Carcass traits and physical characteristics of eggs in Japanese quail as affected by genotype, sex and hatch

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Abstract The effect of genotype, sex and hatch on carcass traits and physical characteristics of eggs was investigated in the Japanese quail. Two strains of Japanese quails including the White (P1) and Wild (P2) genotypes were chosen as the parental generation and crossed reciprocally (10 single-pair mating) to create the F1 progeny. The F1 birds (27 males and 81 females) were mated randomly to produce the F2 progeny (1320 birds). The White and Wild birds were simultaneously reared with F1 and F2 birds as control groups. The statistical model included the fixed effects of the genetic group, sex and hatch. Orthogonal comparisons were used to test the observed heterosis including the F1:P1+P2; F2:P1+P2 and F1+F2:P1+P2. The effect of sex on slaughter weight and carcass percentage was significant ($P < 0.01$). Slaughter weight was higher in females than in males. Effects of genetic group and hatch on the egg weight were significant ($P < 0.05$). The genetic effects on slaughter weight, carcass weight and carcass percentage were also significant ($P < 0.01$). The F1 progeny had the highest slaughter weight and carcass weight but the carcass percentage of F1 birds was lower than that of F2 birds. The F1 birds performed better than the average of the parental strains showing heterotic rates of +10.09 and +8.56% for slaughter and carcass weights, respectively.

Keywords: Japanese quail, genetic group, carcass traits, egg

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Introduction

Japanese quails (*Coturnix japonica*) are small bodied birds with high potential for production because of their short generation interval, adaptability to rearing conditions and high genetic polymorphism (Kayang et al., 2004). Quail meat is lean and both eggs and meat are low in cholesterol (Garwood and Diehl, 1987). Therefore, rapid multiplication of these birds makes their meat and egg readily available for human consumption with little risk of public health implications. Kawahara and Saito (1976) estimated the genetic parameters of organs and body weights in the Japanese quail. Toelle et al. (1991) estimated genetic and phenotypic relationships between body weight, carcass and several internal organs. Minvelle et al. (1999) reported on the carcass characteristics of a heavy Japanese quail line under introgression with the roux gene.

Seizai et al. (2010) found that sex had a significant effect on carcass weight and females had higher carcass weight than males; carcass yield was 75.5% for females and 73.4% for males. Panda and Singh (1990) reported a slaughter yield of 65.2% for males and 66% for females at the age of 35 days. Almeida et al. (2002) studied the growth performance of two lines of quails under two nutritional conditions. Marks (1993) reported the effects of long-term selection for four-week body weight on carcass composition, feed intake and feed efficiency. The effect of separate and mixed rearing of male and female Japanese quails *(Coturnix japonica)* on fattening performance and carcass characteristics was studied by Selim et al. (2006) who reported higher carcass quality and lower feed conversion ratio in female than in males.

Farooq et al. (2001) considered egg and shell weight as the two most important factors affecting hatchability, provided that management is not a limiting factor. Egg weight of the Japanese quail is approximately 10 grams (Woodard et al., 1973). Egg quality traits are affected by factors such as genetics (Hermiz and Ali, 2012 ; Rajkumar et al., 2009), nutrition (Güçlü et al., 2008), bird origin (Lewko and Gornowicz, 2009), and rearing conditions (Holt et al., 2010). Egg morphology and quality is also influenced by age (Genchev, 2012; Nowaczewski et al., 2010; Philomina and Pillai Ramakrishna, 2000). Many researchers have reported significant genotype differences related to egg weight (Monirak et al., 2003; Anderson et al., 2004). There is no published work on the combined effects of the genotype, sex and hatch on carcass traits and physical characteristics of eggs in Japanese quail; therefore, this study was conducted to investigate the effect of the genotype, sex and hatch on these traits and to estimate the heterotic rates for carcass traits.

