	298.50 ± 1.87[cd]
Mass selection × 14 weeks	312.81 ± 1.20[a]	329.42 ± 1.21[a]	298.42 ± 1.47[a]	309.92 ± 1.31[b]
Random bred × 10 weeks	275.64 ± 0.45[d]	292.53 ± 0.42[d]	275.42 ± 0.78[c]	295.25 ± 1.57[d]
Random bred × 12 weeks	248.75 ± 0.50[c]	301.11 ± 0.45[c]	285.08 ± 0.95[b]	301.00 ± 1.50[c]
Random bred × 14 weeks	295.11 ± 0.48[b]	311.08 ± 0.47[b]	299.75 ± 1.49[a]	314.83 ± 1.98[a]
Closebred flocks × parental age groups				
Major × 10 weeks	281.59 ± 1.11[c]	298.48 ± 1.45[c]	275.67 ± 0.75[d]	289.00 ± 1.46[d]
Major × 12 weeks	292.04 ± 1.19[b]	307.85 ± 1.15[b]	284.22 ± 1.02[c]	297.33 ± 1.24[bc]
Major × 14 weeks	307.04 ± 1.86[a]	323.52 ± 1.92[a]	297.11 ± 1.29[b]	309.00 ± 1.80[a]
Kaleem × 10 weeks	282.19 ± 1.14[c]	298.96 ± 1.07[c]	274.78 ± 0.98[d]	290.67 ± 2.07[d]
Kaleem × 12 weeks	292.07 ± 1.24[b]	309.37 ± 1.27[b]	284.89 ± 1.12[c]	301.89 ± 1.78[b]

Table 1.(Continued).

Selection strategies	Female		Male	
	Initial[1]	Final[2]	Initial[1]	Final[2]
Kaleem × 14 weeks	307.81 ± 2.28^{a}	323.81 ± 2.13^{a}	296.33 ± 1.25^{b}	310.00 ± 1.89^{a}
Sadaat × 10 weeks	282.04 ± 1.00^{c}	298.22 ± 1.01^{c}	275.33 ± 1.07^{d}	293.33 ± 1.95^{cd}
Sadaat × 12 weeks	291.00 ± 1.11^{b}	306.78 ± 1.13^{b}	286.00 ± 1.13^{c}	300.11 ± 1.30^{b}
Sadaat × 14 weeks	308.00 ± 2.15^{a}	323.04 ± 2.12^{a}	299.56 ± 1.73^{ab}	311.89 ± 1.83^{a}
Zahid × 10 weeks	282.11 ± 0.92^{c}	298.30 ± 0.83^{c}	274.22 ± 1.06^{d}	292.33 ± 1.96^{cd}
Zahid × 12 weeks	292.04 ± 1.11^{b}	308.93 ± 1.23^{b}	285.00 ± 1.17^{c}	298.89 ± 2.31^{b}
Zahid × 14 weeks	307.37 ± 2.12^{a}	324.00 ± 2.35^{a}	301.67 ± 1.45^{a}	314.22 ± 1.81^{a}

Different superscripts on means within the column represent significant differences among their means ($p \leq 0.05$); [1]body weight at the start of experiment (8 weeks); [2]body weight at termination of experiment (20 weeks).

Table 2. Effect of different Selection strategies on overall feed intake and average egg weight (means ± S.E) from 4 CBS and 3 age groups of parent Japanese quail.

Selection strategies × parental age groups	Feed intake/bird (g)	
	Daily	Fortnightly
Pedigree	29.91 ± 0.25^{a}	388.85 ± 3.29^{a}
Mass selection	28.37 ± 0.08^{b}	368.85 ± 1.00^{b}
Random bred	27.70 ± 0.32^{c}	356.72 ± 2.44^{c}
Closebred flocks		
Major	28.44 ± 0.20	369.74 ± 2.60
Kaleem	29.23 ± 0.44	375.51 ± 4.04
Sadaat	28.20 ± 0.30	366.62 ± 3.86
Zahid	28.77 ± 0.23	374.03 ± 2.94
Parental age groups		
10 weeks	28.54 ± 0.20	371.07 ± 2.54
12 weeks	28.81 ± 0.21	374.57 ± 2.67
14 weeks	28.62 ± 0.37	368.78 ± 3.59
Selection strategies × closebred flocks		
Pedigree × Major	29.27 ± 0.46^{bc}	380.53 ± 5.98^{b}
Pedigree × Kaleem	30.84 ± 0.64^{a}	400.87 ± 8.28^{a}
Pedigree × Sadaat	29.22 ± 0.43^{bc}	379.80 ± 5.58^{b}
Pedigree × Zahid	30.32 ± 0.38^{ab}	394.20 ± 4.91^{a}
Mass selection × Major	28.57 ± 0.09^{cde}	371.42 ± 1.20^{bc}
Mass selection × Kaleem	28.17 ± 0.22^{cde}	366.20 ± 2.88^{bcd}
Mass selection × Sadaat	28.31 ± 0.11^{cde}	368.05 ± 1.45^{bc}
Mass Selection × Zahid	28.44 ± 0.15^{cde}	369.75 ± 2.00^{bc}
Random bred × Major	27.48 ± 0.20^{de}	357.27 ± 2.63^{cd}
Random bred × Kaleem	28.68 ± 1.03^{cd}	359.47 ± 2.60^{cd}
Random bred × Sadaat	27.08 ± 0.69^{e}	352.00 ± 8.92^{d}
Random bred × Zahid	27.55 ± 0.17^{de}	358.13 ± 2.19^{cd}
Pedigree × 10 weeks	29.68 ± 0.45^{ab}	385.85 ± 5.82^{a}
Pedigree × 12 weeks	30.20 ± 0.43^{a}	392.55 ± 5.53^{a}

