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Growth, Feed Consumption and Carcass Composition of *Coturnix japonica*, *Coturnix ypsilophorus* and their Reciprocal Crosses

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Abstract: A study was conducted to compare Body Weight (BW), feed intake, feed efficiency up to 49 days of age and carcass characteristics of two quail strains namely, (Co: Japanese quail (*Coturnix japonica*), Ra: Range quail (*Coturnix ypsilophorus*) and their reciprocal crosses H1: Hybrid 1(Ra♂×Co♀) and H2: Hybrid 2 (Co♂×Ra♀) in four hatches. Body weights of four groups (Co, Ra, H1 and H2) at 1, 7, 14, 21, 28, 35, 42, 49, 56 and 63 days of ages between of four groups were significantly different ($p<0.1$). Body weight of female at 49, 56 and 63 days of age were significantly higher than males, but there was no significant difference between male and females at the other recorded BW ($p>0.05$). Feed intake of H2 group was also significantly larger than that other groups ($p<0.01$), while feed efficiency of four groups were not different ($p>0.05$). At 49 days of age, Carcass percentages, breast percents, wing weights and giblet weights of four groups were significantly different ($p<0.01$), while there was no significant difference for carcass weights (eviscerated), breast weights, carcass rests (thigh, leg and back) among them ($p>0.05$). Carcass weights, carcass percents, breast weights were significantly affected by sex ($p<0.01$), while sex for breast percents was not effective ($p>0.05$). Heterosis percents for the BW at 1 to 63 days of ages were estimated. Heterosis was positive for BW at 1, 14, 21, 28, 49, 56 and 63 days of ages, while other of ages was negative.

Key words: Japanese quail, range quail, feed efficiency, carcass traits, heterosis

INTRODUCTION

The Japanese quail (*Coturnix japonica*) is the smallest avian species farmed for meat and egg production and it has also assumed as a world wide importance as a laboratory animal (Baumgartner, 1994; Minvielle, 1998; Vali *et al*., 2005a, b, 2006-2008). In relation to nutrition, it is essential to know clearly and precisely the requirements of the animal species according to their production potential. Adequate food and diet formulation helps not only to reach nutritional requirements but also to increase the levels of feed conversion (Rondelli *et al*., 2003). Carcass composition is normally modified by age, sex, handling and diet manipulation and it is also believed that fat deposition increases with age which is simply related to maturity and happens in the majority of species (Rondelli *et al*., 2003). Numerous selection experiments on live body weight have been carried out (Oguz and Minvielle, 2001) and were quite successful at increasing or decreasing body weight. In some of them, carcass and quality traits were also monitored Marks (1993a). Marks (1993a) investigated that body weight, feed intake, feed efficiency and carcass composition changes following 51 generation of selection for high 4 week body weight in Japanese quail. Caron and Minvielle (1990) reported mass selection for increased, live body weight at 45 days of age was carried out for 17 or 20 generations in three lines (1, 2 and 3) of Japanese quail. A review of BW data Darden and Marks (1989) from reciprocal crosses arising from mating Japanese quail lines divergently selected for 4-weeks BW reveal rather large reciprocal effects between crosses. Initial BW differences were expected because of the large egg size difference between high and low dams line. However, large BW difference (15 to 24%) remaining at 4 weeks of age were unexpected (Marks, 1993b). In the present study, the aims were to study BW, feed intake, feed efficiency and carcass characteristics of Japanese quail (*Coturnix japonica*) and Range quail (*Coturnix ypsilophorus*) and their reciprocal crosses (Co Japanese quail, Ra: Range quail, H1: hybrid 1(Ra♂×Co♀) and H2: Hybrid 2 (Co♂×Ra♀)) and also to estimate heterosis percent for BW up to 63 days of age.