Materials and Methods

This study was carried out at the Livestock Research Center of Shahid Bahonar University of Kerman, Iran. A three-generation resource population was developed by using two distinct Japanese quail strains, wild (meat type) and white (layer type). The white (S) and wild (W) founder strains (10 males and 10 females) were crossed to produce F1 parents. The F1 birds including 27 males and 81 females (SW and WS) reciprocal half of cross progeny were generated by S male × W female and W male × S female reciprocal crosses, respectively. The F_1 birds were intercrossed, generating 1320 F_2 offspring in five consecutive hatches. The parents were kept in group cages and fed a layer diet *ad libitum*. The F2 progeny were raised for 5 weeks in an environmentally controlled room with continuous artificial lighting and at a temperature which was decreased gradually from 37 to 25°C. The progeny received water and a mash starter diet (0–21 days) and a mash growing diet (22–35 days) *ad libitum*. Traits measured on carcass included weight before slaughter, carcass weight, carcass percent, carcass parts and internal organs.

Good-shaped and sound shelled-eggs were selected to be hatched. Cracked, odd-colored and other abnormal eggs were excluded. The collected eggs were numbered according to the genotype and kept for seven days at 15 - 20 °C and a relative humidity of 75 - 80%. The eggs were incubated for 15 days at a temperature of 37.8 °C and a relative humidity of 63%. The eggs were individually transferred to hatchery trays in an incubator that was maintained at 37 °C and at a relative humidity of 74% until hatching. During incubation, the eggs were turned automatically every hour. At the end of the incubation period all un-hatched eggs were checked for fertility, where 2300 eggs from each group (parental strains and F1) were sampled. The egg width and length, egg, yolk, albumen, and dried shell weight, and egg shape index were measured.

Data on slaughter weight, and carcass weight and percentage from 675 birds from four genetic combinations [pure wild (P2), pure white (P1), F1 and F2] and eight different hatches were used. Orthogonal comparisons were used to test the observed heterosis including the F1:P1+P2; F2:P1+P2 and F1+F2:P1+ P2.

The following main model was used to determine the effect of genotype, sex and hatch on carcass traits and physical characteristics of the eggs:

$$Y_{ijkm} = \mu + s_i + v_j + h_k + e_{ijkm} \quad (1)$$

where, Y_{ijkm} is the observed phenotype of the individual m; μ is the population mean; s^i, v^j and h^k are the effect of i^{th} sex (for carcass traits), j^{th} genotype and k^{th} hatch on carcass traits and physical characteristics of eggs, respectively, and e_{ijkm} is the random residual error. The two-way interactions between the genotype and sex were also determined for several traits. All descriptive statistical analyses were conducted using ASReml (Gilmour et al., 2006), and the residuals were checked for normality. The Duncan's multiple range test was applied when a factor affected a trait significantly.

Results and Discussion

The effects of genotypes on slaughter weight, carcass weight and carcass percentage are shown in Table 1.

Table 1. Effect of genotype on slaughter weight, carcass weight and carcass percentage in quails (LSM±SE)

Genotype group	Carcass percentage	Carcass weight	Slaughter weight
F1	67.0 ± 0.34^{b}	126.7 ± 1.57^{a}	189.5 ± 2.22^{a}
F2	69.3 ± 0.16^{a}	115.2 ± 0.74^{b}	166.1 ± 1.05^{b}
Pure white (P1)	67.0 ± 0.67^{b}	108.6 ± 3.04^{bc}	161.2 ± 4.28^{bc}
Pure wild (P2)	68.6 ± 0.38^{ab}	124.8 ± 1.76^{a}	183.1 ± 2.47^{a}

a,b,c: Means in each column with a common superscript do not differ significantly (P > 0.05).

Mean slaughter weight was 167.9 g and the effect of genetic groups, sex and genotype by hatch interactions were significant (P < 0.0001). Orthogonal comparisons of F1:P1+P2; F1:F2 and F2:P1+P2 were significant (P < 0.05). A positive heterosis (+10.09%) was observed for F1:P1+P2 slaughter weight, but heterosis of F1:F2 and F2:P1+P2 were negative, being -12.36% and -3.51% respectively. Among four different genetic groups of quails, the highest weight was found in F1 and the lowest weight in pure white. Mean carcass weight for all genetic groups was 115.7 g, and the effect of genetic group, sex and genotype-hatch interactions on carcass weight was significant (P < 0.0001). Orthogonal comparisons of F1:P1+P2 and F1:F2 for carcass weight were significant (P < 0.0001) but not for F2:P1+P2. For carcass weight, the observed heterosis of F1:P1+P2 was positive and amounted to +8.56%, but negative heterosis (-9.03%) was found for F1:F2. Mean carcass percentage was 69% and the effects of genetic group, sex and genotype- hatch interactions on carcass percentage were significant (P<0.0001).

