Effects of slaughter age and mass selection on slaughter and carcass characteristics in 2 lines of Japanese quail

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ABSTRACT The aim of this study was to evaluate the relationship between slaughter age and slaughter-carcass characteristics in 2 quail lines. With this aim, a Japanese quail flock subjected to mass selection to increase BW for 4 generations and a control flock that randomly mated for 4 generations were used. Birds of both lines were slaughtered at 4, 5, 6, 7, and 8 wk of age. Weights of carcass, breast, leg, wing, edible inner organs, and abdominal fat, and their percentages in BW were measured. Short-term mass selection for increased BW resulted in an increase for all slaughter and carcass traits, except edible inner organ percentage. Slaughter age had a significant effect on the studied traits, indicating that the BW and weight of carcass, carcass parts, abdominal fat, edible inner organs, and percentage of abdominal fat increased with increased slaughter age. Conversely, the carcass yield and percentages of carcass parts and edible inner organs were decreased with an increase in slaughter age. The present study showed that deterioration in carcass quality occurred with an increase in slaughter age. Furthermore, the differences between the carcass weights over the different ages ranged between 16.83 to 22.45% in favor of the selection line after a short-term mass selection.

INTRODUCTION

Japanese quail have competitive advantages over other minor poultry species such as early sexual maturity, short generation interval, rapid growth rate, and high reproductive capacity (Minvielle, 2004; Varkoohi et al., 2011). Also, the environmental requirements are few and production costs are rather low (Lotfi et al., 2012a). In Turkey, Japanese quail are reared for dual purposes, meat and egg production, generally at small-scale enterprises in semi-urban and rural areas, and quail are not priced according to their weight but sold per piece at the market at 4 to 5 wk of age. However, consumers wish to purchase heavy quail. Due to competition, some enterprises slaughter the birds at older ages, which causes an increase in feed consumption. Furthermore, it has been confirmed that most of the increase in weight is caused by abdominal fat deposition when the optimal slaughtering age of the Japanese quail is exceeded (Toelle et al., 1991). This situation causes significant economic losses to producers and results in lesser quality products for consumers (Seker et al., 2006; Narinc and Aksoy, 2012).

In a survey study carried out in the Antalya province of Turkey, it was revealed that no genetic improvement activities were performed in the commercial flocks and that these flocks consist of randombred animals (Yapici et al., 2006). Genetic selection is a powerful tool to improve economic traits such as BW, carcass weight, feed efficiency, and egg production in livestock. Previous experimental studies showed that the Japanese quail respond quickly to selection for BW (Nestor and Bacon, 1982; Caron et al., 1990; Marks, 1993, 1996; Alkan et al., 2009). Selection experiments in Japanese quail for improving BW at a fixed age have frequently resulted in changes in other unselected traits due to genetic correlations between them. The results of the previous studies indicated that selection for BW also increased weights of carcass and its parts (Caron et al., 1990; Marks, 1990; Oguz and Turkmut, 1999; Oguz, 2005; Zerehdaran et al., 2012). In addition, Yolcu et al. (2006) and Khaldari et al. (2010) reported that selection for BW improved the carcass percentage.

Carcass characteristics are affected by many genetic and environmental factors such as age, sex, genotype, health, nutrition, live weight, thermal conditions, and management (Summers and Leeson, 1979; Yalcin et al., 2010; Shim et al., 2012). A quail flock treated with

mass selection to increase BW at 4 wk of age for 4 generations and a control flock randomly mated for 4 generations were used in this study. The effects of selection and age on the slaughter and carcass characteristics were investigated in the flocks concerned. Therefore, this study aimed to make recommendations to the small-scale commercial producers.