Table 2.(Continued).

Selection strategies × parental age groups	Feed intake/bird (g)	
	Daily	Fortnightly
Pedigree × 14 weeks	29.86 ± 0.46[a]	388.15 ± 5.94[a]
Mass selection × 10 weeks	28.43 ± 0.10[c]	369.55 ± 1.32[bc]
Mass selection × 12 weeks	28.57 ± 0.08[bc]	371.46 ± 1.09[b]
Mass selection × 14 weeks	28.12 ± 0.18[c]	365.55 ± 2.34[bc]
Random bred × 10 weeks	27.52 ± 0.14[c]	357.80 ± 1.82[cd]
Random bred × 12 weeks	27.67 ± 0.18[c]	359.70 ± 2.33[bcd]
Random bred × 14 weeks	27.90 ± 0.94[c]	352.65 ± 6.73[d]
Closebred flocks × parental age groups		
Major × 10 weeks	28.28 ± 0.26	367.65 ± 3.39
Major × 12 weeks	28.78 ± 0.38	374.13 ± 4.89
Major × 14 weeks	28.26 ± 0.39	367.43 ± 5.13
Kaleem × 10 weeks	28.71 ± 0.50	373.22 ± 6.56
Kaleem × 12 weeks	29.24 ± 0.53	380.08 ± 6.84
Kaleem × 14 weeks	29.74 ± 1.11	373.23 ± 7.88
Sadaat × 10 weeks	28.39 ± 0.41	369.12 ± 5.36
Sadaat × 12 weeks	28.47 ± 0.30	370.13 ± 3.87
Sadaat × 14 weeks	27.74 ± 0.74	360.60 ± 9.65
Zahid × 10 weeks	28.79 ± 0.37	374.28 ± 4.79
Zahid × 12 weeks	28.76 ± 0.43	373.93 ± 5.56
Zahid × 14 weeks	28.76 ± 0.40	373.87 ± 5.25

Different superscripts on means within the column represent significant differences among their means ($p \leq 0.05$).

Table 3. Effect of different selection strategies on overall production performance (means ± S.E) from 4 CBS and 3 age groups of parent Japanese quail.

Selection strategies × closebred flocks	Egg weight (g)	Production %	Feed conversion ratio	
			/ dozen eggs[1]	/ kg mass[2]
Pedigree	12.22 ± 0.08[a]	58.00 ± 2.56[b]	0.69 ± 0.08[a]	4.75 ± 0.61[a]
Mass selection	11.26 ± 0.06[b]	73.00 ± 1.56[a]	0.38 ± 0.01[b]	2.83 ± 0.08[b]
Random bred	11.17 ± 0.08[b]	49.44 ± 2.79[c]	0.93 ± 0.13[a]	6.34 ± 0.86[a]
Closebred flocks				
Major	11.48 ± 0.09	60.00 ± 2.87	0.58 ± 0.05	4.02 ± 0.34
Kaleem	11.42 ± 0.11	60.30 ± 3.47	0.76 ± 0.14	5.33 ± 0.99
Sadaat	11.65 ± 0.11	60.74 ± 2.95	0.65 ± 0.10	4.45 ± 0.67
Zahid	11.64 ± 0.14	59.57 ± 3.10	0.70 ± 0.13	4.77 ± 0.79
Parental age groups				
10 weeks	11.56 ± 0.10	58.78 ± 2.95	0.75 ± 0.11	5.24 ± 0.78
12 weeks	11.57 ± 0.10	60.56 ± 2.66	0.67 ± 0.10	4.59 ± 0.63
14 weeks	11.51 ± 0.10	61.11 ± 2.40	0.59 ± 0.07	4.10 ± 0.45
Pedigree × Major	11.93 ± 0.08[b]	60.44 ± 4.76[bcd]	0.58 ± 0.08[ab]	4.02 ± 0.49[abc]

Table 3.(Continued).