Table 2. Effect of hatch on slaughter weight, carcass weight and carcass percentage in quails (LSM±SE)

Hatch	Slaughter weight	Carcass weight	Carcass percentage
1	171.2 ± 3.64[a]	119.0 ± 2.45[a]	69.6 ± 0.54[ab]
2	161.6 ± 1.55[b]	111.2 ± 1.09[b]	68.8 ± 0.24[b]
3	159.2 ± 1.47[b]	112.2 ± 1.04[b]	70.4 ± 0.22[a]
4	172.8 ± 1.80[a]	118.7 ± 1.27[a]	68.7 ± 0.28[b]
5	165.6 ± 2.85[ab]	115.0 ± 2.02[ab]	69.1 ± 0.44[b]

a,b,c: Means in each column with a common superscript do not differ significantly (P > 0.05).

The highest carcass percentage was found in F2 (69.4%) and the lowest one in pure wild (67.1%). Orthogonal comparisons of F1:F2 and F2:P1+P2 for carcass percentage were significant (P<0.01) and the observed heterosis amounted to +3.39 % and +2.25% points, respectively.

Genotype-phenotype correlations for body weight, carcass weight and other organs were reported by Toelle et al. (1991). In addition, Vali et al. (2005) found significant differences in two quail strains for carcass weight, carcass percentage, and breast and femur weight. Our data supports these findings.

The effects of hatch, sex and interaction effects of genotype and sex on slaughter weight, carcass weight and carcass percentage are given in Tables 2, 3 and 4, respectively. Females were heavier than males at slaughter (P < 0.0001). The genetic group and sex of significantly affected the carcass weight (P < 0.0001), and the interaction between genotype and sex was also significant (P < 0.05). Effects of genetic group, sex and interaction between genotype and sex were significant (P < 0.01) on carcass percentage. Males had higher carcass percentage than females (P < 0.0001). Slaughter weight was higher in females than males. These findings are in agreement with data reported by Vali et al. (2005). In agreement with the findings of Satoru Okamoto et al. (1986), the interaction between genotype and sex was significant for carcass weight, slaughter weight and carcass percentage in the present study.

Table 3. Effect of sex on slaughter weight, carcass weight and carcass percentage in quails (LSM±SE)

Sex	Slaughter weight	Carcass weight	Carcass percentage
Female	181.0 ± 2.41[a]	120.7 ± 1.69	67.0 ± 0.38[a]
Male	173.0± 1.88	119.0 ± 1.09	68.9 ± 0.29

a: Significantly different from male (P < 0.01)

In this study, the relative weight of intestines to the carcass weight and the intestinal weight in the F2 birdswere 29.1% and 13.2 g, respectively, and were significantly affected by the hatch and sex (P < 0.0001). The mean breast weight and breast percentage were 22.0 g and 29.2%, respectively, and were affected by the gender of the bird (P < 0.0001). The mean liver weight, liver percentage, heart weight and heart percentage were 3.3 g , 4.7 %, 0.83 g and 1.1%, respectively; these were significantly affected by the hatch and gender (P < 0.0001). Vali et al. (2005) reported a significant genotype effect on carcass weight, carcass percentage, breast weight, and femur percentage in Japanese (*Coturnix japonica*) and Range (*Coturnix ypisilophorus*) quails. The observed effects of the gender on carcass traits found in the present work are in accord with those reported by others (Caron and Minvielle, 1990; Toelle et al., 1991; Minvielle et al., 1999).