MATERIALS AND METHODS

The experiment was carried out in a curtain-sided poultry house located in the Research and Application Unit in Department of Animal Science, Faculty of Agriculture, Akdeniz University. The care and use of animals were in accordance with laws and regulations of Turkey and approved by the Ethical Committee of Akdeniz University. The quail lines used were a high BW line selected for 4 consecutive generations according to BW at 4 wk of age (**S** line) and a randombred control line (**C** line) of the same base population. The S and C lines were established by applying mass selection based on phenotype and a random selection with 10 and 40% selection intensity for males and females, respectively. Eighty male and 320 female breeders from each line were mated (1:4 male:female ratio) at 12 wk of age, and their fertile eggs were collected for 1 wk. Eggs were placed in an incubator (maximum capacity 5,000 eggs), and the experimental chicks were obtained at a single hatch. In total, 800 one-day-old quail chicks belonging to both lines were wing banded after hatching and housed in brooding cages (82.56 cm²/quail) until sex determination at 21 d of age. Then, they were transferred to grower cages (150 cm²/quail). A diet containing 24% CP and 2,900 kcal of ME/kg was used for the first 21 d, finisher ration had 21% CP and 2,800 kcal of ME/kg. Ad libitum feeding and a 23-h lighting program were applied from hatch to the end of the experiment.

The birds were slaughtered at 4, 5, 6, 7, and 8 wk of age. Every week, 60 quail were randomly selected from both lines for slaughter, taking into account the balance between sexes and parents where possible. The BW of all male and female quail were determined 6 h after feed withdrawal and birds slaughtered in an experimental processing plant. The birds were electrically stunned in a water bath (average ± SD, 275 V ± 6.0 and 60 mA ± 0.15; applied for 4 s) as described by Tserveni-Gousi et al. (1999) and then killed by cutting a jugular vein. Following a 4-min bleeding time, each quail was dipped in a water bath at 55°C for 2 min and defeathered mechanically, and feet were removed. The whole legs were removed from the carcasses. Wings were removed by cutting through the shoulder joint at the proximal end of the humerus. The whole breast portion was obtained by cutting through the ribs, thereby separating the breast portion from the back. After carcass dissection, the remaining abdominal fat on cold carcasses was collected. To reduce variation in the cutting procedure, all dissections were carried out by operators with the same level of experience. Weights of cold carcass (**CW**), breast (**BRW**), leg (**LW**), wing (**WW**), abdominal fat (**AFW**), and edible inner organ (**EIOW**) were obtained using an electronic digital balance with a sensitivity of 0.01 g. Carcass (**CY**), breast (**BRY**), leg (**LY**), wing (**WY**), total fat pad (**AFY**), and edible inner organ (**EIOY**) yields were calculated in relation to BW.

Statistical analyses were performed using SAS 9.3 software (SAS Institute Inc., 2009). The effects of line and age (linear, quadratic, and cubic) on the slaughter and carcass characteristics were analyzed with MIXED procedure of the software. For each significant effect, Duncan's multiple range test was applied ($P < 0.05$) to compare average values of the responses.

RESULTS AND DISCUSSION

Effects of line and age on weights of body, carcass, carcass parts, abdominal fat, and edible inner organs are shown in Table 1. Regression equations and fitted curves of BW and CW, carcass parts (BRW, LW, WW), and AFW and EIOW are shown in Figures 1, 2, and 3, respectively. The results showed that short-term mass selection for BW resulted in correlated responses in slaughter traits.

At all ages, there were significant differences in BW attributable to genotype. The S line quail were consistently heavier than C line quail at all ages. The equations for BW of S and C birds have both linear and quadratic terms ($P < 0.05$), indicating that BW increased more quickly with increasing age (Figure 1). The average BW at 4 wk of age, the selection criteria, were determined as 141.63 and 164.07 g in the C and S lines, respectively. Oguz et al. (1996), who applied selection for 5 generations according to the 4-wk BW, reported that a 19.5% increase occurred in the 4-wk BW (control line: 133.64 g and selection line: 159.69 g). Aggrey et al. (2003) and Reddish et al. (2003) reported similar results for their selection studies. These results reveal that the short-term mass selection carried out for the 4-wk BW led to a significant increase in the BW averages. The average BW of C line (141.63 g) was lower for the birds slaughtered at 4 wk of age than for all other ages examined. Further, the average BW for S and C lines at 5 wk of age were found to be 194.76 and 164.50 g, respectively. As can be seen from Table 1, the averages of BW for S and C lines at 6 to 8 wk of age were 211.80, 220.45, 225.55 g, and 181.61, 187.70, 195.37 g, respectively. These average values of BW for consecutive weeks are in agreement with the results of previous studies in selected or nonselected quail (Akbas