MATERIALS AND METHODS

The study was conducted in Isfahan University of Technology at 2005 until 2006 and was written in material and method part reported by Vali *et al.* (2005). A total of 500 quails (quails were randomly selected from strains reported by Vali *et al.* (2005a, b)) include 250 Japanese quails and 250 Range quails were randomly selected from the parents population, (the parents population were contained quails at 105 days of age, which they were recorded for weekly BW until 63 days of age) and were randomly divided to four groups: (1) Japanese male and female quails (Co♂×Co♀). (2) Range male and female quails (Ra♂×Ra♀). (3) Range male quails and Japanese female quails (Ra♂×Co♀). (4) Japanese male quails and Range female quails (Co♂×Ra♀). These four groups were kept in separate pen at 1 male to 3 female's ratio. After 15 days when these groups were placed in pens, the fertile eggs were collected from each group and coded. Eggs were antisepticized by formaldehyde and then they were set in incubator (14 days in Setter and 2 days in Hatcher). Setter and Hatcher were divided into separate parts per groups according to the egg code. At each hatch 50 quails from each group (a total of 800 quails in 4 hatches) were wing banded and transferred to a litter house with 35°C temperature. The temperature was decreased 3°C on weekly bases and after 4th week, supplemental heating was disconnected. The chicks had access to continuous lighting for the first 48 h. Thereafter, daily light was reduced to 15 h (6:00 am until 9:00 pm) and was maintained for the rest of the experiment. Diet contained 22% crude protein and 2800 kcal kg^{-1} metabolizable energy. Food and water were available ***ad libitum.*** Food intake and BW individually were recorded weekly for each group. A total of 160 quail (10 males and 10 females) at 49 days of age of each group and two hatches were randomly selected and slaughtered in order to study carcass characteristics. They were fasted for 10 to 12 h before they were slaughtered, bled and plucked. Evisceration was performed by hand. Carcass weight and carcass part weights (breast, wing and giblet) were recorded for each chicken. General Linear Models (GLM) procedures of SAS institute (1998) were employed for analyses of the data and the following models were used for analysis:

$$Y_{ijkl} = \mu + GR_i + HA_j + SE_k + e_{ijkl}$$

$$Y_{ijkl} = \mu + GR_i + HA_j + WE_k + e_{ijkl}$$

Where:

Y_{ijkl} = The individual observation for trait Y
μ = The overall mean for trait Y_{ijkl}

Gr_i = The effect of the ith group
Ha_j = The effect of jth hatch
Se_k = The effect of the kth sex
We_k = The effect of the kth week
e_{ijkl} = Random error

RESULTS AND DISCUSSION

Least squares means and standard error by group, sex, hatch and overall means of BW and the symbols of significance for the main effects are shown in Table 1and 2. The BW of four groups at 1, 7, 14, 21, 28, 35, 42, 49, 56 and 63 days of ages were significantly different ($p<0.01$). At all ages except 1 day of age, Japanese quail, were the heaviest in four groups, but BW at 7, 21, 35, 42, 49 and 63 days of age between Japanese quail and H1 were not different ($p>0.05$). The BW between H1 and H2 at 14, 42 days of ages were not significantly different ($p>0.05$), however BW of H1 at 1, 7, 21, 28, 35, 49, 56 and 63 days of ages were significantly ($p<0.01$) heavier than H2 (Table 1, 2). Results obtained for BW in Japanese quail at 42 day of age were agreed or higher than the previous studies, which were unselected, but it was lower than selected groups (Bacon *et al*., 1986; Marks, 1993a; Grasteau

Table 1: Least squares means and standard error for body weights (BW: grams) in quails

Source	BW1	BW7	BW14	BW21	BW28
Overall mean	7.88±0.04	21.63±0.24	49.15±0.46	76.67±0.73	110.31±1.01
Group					
Co†	7.84±0.06^{b}	22.92±0.28^{a}	51.25±0.61^{a}	79.37±0.99^{a}	115.54±1.29^{a}
Ra‡	8.23±0.07^{a}	21.73±0.33^{b}	48.01±0.72^{b}	74.61±1.17^{bc}	109.06±1.52^{b}
H1§	8.23±0.15^{a}	22.32±0.08^{ab}	44.89±1.75^{b}	78.36±2.83^{ab}	106.24±3.68^{b}
H2¶	7.14±0.14^{c}	18.20±0.77^{c}	45.55±1.68^{b}	70.82±2.72^{c}	97.53±3.54^{c}
Sex					
Female	7.82±0.07^{a}	21.01±0.38^{a}	47.26±0.63^{a}	75.65±1.53^{a}	107.72±1.75^{a}
Male	7.92±0.07^{a}	21.58±0.37^{a}	47.60±0.82^{a}	75.93±1.33^{a}	106.47±1.73^{a}
Hatch					
1	8.21±0.06^{a}	17.74±0.33^{c}	48.51±0.72^{ab}	81.13±1.17^{a}	116.63±1.52^{a}
2	7.91±0.07^{b}	22.77±0.54^{a}	46.54±1.19^{bc}	74.65±1.93^{b}	100.59±2.51^{b}
3	7.69±0.11^{b}	21.32±0.60^{b}	44.62±1.30^{c}	74.17±2.11^{b}	113.04±2.75^{a}
4	7.70±0.09^{b}	23.34±0.48^{a}	50.04±1.04^{a}	73.21±1.69^{b}	98.12±2.21^{b}