Selection strategies × closebred flocks	Egg weight (g)	Production %	Feed conversion ratio	
			/ dozen eggs[1]	/ kg mass[2]
Pedigree × Kaleem	12.08 ± 0.16[b]	50.67 ± 6.06[de]	1.00 ± 0.29[a]	7.00 ± 2.16[ab]
Pedigree × Sadaat	12.30 ± 0.16[ab]	62.67 ± 4.77[abcd]	0.60 ± 0.12[ab]	4.07 ± 0.82[abc]
Pedigree × Zahid	12.57 ± 0.16[a]	58.22 ± 4.76[cde]	0.59 ± 0.06[ab]	3.93 ± 0.40[abc]
Mass selection × Major	11.35 ± 0.12[c]	74.67 ± 2.62[ab]	0.37 ± 0.01[b]	2.71 ± 0.11[c]
Mass selection × Kaleem	11.02 ± 01.4[c]	76.00 ± 3.11[a]	0.37 ± 0.02[b]	2.76 ± 0.14[c]
Mass selection × Sadaat	11.47 ± 0.10[c]	71.56 ± 3.35[abc]	0.39 ± 0.02[b]	2.84 ± 0.15[c]
Mass selection × Zahid	11.19 ± 0.14[c]	69.78 ± 3.43[abc]	0.40 ± 0.02[b]	3.02 ± 0.20[bc]
Random bred × Major	11.15 ± 0.16[c]	44.89 ± 4.04[e]	0.78 ± 0.11[ab]	5.33 ± 0.76[abc]
Random bred × Kaleem	11.16 ± 0.16[c]	54.22 ± 6.37[de]	0.90 ± 0.28[ab]	6.24 ± 1.95[abc]
Random bred × Sadaat	11.19 ± 0.19[c]	48.00 ± 5.29[de]	0.96 ± 0.27[ab]	6.45 ± 1.75[abc]
Random bred × Zahid	11.17 ± 0.20[c]	50.67 ± 6.53[de]	1.10 ± 0.35[a]	7.35 ± 2.23[a]
Selection strategies × parental age groups				
Pedigree × 10 weeks	12.35 ± 0.16[a]	53.00 ± 5.50[cd]	0.94 ± 0.23[ab]	6.48 ± 1.70[a]
Pedigree × 12 weeks	12.11 ± 0.09[a]	60.33 ± 3.70[bc]	0.57 ± 0.06[bc]	3.91 ± 0.39[ab]
Pedigree × 14 weeks	12.20 ± 0.15[a]	60.67 ± 3.90[bc]	0.57 ± 0.06[bc]	3.87 ± 0.38[ab]
Mass selection × 10 weeks	11.41 ± 0.10[b]	74.33 ± 2.75[a]	0.37 ± 0.02[c]	2.75 ± 0.13[b]
Mass selection × 12 weeks	11.24 ± 0.13[bc]	75.33 ± 2.17[a]	0.36 ± 0.01[c]	2.71 ± 0.08[b]
Mass selection × 14 weeks	11.12 ± 0.09[bc]	69.33 ± 3.07[ab]	0.41 ± 0.02[c]	3.05 ± 0.16[b]
Random bred × 10 weeks	10.91 ± 0.08[c]	49.00 ± 4.87[cd]	0.93 ± 0.22[ab]	6.50 ± 1.52[a]
Random bred × 12 weeks	11.38 ± 0.18[b]	46.00 ± 4.98[d]	1.08 ± 0.27[a]	7.14 ± 1.72[a]
Random bred × 14 weeks	11.21 ± 0.14[bc]	53.33 ± 4.74[cd]	0.80 ± 0.20[abc]	5.39 ± 1.27[ab]
Closebred flocks × parental age groups				
Major × 10 weeks	11.54 ± 0.09	64.44 ± 5.73	0.58 ± 0.12	4.02 ± 0.81
Major × 12 weeks	11.40 ± 0.21	57.33 ± 4.50	0.58 ± 0.08	4.09 ± 0.49
Major × 14 weeks	11.50 ± 0.13	58.22 ± 4.71	0.56 ± 0.06	3.96 ± 0.42
Kaleem × 10 weeks	11.48 ± 0.24	48.89 ± 7.35	1.27 ± 0.38	8.99 ± 2.73
Kaleem × 12 weeks	11.41 ± 0.20	64.44 ± 4.72	0.50 ± 0.05	3.49 ± 0.29
Kaleem × 14 weeks	11.36 ± 0.14	67.56 ± 4.82	0.50 ± 0.08	3.53 ± 0.51
Sadaat × 10 weeks	11.48 ± 0.21	60.00 ± 4.65	0.60 ± 0.12	4.18 ± 0.82
Sadaat × 12 weeks	11.76 ± 0.17	62.22 ± 5.47	0.60 ± 0.13	4.15 ± 0.87
Sadaat × 14 weeks	11.73 ± 0.19	60.00 ± 5.52	0.75 ± 0.26	5.03 ± 1.67
Zahid × 10 weeks	11.73 ± 0.26	61.78 ± 5.30	0.55 ± 0.07	3.79 ± 0.47
Zahid × 12 weeks	11.73 ± 0.16	58.22 ± 6.65	1.00 ± 0.36	6.61 ± 2.27
Zahid × 14 weeks	11.47 ± 0.28	58.67 ± 4.18	0.54 ± 0.05	3.89 ± 0.43