Table 1. Effects of slaughter age and line on weights (g) of body, carcass, carcass parts, and edible inner organs[1]

Item	Line	BW	CW	BRW	LW	WW	AFW	EIOW
Wk								
4	C	141.6[d]	100.5[e]	34.7[d]	22.9[d]	10.4[d]	0.60[d]	7.8[d]
	S	164.1[c]	118.4[c]	40.9[c]	26.8[c]	11.8[c]	0.59[d]	8.9[c]
5	C	164.5[c]	113.8[d]	41.0[c]	26.3[c]	10.6[d]	0.97[cd]	8.5[c]
	S	194.8[b]	139.4[b]	49.9[b]	32.6[a]	13.3[a]	1.35[c]	10.0[b]
6	C	181.6[b]	123.7[c]	44.6[b]	28.3[b]	11.5[c]	1.19[c]	8.9[c]
	S	211.8[a]	146.0[a]	53.0[a]	33.7[a]	13.4[a]	1.71[bc]	9.5[b]
7	C	187.7[b]	128.1[c]	46.0[b]	28.8[b]	12.4[b]	1.68[bc]	8.9[c]
	S	220.5[a]	149.7[a]	53.8[a]	34.3[a]	13.9[a]	2.98[ab]	10.0[b]
8	C	195.4[b]	130.4[b]	47.0[b]	29.4[b]	11.2[c]	2.20[b]	9.3[b]
	S	225.6[a]	152.5[a]	55.7[a]	34.8[a]	13.3[a]	3.80[a]	10.7[a]
SEM		0.94	0.60	0.26	0.15	0.08	0.04	0.08
Source (significance)								
Age								
Linear		*	*	*	*	*	*	*
Quadratic		*	*	*	*	*	*	NS
Cubic		NS	NS	*	*	*	NS	NS
Line		*	*	*	*	*	*	*

[a–d]Means in a column with no common superscript differ significantly ($P < 0.05$).

[1]C = control line; S = selection line; BW, g; CW = cold carcass weight, g; BRW = breast weight, g; LW = leg weight, g; WW = wing weight, g; AFW = abdominal fat weight, g; EIOW = edible inner organ weight, g.

*$P < 0.05$.

and Oguz, 1998; Balcioglu et al., 2005; Narinc et al., 2009; Sari et al., 2011; Lotfi et al., 2012b; Alkan et al., 2012).

The first and second order polynomial coefficients were found to be significant for age effect on CW, which increased with age-in both lines. These results agree with those reported by Yalcin et al. (1995) who reported an increase in the CW of quail between 5 to 9 wk of age. The line effect was significant on CW being higher for S line than for the C line at all ages (Table 1), in agreement with Caron et al. (1990), Minvielle et al. (2000), and Khaldari et al. (2010). The lowest mean value of CW (100.51 g) was found in C line birds slaughtered at 4 wk of age, whereas the highest mean values of CW (146.02, 149.68, 152.51 g, respectively) were obtained from S line birds slaughtered at 6 to 8 wk of age ($P < 0.05$). The mean values of carcass weights at different slaughter ages were in agreement with those reported between 98.1 and 138.2 g (Yalcin et al., 1995; Aksit et al., 2003; Vali et al., 2005; Winter, 2005; Khaldari et al., 2010; Lotfi et al., 2011).