†Co: Japanese quail (*Coturnix japonica*), ‡Ra: Range quail (*Coturnix ypsilophorus*), §H1: Hybrid 1 (Ra♂×Co♀), ¶H2: Hybrid 2 (Co♂×Ra♀). Letters$^{(a, b, c)}$ Means within each subclass column with superscript are significantly different ($p>0.01$)

Table 2: Least squares means and standard error for body weights (BW: grams) in quails

Source	BW35	BW42	BW49	BW56	BW63
Overall mean	139.32±1.12	170.33±2.22	189.45±1.23	20.8.02±1.86	215.35±2.93
Group					
Co†	145.86±1.49^{a}	177.50±3.19^{a}	193.89±1.59$_{a}$	211.22±2.38^{a}	221.92±3.80^{a}
Ra‡	138.79±1.75^{b}	167.21±3.76^{b}	189.34±1.85^{b}	207.43±2.53^{a}	205.97±4.71^{b}
H1§	137.43±4.24^{ab}	171.94±9.07^{ab}	191.70±4.47^{ab}	207.87±4.62^{a}	221.92±5.60^{a}
H2¶	125.65±4.08^{c}	158.01±8.73^{b}	176.63±4.30^{c}	196.13±4.35^{b}	205.64±5.35^{b}
Sex					
Female	138.38±2.02^{a}	170.77±4.33^{a}	196.06±2.13^{a}	219.36±2.34^{a}	233.62±3.85^{a}
Male	135.48±1.99^{a}	166.55±4.27^{a}	179.72±2.11^{b}	191.96±2.39^{b}	194.11±4.01^{b}
Hatch					
1	134.37±1.75^{b}	165.99±3.75^{a}	187.53±1.85^{b}	204.51±1.98^{a}	211.92±2.12^{a}
2	137.59±2.89^{ab}	173.25±6.18^{a}	198.02±3.04^{a}	206.81±2.99^{a}	215.81±6.32^{a}
3	143.25±3.17^{a}	170.11±6.78^{a}	188.56±3.40^{b}	NAЉ	NA
4	132.50±2.54^{b}	165.30±5.44^{a}	177.46±2.68^{c}	NA	NA

†Co: Japanese quail (*Coturnix japonica*), ‡ Ra: Range quail (*Coturnix ypsilophorus*), §H1: Hybrid1 (Ra♂×Co♀), ¶ H2: Hybrid 2 (Co♂×Ra♀), ЉNA: Not available. Letters$^{(a, b, c)}$ Means within each subclass column with superscript are significantly different ($p>0.01$)

Table 3: Least-squares mean of feed intake, individual gain, feed efficiency and mortality in quail

Source	Individual feed intake (g/day/bird)	Individual gain (g/day/bird)	Feed efficiency	Mortality (%)
Group				
Co†	11.74±0.05^{b}	3.53±0.10^{a}	3.38±0.10^{a}	3.0±0.67^{a}
Ra‡	11.75±0.05^{b}	3.47±0.10^{a}	3.37±0.10^{a}	3.3±0.67^{a}
H1§	11.80±0.10^{b}	3.31±0.20^{a}	3.60±0.21^{a}	3.6±1.33^{a}
H2¶	12.23±0.10^{a}	3.66±0.20^{a}	3.55±0.21^{a}	2.8±1.33^{a}
Sex				
Female	11.83±0.05^{a}	3.47±0.10^{a}	3.53±0.10^{a}	2.5±0.67^{a}
Male	11.93±0.05^{a}	3.52±0.10^{a}	3.42±0.11^{a}	3.8±0.68^{a}
Week				
1	2.63±0.09^{g}	1.44±0.18^{d}	1.96±0.19^{e}	6.1±2.04^{a}
2	6.55±0.08^{f}	3.50±0.17^{c}	2.02±0.18^{e}	5.1±1.16^{a}
3	9.80±0.08^{e}	3.76±0.17^{bc}	2.72±0.18^{d}	3.5±1.08^{b}
4	11.60±0.08^{d}	4.47±0.17^{a}	2.70±0.18^{d}	2.8±1.01^{b}
5	15.25±0.08^{c}	4.06±0.17^{ab}	4.07±0.18^{c}	1.9±0.98^{b}
6	18.19±0.08^{b}	4.06±0.17^{ab}	4.67±0.18^{b}	1.5±0.97^{b}
7	19.14±0.08^{a}	3.16±0.17^{c}	6.20±0.18^{a}	1.3±0.97^{b}