The effects of hatch and genotype on physical characteristics of eggs are presented in Tables 6 and 7. The mean egg weight across different genetic groups was 11.50 g. Egg weight in the first hatch was higher than in other hatches. The estimated mean egg weight in this study was lower than the estimate of 12.90 g reported by Yannakopoulos and Tserveni-Gousi (1986)

Table 4. Interaction effects of genotype and sex on slaughter weight, carcass weight and carcass percentage in quails (LSM±SE)

Sex	Genotype group	Slaughter weight	Carcass weight	Carcass percentage
Female	F1	193.1 ± 3.31[a]	126.1 ± 2.30[a]	65.7 ± 0.51[b]
	F2	181.4 ± 2.48[a]	124.6 ± 1.72[a]	69.1 ± 0.38[a]
	pure white (P1)	161.3 ± 5.34[c]	107.4 ± 3.82[c]	65.9 ± 0.85[b]
	pure wild (P2)	188.3 ± 4.89[ab]	124.7 ± 3.48[a]	67.1 ± 0.78[b]
Male	F1	182.6 ± 3.07[b]	125.6 ± 2.13[a]	68.7 ± 0.47[a]
	F2	168.6 ± 2.47[c]	117.2 ± 1.71[bc]	69.9 ± 0.38[a]
	pure white (P1)	162.2 ± 5.62[c]	110.4 ± 3.92[c]	68.0 ± 0.87[a]
	pure wild (P2)	178.4 ± 2.92[bc]	122.9 ± 2.03[ab]	69.2 ± 0.45[a]

a,b,c: Means in each column with a common superscript do not differ significantly (P > 0.05).

Table 5. Effects of sex on carcass parts and internal organs in quail (LSM±SE)

	Brest %	Breast weight	Femur %	Femur weight	Head %	Head weight	Intestine %	Intestine weight
Sex	ns	ns	ns	ns	*	*	*	*
Female	29.1 ± 0.28	22.2 ± 0.49	24.7 ± 0.26	19.0 ± 0.44	9.1 ± 0.09	6.3± 0.07	19.7 ± 0.32	14.1 ± 0.26
Male	29.1 ± 0.27	21.8 ± 0.47	24.8 ± 0.25	18.7 ± 0.43	9.3 ± 0.09	6.6 ± 0.07	18.0 ± 0.31	12.3 ± 0.25
Overall	29.1 ± 0.23	22.0 ± 0.39	24.8 ± 0.21	18.8 ± 0.35	9.2 ± 0.07	6.4 ± 0.06	18.8 ± 0.26	13.2 ± 0.21
	Testis %	Testis weight	Ovary%	Ovary weight	Back %	Back weight	Liver %	Liver weight
Sex					ns	ns	*	*
Female	---	---	1.1 ± 0.27	1.4 ± 0.33	12.1 ± 0.13	9.3 ± 0.20	4.9 ± 0.07	3.6 ± 0.07
Male	2.0 ± 0.80	2.3 ± 0.12	---	---	11.9 ± 0.12	8.9 ± 0.19	4.4 ± 0.06	3.0 ± 0.07
Overall	2.0 ± 0.80	2.3 ± 0.12	1.1 ± 0.27	1.4 ± 0.33	12.0 ± 0.10	9.1 ± 0.16	4.7 ± 0.05	3.3 ± 0.05
	Neck %	Neck weight	Heart %	Heart weight	Wing %	Wing weight		
Sex	ns	ns	ns	ns	ns	ns		
Female	5.9 ± 0.08	4.3 ± 0.08	1.0 ± 0.02	0.8 ± 0.02	11.7 ± 2.76	8.4 ± 3.04		
Male	5.8 ± 0.07	4.3 ± 0.08	1.1 ± 0.01	0.8 ± 0.02	14.2 ± 2.66	11.2 ± 2.94		
Overall	5.8 ± 0.06	4.3 ± 0.07	1.1 ± 0.06	0.8 ± 0.01	12.9 ± 2.22	9.8 ± 2.45		

*: Significant effect of sex (P < 0.01) ; ns: not significant

but higher than 10.60 and 9.81 reported by Gonzalez (1995) and Wilson and Huang (1962), respectively. We found significant differences (P < 0.05) in egg weight between pure white (P1) and pure wild (P2) but the heterosis on egg weight for F1 compared with the mean of the pure strains (P1 and P2) was not significant. The minimum and maximum egg weights reported (Vali et al., 2006) for Japanese quail (*Coturnix japonica*) and Range quail (*Coturnix ypisilophorus*) were 7.08 and 13.84 g, respectively. However, these records were 7.01 and 13.84 g for the Range quail. Significant effects of genetic group and hatch on egg weight were reported by Punya Kumari (2008).