The equations for BRW, LW, and WW have linear, quadratic, and cubic parameters ($P < 0.05$) indicate that these traits increase with increasing age (Figure 2). Line had a significant effect on the weights of breast, leg, and wing at all ages being greater for S line than C line. The average values observed at 4 wk in the C line for BRW, LW, and WW (34.66, 22.88, and 10.40 g, respectively) traits were the lowest among other weekly averages of both C and S lines ($P < 0.05$). Also, nonsignificant differences in WW weight for 4 and 5 wk of ages were found in C line (Table 1). The highest mean values for BRW (53.02 to 55.67 g) were obtained in S line at the age of 6 to 8 wk, whereas the highest mean values of LW (32.63 to 34.81 g) and WW (13.31 to 13.94 g) were found in S line at the ages of 5 to 8 wk. Similar to our findings, the breast weight,

leg weight, and wing weight were reported in the range of 32.00 to 55.51 g, 24.92 to 31.90, and 10.10 to 14.32 g, respectively, in previous studies (Yalcin et al., 1995; Oguz et al., 1996; Aksit et al., 2003; Narinc et al., 2010, 2013; Khaldari et al., 2011; Lotfi et al., 2011; Sari et al., 2011). In light of these results, it can be concluded that, particularly in S line, rearing birds after 6 wk of age may result in economic losses in terms of BW and CW traits, and after 5 wk of age for BRW, LW, and WW traits.