Different superscripts on means within column represent significant differences among their means ($p \leq 0.05$); [1]feed consumed (kg)/total number of eggs produced × 12; [2]feed consumed (g)/egg mass produced (g).

Table 4. Effect of different selection strategies on slaughter parameters (means ± S.E) from 4 CBS and 3 age groups of female parent Japanese quail (at the age of 20 weeks).

Selection strategies × closebred flocks	Live weight (g)	Dressed weight (g)	Carcass yield (%)
Pedigree	304.03 ± 5.05[a]	172.95 ± 4.33[a]	56.79 ± 0.91[a]
Mass selection	296.58 ± 5.68[a]	165.87 ± 4.08[a]	55.82 ± 0.69[a]
Random bred	274.25 ± 4.38[b]	144.57 ± 6.45[b]	52.18 ± 1.79[b]
Closebred flocks			
Major	295.81 ± 7.18	166.75 ± 6.46	56.22 ± 1.52
Kaleem	287.85 ± 6.78	158.22 ± 5.94	54.55 ± 1.20
Sadaat	289.04 ± 5.50	158.48 ± 6.76	54.42 ± 1.69
Zahid	293.78 ± 5.76	161.05 ± 6.02	54.53 ± 1.41
Parental age groups			
10 weeks	290.67 ± 5.61	158.06 ± 5.05	54.12 ± 1.10
12 weeks	294.83 ± 5.57	163.79 ± 5.89	55.22 ± 1.41
14 weeks	289.36 ± 5.26	161.54 ± 5.38	55.45 ± 1.27
Selection strategies × closebred flocks			
Pedigree × Major	313.11 ± 10.56[a]	181.50 ± 11.75	57.68 ± 2.50
Pedigree × Kaleem	305.56 ± 13.09[ab]	171.07 ± 7.32	56.02 ± 0.85
Pedigree × Sadaat	297.33 ± 5.27[abc]	166.85 ± 8.40	56.05 ± 2.56
Pedigree × Zahid	300.11 ± 10.81[abc]	172.37 ± 7.24	57.40 ± 0.90
Mass selection × Major	296.22 ± 16.57[abc]	164.96 ± 10.00	55.61 ± 0.84
Mass selection × Kaleem	291.44 ± 7.70[abc]	165.34 ± 7.10	56.60 ± 1.34
Mass selection × Sadaat	293.78 ± 12.10[abc]	163.16 ± 9.06	55.34 ± 1.56
Mass selection × Zahid	304.89 ± 8.44[ab]	170.03 ± 7.45	55.73 ± 1.79
Random bred × Major	278.11 ± 6.31[bc]	153.79 ± 10.97	55.38 ± 3.91
Random bred × Kaleem	266.56 ± 10.96[c]	138.33 ± 12.79	51.04 ± 3.03
Random bred × Sadaat	276.00 ± 9.38[bc]	145.43 ± 16.13	51.86 ± 4.20
Random bred × Zahid	276.33 ± 8.80[bc]	140.75 ± 12.93	50.45 ± 3.50
Selection strategies × parental age groups			
Pedigree × 10 weeks	303.25 ± 10.42[ab]	171.63 ± 7.03[a]	56.69 ± 1.62
Pedigree × 12 weeks	305.75 ± 6.97[a]	172.02 ± 9.08[a]	171.63 ± 7.03
Pedigree × 14 weeks	303.08 ± 9.25[ab]	175.19 ± 6.84[a]	57.67 ± 0.77
Mass selection × 10 weeks	293.92 ± 10.13[ab]	161.61 ± 7.58[ab]	54.79 ± 1.01
Mass selection × 12 weeks	297.25 ± 12.54[ab]	162.22 ± 7.62[ab]	54.48 ± 0.75
Mass selection × 14 weeks	298.58 ± 6.85[ab]	173.79 ± 5.89[a]	58.19 ± 1.46
Random bred × 10 weeks	274.83 ± 7.15[bc]	140.95 ± 9.59[b]	50.88 ± 2.53
Random bred × 12 weeks	281.50 ± 7.91[abc]	157.13 ± 13.40[ab]	55.17 ± 3.69
Random bred × 14 weeks	266.42 ± 7.67[c]	135.65 ± 10.16[b]	50.49 ± 3.06
Major × 10 weeks	293.44 ± 13.58	161.48 ± 12.70	54.74 ± 2.92
Major × 12 weeks	301.00 ± 12.49	168.41 ± 11.28	55.81 ± 2.53
Major × 14 weeks	293.00 ± 12.54	170.36 ± 10.63	58.12 ± 2.64
Kaleem × 10 weeks	302.33 ± 12.62	164.97 ± 8.78	54.47 ± 1.54
Kaleem × 12 weeks	277.44 ± 10.28	148.81 ± 10.31	53.11 ± 2.00
Kaleem × 14 weeks	283.78 ± 11.90	160.95 ± 11.95	56.08 ± 2.66
Sadaat × 10 weeks	284.11 ± 7.79	155.32 ± 9.64	54.38 ± 2.40