†Co: Japanese quail (*Coturnix japonica*), ‡ Ra: Range quail (*Coturnix ypsilophorus*), §H1: Hybrid 1(Ra♂×Co♀) , ¶H2: Hybrid 2 (Co♂×Ra♀). Letters$^{(a-g)}$ Means within each subclass column with superscript are significantly different (p>0.01)

and Minvielle, 2003). The BW at 49, 56 and 63 days of age were significantly different (p<0.01) between sexes and females showed higher weight of body than males which is in agreement with earlier studies (Bumgartner, 1994; Minvielle *et al.*, 2000).

The least squares means by groups, hatch and week of feed intake, weight gain and feed efficiency with the symbols of significance for the main effects are shown in Table 3. Mean feed intake was greatest in H2 among groups, but feed efficiency (grams of feed: grams of weight gain) was not different among the groups. Feed intake (grams per bird per day) were significantly different among weeks (p<0.001). Mean feed intake for 1 to 7 weeks of ages were 2.63, 6.55, 9.80, 11.60, 15.25, 18.19, 19.14 g, respectively. Marks (1993a) reported the pattern of increasing feed intake with increasing BW is evident in both the P and C lines and his results support earlier observation regarding increases in feed intake associated with selection responses for increased BW (Marks, 1981). He added the cause of this close relationship, it is difficult to separate true differences in feed intake between selected (fast-growing) and unselected (slow-growing) genotypes. Minvielle *et al.* (1995) reported daily feed intake vary between generation, with a peak at generation 7, but line EE with the highest intake of 33.7 g ingested consistently 4 to 5 g more per day than line DD. Marks (1980) reported the difference of feed intake noted between line of high and low BW are more accentuated in the first days of life, even before differences in BW were established, indicating that there is a high genetic correlation between feed intake and genetic variation of growth rate.

Feed efficiency was significantly different among weeks (p<0.01). Lowest and highest of feed efficiency for 1th and 7nd weeks were 1.96±0.19 and 6.20±0.18, respectively. These values are generally lower than values in report of Marks (1993a). Mortality percent were not significantly (p>0.05) among groups and also between hatch. Mortality percent (Table 3) were not significantly between 1 and 2 of weeks, also among 3, 4, 5, 6 and 7 weeks (p>0.05).

Table 4 lists least squares means for carcass traits by groups, sex and hatch with their standard error and symbols of significance for the main effects. Carcass characteristics were significantly affected by groups source of variation (p<0.01). Carcass weight (evisceration) was not different among groups and values for this trait were 114.48±1.60, 112.63±2.52, 111.79±1.74 and 110.69±2.06 for H1, Ra, Co and H2, respectively (Table 4). All of carcass traits of females were significantly (p<0.01) higher than male except breast percent and carcass percent these are in agreement with previous studies (Caron and Minvielle, 1990;