The effect of short-term selection for BW on the AFW and EIOW was found significant (Table 1). These findings are in agreement with the reports of Caron et al. (1990), Marks (1993), and Oguz and Turkmut (1999). The equations for AFW in S and C lines have both linear and quadratic terms ($P < 0.05$), whereas the EIOW data in both lines show a linear trend for weight gain from 4 to 8 wk of age. The AFW was higher for S line birds than for C line birds at 8 wk of age. This finding confirms the similar results of Baumgartner et al. (1985).

Slaughter age had a linear effect on the CY, indicating that CY decreased with increasing age (Figure 1). One can conclude that the decrease of carcass yield between 4 and 8 wk of age may be attributable to the increase of abdominal fat pad and inedible parts. The S line had significantly ($P < 0.05$) greater carcass yield as a percentage of live weight than C line at 8 wk of age (Table 2). Yolcu et al. (2006) reported that the selection carried out to increase BW also caused an increase in the proportional values of the carcass and the carcass parts in Japanese quail. Similar results were obtained in a study by Caron et al. (1990). From Table 2, it can be seen that the S line birds at 4 wk of age had the highest CY value (75.24%), whereas the C line birds at 8 wk of age had the lowest CY value (69.12%; $P < 0.05$). This may be caused by an increase in weights of
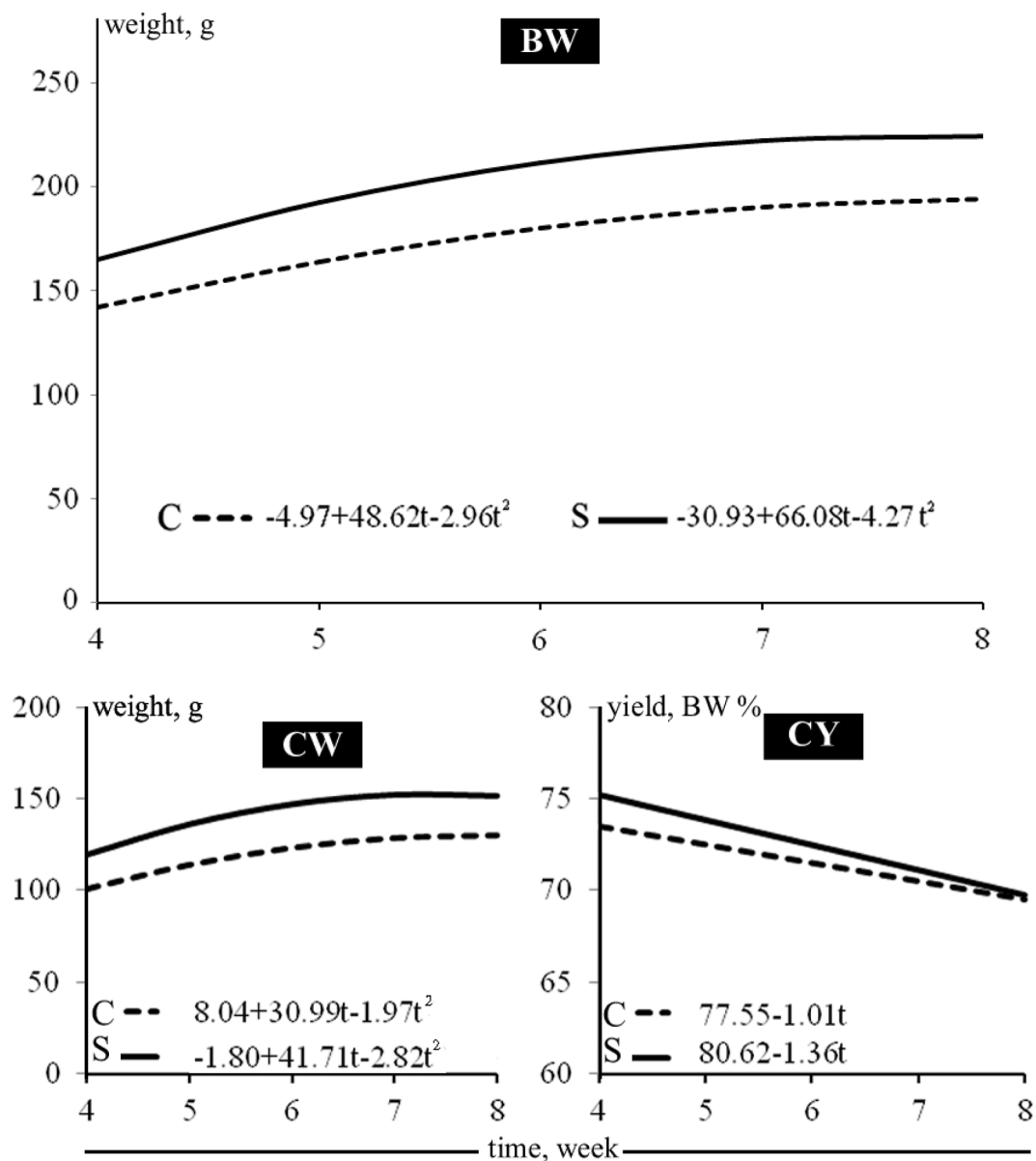
Figure 1. Effects of slaughter age and line (C: control line, S: selection line) on BW, carcass weight (CW), and carcass yield (CY).