Table 4.(Continued).

Selection strategies × closebred flocks	Live weight (g)	Dressed weight (g)	Carcass yield (%)
Sadaat × 12 weeks	291.89 ± 12.50	160.69 ± 15.24	54.64 ± 4.01
Sadaat × 14 weeks	291.11 ± 8.58	159.43 ± 10.88	54.24 ± 2.46
Zahid × 10 weeks	282.78 ± 10.75	150.48 ± 9.95	52.89 ± 2.11
Zahid × 12 weeks	309.00 ± 7.49	177.25 ± 9.26	57.32 ± 2.64
Zahid × 14 weeks	289.56 ± 10.29	155.42 ± 10.83	53.37 ± 2.57

Different superscripts on means within the column represent significant differences among their means ($p \leq 0.05$).

Table 5. Effect of different selection strategies on relative weight of giblet (means ± S.E) from 4 CBS and 3 age groups of female parent Japanese quail (at the age of 20 weeks).

Closebred flocks × parental age groups	Liver (%)	Gizzard (%)	Heart (%)
Pedigree	3.09 ± 0.08^{b}	2.49 ± 0.06^{b}	0.67 ± 0.01^{b}
Mass selection	3.58 ± 0.08^{a}	2.93 ± 0.06^{a}	0.75 ± 0.02^{a}
Random bred	3.09 ± 0.10^{b}	2.60 ± 0.07^{b}	0.71 ± 0.02^{ab}
Closebred flocks			
Major	3.15 ± 0.10	2.50 ± 0.08	0.70 ± 0.02
Kaleem	3.34 ± 0.11	2.73 ± 0.09	0.71 ± 0.03
Sadaat	3.26 ± 0.12	2.67 ± 0.07	0.70 ± 0.02
Zahid	3.26 ± 0.11	2.78 ± 0.08	0.72 ± 0.02
Parental age groups			
10 weeks	3.26 ± 0.10	2.68 ± 0.08	0.71 ± 0.02
12 weeks	3.20 ± 0.10	2.66 ± 0.06	0.70 ± 0.02
14 weeks	3.29 ± 0.08	2.68 ± 0.06	0.72 ± 0.02
Selection strategies × closebred flocks			
Pedigree × Major	2.86 ± 0.16^{de}	2.21 ± 0.09^{e}	0.65 ± 0.03
Pedigree × Kaleem	2.97 ± 0.12^{cde}	2.31 ± 0.14^{de}	0.65 ± 0.03
Pedigree × Sadaat	3.31 ± 0.10^{abcd}	2.64 ± 0.04^{bcd}	0.66 ± 0.01
Pedigree × Zahid	3.22 ± 0.20^{bcde}	2.79 ± 0.13^{abc}	0.70 ± 0.03
Mass selection × Major	3.38 ± 0.10^{abcd}	2.75 ± 0.07^{bc}	0.75 ± 0.03
Mass selection × Kaleem	3.79 ± 0.20^{a}	3.14 ± 0.11^{a}	0.77 ± 0.07
Mass selection × Sadaat	3.72 ± 0.20^{ab}	2.93 ± 0.11^{ab}	0.74 ± 0.03
Mass selection × Zahid	3.43 ± 0.12^{abc}	2.90 ± 0.14^{ab}	0.75 ± 0.03
Random bred × Major	3.21 ± 0.22^{bcde}	2.55 ± 0.18^{bcde}	0.70 ± 0.04
Random bred × Kaleem	3.27 ± 0.15^{abcde}	2.75 ± 0.10^{bc}	0.73 ± 0.03
Random bred × Sadaat	2.74 ± 0.17^{e}	2.43 ± 0.13^{cde}	0.70 ± 0.04
Random bred × Zahid	3.12 ± 0.22^{cde}	2.66 ± 0.14^{bcd}	0.71 ± 0.03
Pedigree × 10 weeks	3.09 ± 0.16^{bcd}	2.47 ± 0.16^{d}	0.67 ± 0.03^{bc}
Pedigree × 12 weeks	3.07 ± 0.15^{cd}	2.53 ± 0.07^{cd}	0.65 ± 0.02^{c}
Pedigree × 14 weeks	3.11 ± 0.1^{bcd}	2.47 ± 0.09^{d}	0.67 ± 0.02^{bc}
Mass selection × 10 weeks	3.58 ± 0.18^{ab}	3.00 ± 0.08^{a}	0.76 ± 0.03^{ab}
Mass selection × 12 weeks	3.54 ± 0.16^{abc}	2.85 ± 0.13^{abc}	0.69 ± 0.03^{bc}