The mean egg length was 32.3 mm, confirming the estimate reported by González (1995). The effect of genetic group on egg length was significant (P < 0.05). Egg length in the pure wild (P2) was higher than in white (P1) and F1 (P < 0.0001) but no significant heterosis was found for this trait. The overall means of the egg width and shape index were 25.5 mm and 79.0, respectively; genetic group and hatch did not affect these traits. The mean eggshell weight was 1.6 g and was significantly affecetd by the genetic makeup (P < 0.05). The mean eggshell thickness was estimated at 1.05 mm. The highest mean eggshell thickness was found in the first hatch (P < 0.05). The mean albumen and yolk weights were 5.7 g and 3.9 g, respectively.Albumen and yolk weights in the first hatch were higher than those of subsequent hatches. There was a significant difference between pure white (P1) and pure wild (P2) for these traits (P < 0.0001). The mean hatching weight was 7.5 g, being affected by the genetic makeup (P < 0.05). Orthogonal comparison of F1:P1+P2 was significant for hatching weight (P < 0.05) and amounted to +4.63%. In conclusion, significant effects of hatch, sex and genetics on carcass composition were recorded in quails. While diversity in egg

Table 6. Effects of hatch on physical characteristics of eggs in quail (LSM±SE)

Hatch	Yolk weight (g)	Hatching weight (g)	Eggshell weight (g)	Albumen weight (g)	Eggshell thickness (mm)	Shape index	Egg length	Egg width	Egg weight
1	3.7 ± 0.07[a]	---	---	5.6 ± 0.10[a]	1.0 ± 0.01[a]	---	---	---	11.5 ± 0.21[a]
2	3.6 ± 0.07[b]	---	---	5.5 ± 0.09[b]	1.0 ± 0.01[b]	---	---	---	11.2 ± 0.21[b]
3	3.6 ± 0.08[b]	---	---	5.4 ± 0.10[b]	1.0 ± 0.02[b]	---	---	---	11.1 ± 0.22[b]
4	3.7 ± 0.07[b]	7.4 ± 0.07	1.5 ± 0.09	5.5 ± 0.09[b]	1.0 ± 0.01[b]	79.8 ± 0.46	32.0 ± 0.15	25.5 ± 0.11	11.3 ± 0.20[b]
5	3.7 ± 0.05[b]	7.4 ± 0.05	1.5 ± 0.00	5.6 ± 0.06[b]	1.0 ± 0.01[b]	78.8 ± 0.33	32.2 ± 0.10	25.4 ± 0.08	11.3 ± 0.14[b]

a,b: Means in each column with a common superscript do not differ significantly (P > 0.05).

Table 7. Effect of genotype group on physical characteristics of eggs in quail (LSM±SE)

Genotype group	Yolk weight (g)	Hatching weight (g)	Eggshell weight (g)	Albumen weight (g)	Eggshell thickness (mm)	Shape index	Egg length	Egg width	Egg weight
F1	3.8±0.03[ab]	5.4±0.28[a]	1.4±0.03[b]	5.6±0.05[ab]	1.0±0.00	79.8±0.60	32.1±0.19[b]	25.6±0.15	11.5±0.10[ab]
Pure white (P1)	3.5±0.09[a]	4.9±0.28[b]	1.3±0.03[a]	5.3±0.12[a]	0.9±0.02	79.5±0.48	31.8±0.15[a]	25.2±0.12	10.8±0.26[a]
Pure wild (P2)	3.7±0.08[b]	5.3±0.28[ab]	1.4±0.03[ab]	5.6±0.10[b]	1.0±0.02	78.6±0.36	32.5±0.11[a]	25.5±0.09	11.4±0.22[b]

a,b: Means in each column with a common superscript do not differ significantly ($P > 0.05$)

egg characteristics may result from differences in age, feeding methods and other management practices, the genetic effect is also a major source of variation for these traits.

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