inedible parts in parallel with the start of sexual maturity. Carcass yield of S line and C line ranged from 75.24 to 70.02% and 73.70 to 69.12% from 4 to 8 wk of age, respectively. Similar results have been reported by various researchers (Caron et al., 1990; Yalcin et al., 1995; Oguz et al., 1996; Aksit et al., 2003; Narinc et al., 2010; Khaldari et al., 2011; Lotfi et al., 2011).

Slaughter age had a significant effect on BRY, LY, and WY for which significant differences were also observed between S and C lines. The S line had significantly ($P < 0.05$) greater BRY as a percentage of BW than C line at all the ages except wk 6 and 7 (Table 2). In contrast to the breast weight, depending on the increasing slaughter ages, BRY decreased in both lines. The mean BRY values of S and C line birds between 4 and 8 wk of age were ranged from 25.82 to 24.75% and 24.95 to 24.17%, respectively ($P < 0.05$). Yalcin et al. (1995) reported lower BRY values ranging from 20

to 22% between 5 and 9 wk of age. Also, Yalcin et al. (1995) reported that there was no significant difference among the slaughter ages with respect to breast percentage. In our study, the mean BRY values obtained for 2 lines at varying ages are lower than those reported by Winter (2005), Sari et al. (2011), and Narinc et al. (2013) as 30.01, 26.78, and 27.45%, respectively. On the other hand, these average values of BRY are in good agreement with those reported (23.89–24.27%) by Aksit et al. (2003), Narinc et al. (2010), Khaldari et al. (2011), and also higher than those reported (20.28–22.27%) by Alkan et al. (2010), Khaldari et al. (2010), Tarhyel et al. (2012) in quail. Mean values of the LY in the present study were found to range from 15.51 to 16.79% in S line, and from 15.14 to 16.13% in C line. In the S line, nonsignificant differences ($P < 0.05$) were observed for LY between 7 and 8 wk of age (15.59 and 15.51%) and between 4 and 5 wk of age (16.39 and
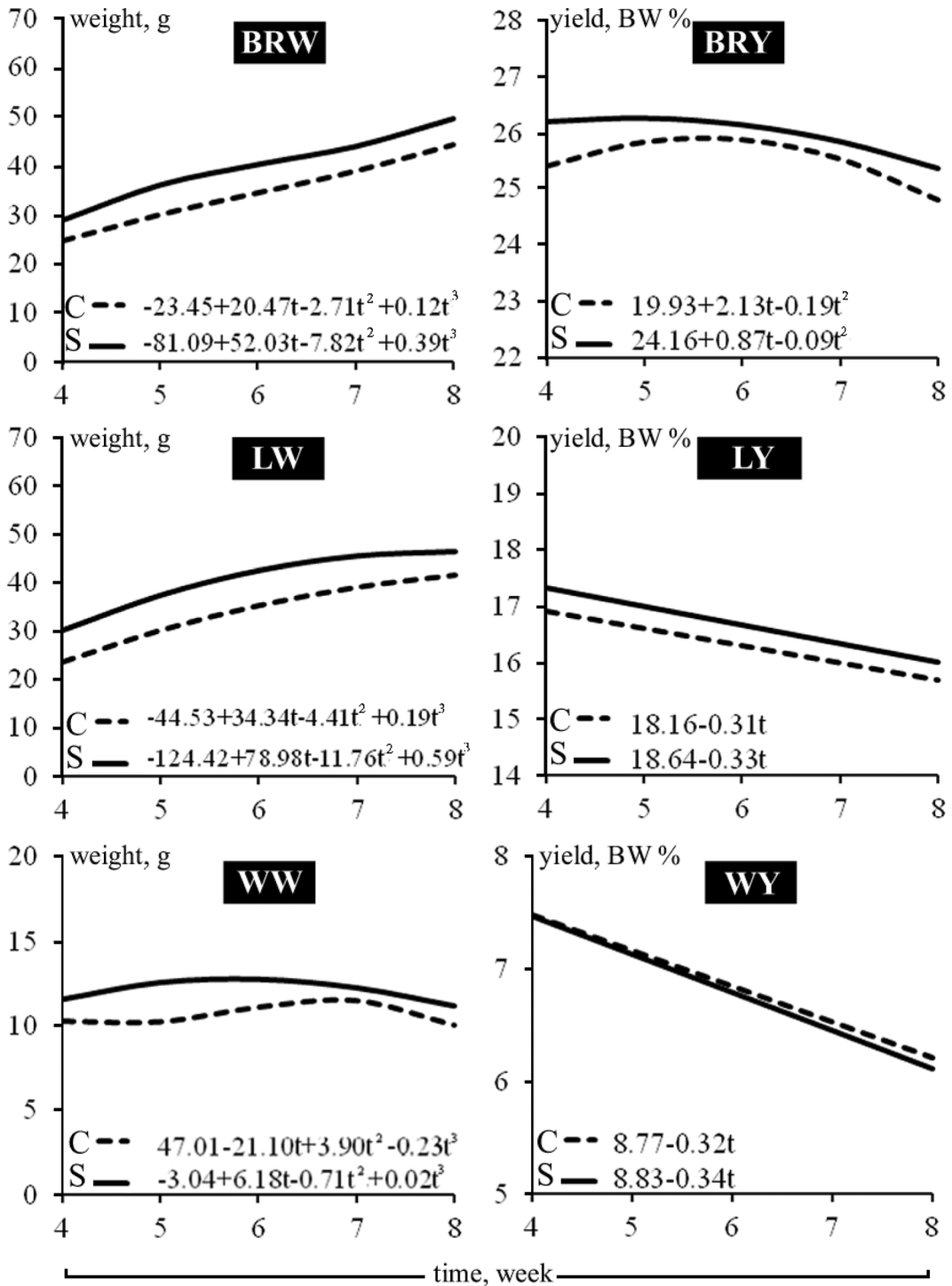
Figure 2. Effects of slaughter age and line (C: control line, S: selection line) on weights and yields of carcass parts. BRW = breast weight; BRY = breast yield; LW = leg weight; LY = leg yield; WW = wing weight; WY = wing yield.