Table 5.(Continued).

Closebred flocks × parental age groups	Liver (%)	Gizzard (%)	Heart (%)
Mass selection × 14 weeks	3.62 ± 0.09^{a}	2.93 ± 0.08^{ab}	0.81 ± 0.05^{a}
Random bred × 10 weeks	3.12 ± 0.18^{bcd}	2.56 ± 0.14^{cd}	0.72 ± 0.03^{bc}
Random bred × 12 weeks	2.99 ± 0.18^{d}	2.60 ± 0.11^{bcd}	0.75 ± 0.04^{abc}
Random bred × 14 weeks	3.15 ± 0.17^{abcd}	2.63 ± 0.12^{bcd}	0.67 ± 0.02^{bc}
Closebred flocks × parental age groups			
Major × 10 weeks	3.07 ± 0.23	2.43 ± 0.17	0.72 ± 0.04
Major × 12 weeks	3.06 ± 0.18	2.51 ± 0.12	0.66 ± 0.03
Major × 14 weeks	3.32 ± 0.13	2.57 ± 0.13	0.73 ± 0.03
Kaleem × 10 weeks	3.15 ± 0.15	2.54 ± 0.19	0.66 ± 0.03
Kaleem × 12 weeks	3.47 ± 0.24	2.90 ± 0.16	0.72 ± 0.05
Kaleem × 14 weeks	3.41 ± 0.17	2.75 ± 0.12	0.76 ± 0.07
Sadaat × 10 weeks	3.45 ± 0.26	2.78 ± 0.12	0.72 ± 0.02
Sadaat × 12 weeks	3.21 ± 0.16	2.66 ± 0.11	0.70 ± 0.04
Sadaat × 14 weeks	3.11 ± 0.20	2.56 ± 0.12	0.69 ± 0.02
Zahid × 10 weeks	3.37 ± 0.18	2.95 ± 0.16	0.76 ± 0.03
Zahid × 12 weeks	3.07 ± 0.21	2.57 ± 0.08	0.71 ± 0.02
Zahid × 14 weeks	3.33 ± 0.17	2.83 ± 0.13	0.69 ± 0.04

Different superscripts on means within the column represent significant differences among their means ($p \leq 0.05$).

Table 6. Analysis of variance of different treatments and their interaction.

Traits	SS	CBF	PA	SS × CBF	SS × PA	CBF × PA
8-WK FBW (g)	< 0.0001	0.9159	<0.0001	0.1102	<0.0001	0.9442
20-WK FBW (g)	< 0.0001	0.2901	<0.0001	0.1593	<0.0001	0.9185
8-WK MBW (g)	0.5712	0.2200	<0.0001	0.2555	0.9213	0.1590
20-WK MBW (g)	<0.0001	0.0329	<0.0001	0.0086	0.5000	0.4057
FIB, daily (g)	<0.0001	0.0542	0.7152	0.3085	0.8818	0.7005
FIB, fortnightly (g)	<0.0001	0.1039	0.2409	0.1591	0.9156	0.9187
EW (g)	<0.0001	0.1268	0.8333	0.1266	0.0301	0.5856
Prod %	<0.0001	0.9917	0.7655	0.3463	0.3358	0.1199
FCRdz	0.0001	0.6494	0.4533	0.6681	0.4031	0.0194
FCRem	0.0003	0.5922	0.4047	0.6460	0.4276	0.0173
LW (g)	0.0005	0.7680	0.7508	0.9381	0.9159	0.3983
DW (g)	0.0008	0.7427	0.7458	0.9747	0.4729	0.5758
CY (%)	0.0343	0.8008	0.7397	0.9472	0.4071	0.8416
LVW (%)	< 0.0001	0.6042	0.7612	0.0735	0.9945	0.3854
GW (%)	< 0.0001	0.0256	0.9700	0.0182	0.8199	0.0617
HW (%)	0.0042	0.8692	0.6986	0.9763	0.0390	0.3195