Table 4: Least squares means and standard error for carcass traits in quails

Source	TC(g)	CW(g)	CP (%)	BRW(g)	BP (%)	WW(g)	GHL(g)
Overall mean	161.82±1.71	109.54±2.98	61.81±0.36	44.50±0.55	40.63±0.19	10.93±0.14	13.87±0.19
Group							
Co†	169.11±2.47^{a}	111.79±1.74^{a}	60.13±0.46^{b}	45.25±0.82^{a}	40.46±0.35^{ab}	10.99±0.19^{b}	14.63±0.31^{a}
Ra‡	167.14±3.58^{a}	112.63±2.52^{a}	60.37±0.67^{b}	46.68±1.20^{a}	41.48±0.51^{a}	10.62±0.27^{b}	13.91±0.45^{ab}
H1§	164.08±2.27^{ab}	114.48±1.60^{a}	64.00±0.42^{a}	46.31±0.76^{a}	40.47±0.32^{ab}	11.84±0.17^{a}	13.47±0.28^{b}
H2¶	158.00±2.92^{b}	110.69±2.06^{a}	64.26±0.54^{a}	44.43±0.98^{a}	40.15±0.42^{b}	11.19±0.22^{b}	12.99±0.37^{b}
Sex							
Female	169.59±2.07^{a}	114.80±1.46^{a}	61.40±0.38^{b}	46.76±0.69^{a}	40.77±0.29^{a}	11.41±0.16^{a}	14.42±0.26^{a}
Male	159.57±1.98^{b}	110.00±1.40^{b}	62.98±0.37^{a}	44.57±0.66^{b}	40.52±0.28^{a}	10.92±0.15^{b}	13.08±0.25^{b}
Hatch							
1	156.59±1.74^{b}	103.76±1.22^{b}	60.45±0.32^{b}	42.47±0.58^{b}	40.90±0.25^{a}	10.23±0.13^{b}	14.04±0.22^{a}
2	172.58±2.32^{a}	121.04±1.63^{a}	63.93±0.43^{a}	48.87±0.77^{a}	40.38±0.33^{a}	12.10±0.18^{a}	13.46±0.29^{a}

†Co: Japanese quail (*Coturnix japonica*), ‡Ra: Range quail (*Coturnix ypsilophorus*), § H1: Hybrid 1(Ra♂×Co♀), ¶ H2: Hybrid 2 (Co♂×Ra♀). Letters $^{(a, b)}$ Means within each subclass column with superscript are significantly different (p>0.01). TC: Total carcass (carcass with head and feet), CW: Carcass weight (evisceration), CP: Carcass percent (body weight/carcass weight), BRW: Breast weight, BP: Breast percent (breast weight/carcass weight), WW: Wing weight, GHL: Gizzard, heart and liver weight (giblet)

Table 5: Estimations of average heterosis percent

	Body weight (g)				
Age (days)	Ra†	Co‡	H1§	H2¶	Heterosis (%¤)
1	7.21	7.45	8.05	7.51	3.07
7	16.23	17.92	16.64	14.65	-4.19
14	34.52	38.44	39.76	46.63	9.20
21	62.50	69.02	70.59	76.23	5.82
28	95.01	104.79	105.55	107.15	3.23
35	123.98	132.57	127.37	123.27	-1.15
42	153.11	161.81	158.70	155.41	-0.13
49	168.29	179.47	180.46	176.49	1.32
56	185.35	186.02	209.47	194.39	4.37
63	193.69	194.24	223.93	202.84	5.01

† Ra: Range quail (*Coturnix ypsilophorus*), ‡ Co: Japanese quail (*Coturnix japonica*), § H1: Hybrid 1(Ra♂×Co♀), ¶ H2: ¤Hybrid 2 (Co♂×Ra♀). ¤ Heterosis (%) $= \left(\left(\frac{\left((\bar{H}1+\bar{H}2)-(\bar{R}A+\bar{C}O)\right)}{(\bar{R}A+\bar{C}O)}\right)\Big/2\right)\times 100$

Minvielle *et al.*, 2000). There was no different in the breast percents and giblet (liver+heart+gizzard) between hatches, while for other traits (total carcass, carcass weight, carcass percent, breast weight and wing weight) were significantly different (p<0.01).

Positive heterosis was for BW at 1, 14, 21, 28, 49, 56 and 63 days of ages, while other of ages was negative heterosis (Table 5). Heterosis percent were for BW at 14 days of age the highest (9.20%) and the lowest for 7 days (-4.19%). There are very few reports on heterosis particularly strain crossing. Minvielle *et al.* (1995) reported heterosis for early egg production and feed in take in Japanese quail with two lines and explained heterosis for daily feed in take was positive but largely not significant. Piao *et al.* (2004) reported large heterosis was found for the age at first egg, the number of eggs and the total egg weight up days of age. However, the average egg weight of SR (crossing) was lighter than that of RR (random bred population), showing no heterosis.

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