16.79%). The average values of LY in our study were in agreement with those reported between 13.73 and 17.23% in quail (Aksit et al., 2003; Winter, 2005; Khaldari et al., 2011; Sari et al., 2011; Narinc and Aksoy, 2012). The results (5.82 to 7.45%) obtained for WY in our study are in agreement with the results of a previous report given as 5.99 and 8.70% (Yalcin et al., 1995).

The equations for AFY have linear, quadratic, and cubic terms ($P < 0.05$), indicating that these traits increased with increasing age (Figure 3). These results agree with a previous study presented by Yalcin et al. (1995) in which an increase was determined for AFY between 5 to 9 wk of age. The difference between lines in terms of AFY was statistically significant ($P < 0.05$). The S line birds slaughtered at 6, 7, and 8 wk of age have higher mean values of AFY than C line birds (Table 2). Selection for BW results in an increase for AFY as reported by Caron et al. (1990), Toelle et al. (1991),

Table 2. Effects of slaughter age and line on yields (%) of carcass, carcass parts, and edible inner organs[1]

Item	Line	CY	BRY	LY	WY	AFY	EIOY
Wk							
4	C	73.7[ab]	25.0[b]	16.1[b]	7.4[a]	0.43[d]	5.7
	S	75.2[a]	25.8[a]	16.4[a]	7.5[a]	0.37[d]	5.6
5	C	72.0[b]	24.9[b]	16.0[b]	6.5[c]	0.58[cd]	5.4
	S	74.0[ab]	25.7[a]	16.8[a]	6.9[b]	0.68[cd]	5.3
6	C	71.6[bc]	24.7[b]	15.7[c]	6.4[c]	0.66[cd]	5.1
	S	72.1[b]	25.1[b]	16.0[b]	6.4[c]	0.81[c]	5.2
7	C	70.0[c]	24.7[b]	15.5[c]	6.7[b]	0.88[c]	4.9
	S	70.9[bc]	24.9[b]	15.6[c]	6.4[c]	1.35[ab]	4.7
8	C	69.1[d]	24.2[c]	15.1[d]	5.8[d]	1.13[b]	4.9
	S	70.0[c]	24.8[b]	15.5[c]	6.0[d]	1.68[a]	4.9
SEM		0.17	0.10	0.06	0.04	0.02	0.04
Source (significance)							
Age							
Linear		*	*	*	*	*	*
Quadratic		NS	NS	*	NS	*	NS
Cubic		NS	NS	*	NS	*	NS
Line		*	*	*	*	*	NS

[a–d]Means in a column with no common superscript differ significantly ($P < 0.05$).