WK = week; FBW = female body weight; MBW = male body weight; FIB = feed intake per bird; EW = egg weight; Prod = Production; FCRdz = feed conversion ratio per dozen eggs; FCRem = feed conversion ratio per kg egg mass; LW = live weight; DW = dressed weight; CY = carcass yield; LVW = liver weight; GW = gizzard weight; HW = heart weight; SS = selection strategies; CBF = closebred flocks; PA = parental age groups.

In the present study, significant differences were observed in daily as well as fortnightly feed intake among different selection strategies ($p \leq 0.05$) (Tables 2–6). Pedigree based selected birds had the highest average daily (29.91 vs. 28.37, 27.70 g) and fortnightly feed intake (388.85 vs. 368.85, 356.72 g) followed by the birds from mass selected and random bred control groups. Furthermore, significant interactions between selection strategies and closebred flocks and selection strategies and parental age groups were observed regarding daily and fortnightly feed intake ($p \leq 0.05$). Different responses from the selection could be due to selection accuracy in pedigree-based selected birds. Similarly, in Japanese quail higher feed intake was observed in birds selected for higher body weight [19]. In this study, feed intake did not differ significantly among different closebred flocks and age groups. The findings of this study correspond to the study of Iqbal et al. [22] who reported that there was no difference in feed intake of four close bred flocks of Japanese quails. However, in another study, significant differences in average daily feed intake among different closebred flocks of Japanese quail were also reported [23].

In the present study, significant differences were observed in average egg weight (g) among different selection strategies ($p \leq 0.05$) (Tables 3–6). Pedigree based selected birds showed higher egg weight as compared to mass selected and random bred control (12.22 vs. 11.26, 11.17 g). Interactions were significant between selection strategies and closebred flocks and selection strategies and parental age groups regarding egg weight ($p \leq 0.05$). Better response from pedigree-based selected birds could be due to increased allele's frequency of genes controlling production trait in Japanese quail. Similarly, significant improvement in egg weight of Japanese quail was reported in Japanese quail selected for higher 3-week body weight in three generations [24]. Nonsignificant differences were observed in average egg weight (g) among different closebred flocks and age groups. Similarly, in another study, a nonsignificant difference was noted regarding the egg weight of two quail strains (Japanese quail and Range quail) [25].

Significant differences were observed in hen day production (%) among different selection strategies ($p \leq 0.05$) (Tables 3–6). Mass selected birds had the highest production % followed by the bird having pedigree-based and random bred control groups (73 vs. 58, 49.44 %). The interactions among selection strategies with closebred flocks and parental age groups were also significant ($p \leq 0.05$). Differential responses from different selection groups might be attributed to additive genetic variance and selection accuracy resulted in higher production performance especially average daily egg production. However, a contradictory study also reported a nonsignificant difference regarding egg production percent among pedigreed, mass selected, and random bred lines of Japanese quail [24]. Nonsignificant differences were observed in the average daily egg production rate among different closebred flocks and age groups. However, another study reported that parental age significantly influences progeny performance; indicated better egg production and egg weight in the progeny of 20 weeks old European quails [26]. Furthermore, significant differences in egg production rate were also noted among different closebred flocks of Japanese quail [27].

Significant differences were observed in FCR/dozen eggs among different selection strategies ($p \leq 0.05$) (Tables 3–6). Mass selected birds showed the best FCR/dozen eggs as compared to pedigree-based selected and random bred control groups (0.38 vs. 0.69, 0.93) which might have been due to better feed efficiency in those birds. Significant interactions were also observed between selection strategies and closebred flocks and selection strategies and parental age groups ($p \leq 0.05$). Similarly, another study indicated better feed efficiency in birds selected for higher four-week body weight in Japanese quail [19]. Nonsignificant differences were observed in FCR/dozen eggs among different closebred flocks and age groups. The findings of the present study correspond with the findings of Iqbal et al. [22] who did not find any difference regarding feed conversion rate among four close bred flocks of Japanese quail. However, another study reported a significant difference in FCR/g egg mass among different closebred flocks of Japanese quail [21].