[1]C = control line; S = selection line. Yields were expressed as a percentage of BW; CY = cold carcass yield, %; BRY = breast yield, %; LY = leg yield, %; WY = wing yield, %; AFY = abdominal fat yield, %; EIOY = edible inner organ yield, %.
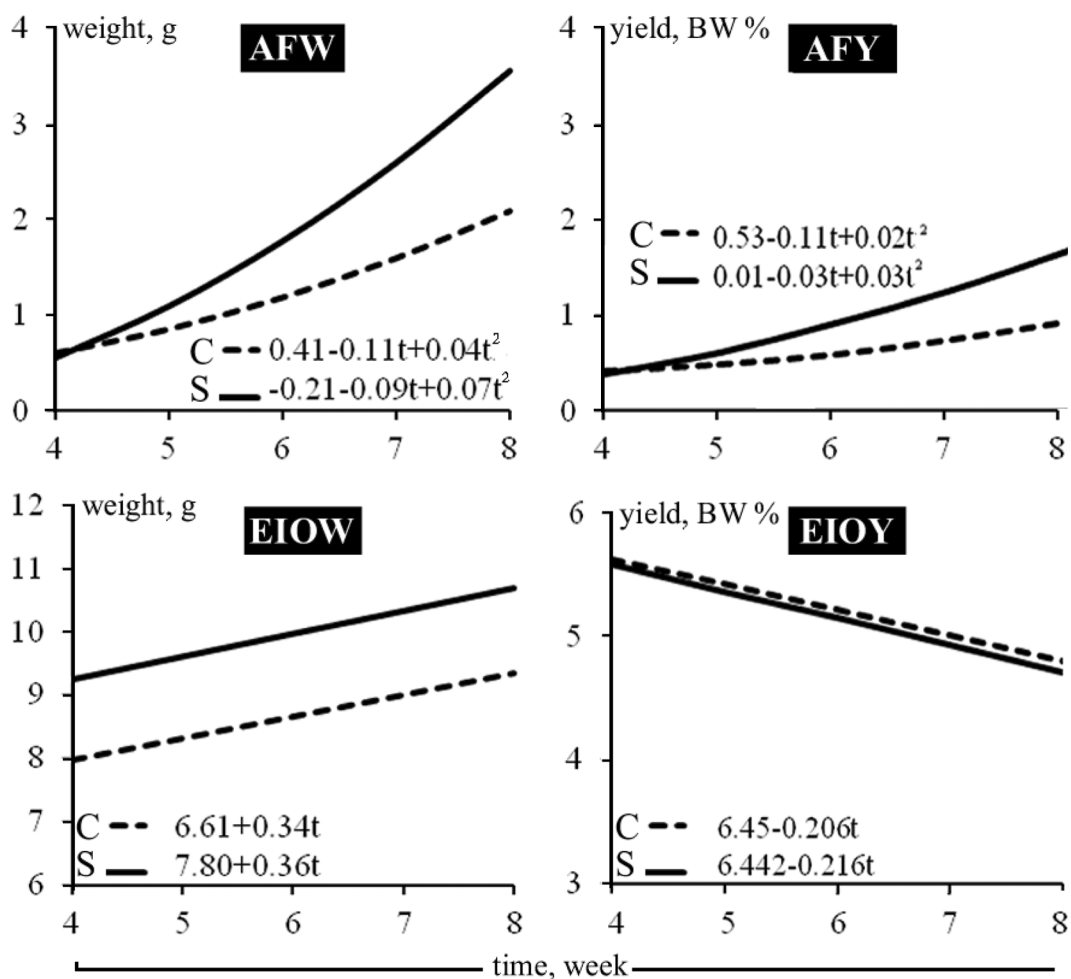
*$P < 0.05$.

Figure 3. Effects of slaughter age and line (C: control line, S: selection line) on weights (W) and yields (Y) of abdominal fat (AF) and edible inner organs (EIO).

Oguz et al. (1996), Alkan et al. (2010), and Narinc and Aksoy (2012). Slaughter age had a linear effect on EIOY, whereas EIOY showed no significant difference between lines, which are consistent with the other reports (Caron et al., 1990; Toelle et al., 1991; Yalcin et al., 1995).

The results of the present study indicated that S line quail have reached a carcass weight at 5 wk of age that could be achieved at 8 wk of age by C line quail (Table 1). Moreover, it should be noted that the optimal slaughtering age that results in maximum carcass weight is 6 wk of age in the S line ($P < 0.05$). The graph of CW in Figure 1 further supports this conclusion where a maximum was reached and remained relatively constant after 6 wk of the experiment. This study revealed that the mass selection for increased BW resulted in an increase for all slaughter traits, except EIOY, in Japanese quail. Furthermore, depending on the increase of slaughter age, BW, CW, BRW, LW, WW, AFW, EIOW, and AFY were increased, whereas CY, BY, LY, WY, and EIOY were decreased. In particular, the decrease in CY and the increase in AFY with slaughter age results in a reduction in total income of commercial producers. Hence, it can be concluded that a short-term mass selection should be applied for high carcass weight. Mass selection is a method where phenotypic values are used as breeding values and do not require complicated mathematical calculations such as those in the BLUP and index methods, and easy to apply. With short-term mass selection, quail producers can perform selection for 4 generations in about a year. In the study it was determined that the differences between the carcass weights over ages were ranged between 16.83 to 22.45% in favor of the S line with the same method. It is considered that in countries where the carcasses are priced per piece, producers following this process will improve product quality and enhance consumer satisfaction.

ACKNOWLEDGMENTS

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