Significant differences were observed in FCR/kg egg mass among different selection strategies ($p \leq 0.05$) (Tables 3–6). Mass selected birds depicted better FCR/kg egg massas compared to pedigree-based selected and random bred control groups (2.83 vs. 4.75, 6.34); whereas interactions were significant between selection strategies and closebred flocks and selection strategies and parental age groups ($p \leq 0.05$). Improved FCR/kg egg mass in mass selected birds might be attributed to lower fat deposits in mass selected birds with higher egg weight. Similarly, improved FCR in selected lines of Japanese quail was reported as compared to control ones [23]. Nonsignificant differences were observed among different closebred flocks and age groups. However, another study revealed significant differences in FCR/kg egg mass among different closebred flocks of Japanese quail [21].

3.2. Carcass traits

Significant differences were observed in live body weight (g) among females from different selection strategies ($p \leq 0.05$) (Tables 4–6). Selected females (pedigree, mass selected) showed higher live body weight as compared to the random bred control (304.03, 296.58 vs. 274.25 g) group. Significant interactions were also observed between selection strategies and closebred flocks and selection strategies and parental age groups ($p \leq 0.05$). Similarly, a significant effect of the selection line on body weight was observed in female Japanese quail selected for higher 5-week bodyweight [28]. However, no significant effect of closebred flocks and age groups was observed regarding female live weight in the present study. Similarly, nonsignificant differences in live body weight among four closebred flocks of Japanese quail [29].

Significant differences were observed in dressed weight (g) among females from different selection strategies ($p \leq 0.05$) (Tables 4–6). Selected birds (pedigree, mass selected) revealed higher dressed weight as compared to random bred control (172.95, 165.87 vs. 144.57 g). A significant interaction was also noted regarding dressed weight between selection strategies and parental age groups ($p \leq 0.05$). Similarly, a significant effect of selection on carcass weight was observed in birds selected for higher four-week breast weight in Japanese quail [30]. Nonsignificant differences were observed in dressed weight among different closebred flocks and age groups. Similarly, no significant effect of closebred flocks on carcass weight was observed in Japanese quail [29]. However, a significant effect of age on carcass weight in Japanese quail was also observed [31].

Significant differences were observed in carcass yield percentage among different selection strategies ($p \leq 0.05$) (Tables 4–6). Selected birds (pedigree, mass selected) showed a higher value for carcass yield percentage as compared to random bred control (56.79, 55.82 vs. 52.18%). Similarly, another study reported high dressing yield in birds selected for higher four-week body weight in 19 generations of Japanese quail [32]. Nonsignificant differences were observed among different closebred flocks, age groups, and their interactions. However, a higher dressing percentage in black-spotted quail was reported as compared to brown and white strains at the age of 5th, 6th, 7th, and 8th week [33].

Significant differences were observed in liver weight rate among different selection strategies. Mass selected birds had the highest value for liver weight as compared to pedigree-based selected and random bred control birds ($p \leq 0.05$) (3.58 vs. 3.09, 3.09%). Significant interactions were also observed between selection strategies and closebred flocks and selection strategies and parental age groups ($p \leq 0.05$). Similarly, a significant effect of selection on liver weight was observed in birds selected for higher four-week body weight [31]. No significant effect of closebred flocks and age groups was observed on liver weight in the current experiment. Similarly, no significant effect of closebred flocks on liver weight rate was observed in Japanese quail [29].

Significant differences were observed in the gizzard weight rate among different selection strategies ($p \leq 0.05$) (Tables 5 and 6). Pedigree based selected birds remained the highest in terms of gizzard weight as compared to random bred and mass selected birds (2.93 vs. 2.60, 2.49%). Interactions were significant between selection strategies and closebred flocks and selection strategies and parental age groups ($p \leq 0.05$). Similarly, a higher giblet weight rate was reported in selected birds as compared to the control line [32]. Not any significant effect of closebred flocks and age groups on gizzard weight was observed in the present study. However, significant differences were observed in gizzard weight among four closebred flocks of Japanese quail [29].

Significant differences were observed in heart weight among different selection strategies ($p \leq 0.05$) (Tables 5 and 6). Mass selected birds had the highest value for heart weight rate as compared to random bred and pedigree-based selected birds (0.75 vs. 0.71, 0.67%). A significant interaction was also observed between selection strategies and parental age groups ($p \leq 0.05$). Similarly, a significant effect of selection on visceral organs was reported in Japanese quail [34]. However, no significant effect of closebred flocks and age groups on gizzard weight rate was observed in the present experiment. Similarly, heart weight rate was not influenced by different closebred flocks in Japanese quail [29].

In conclusion, the pedigree-based selection had significantly better production performance traits especially female body weight, average and fortnightly feed intake, and average egg weight. Moreover, egg production and feed conversion rate were improved in mass selected birds. In future breeding programs, pedigree-based and mass selection should be adopted as a tool to enhance the overall breeding performance and carcass traits of the birds. These selection strategies are easy to apply where phenotypic values are used as breeding values and do not require complex mathematical calculation such as in index methods.

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