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Effects of Different Selection Methods for Body Weight on Some Genetic Parameters in Japanese Quail

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Abstract: The aim of this study was to investigate the effects on some genetic parameters of different selection methods for Body Weight (BW) in Japanese quail. For this aim, line M_{55} was subjected to individual selection for 5 weeks BW while a reciprocal recurrent selection method was applied to lines R_{33} and S_{55}. Selection lasted 2 generations. In individual lines, the percentage deviation of body weight was an average of 1.41, 1.73 and 2.19% in the 1st generation males, females and mixed sex, respectively. These parameters reached 5.57, 7.44 and 6.29% in the 2nd generation. In the reciprocal recurrent selection, heterosis of BW in the crossbred birds occurred in the positive direction and was 3.22 and 1.95% for R_3S_5 and S_5R_3, respectively in the 1st generation. In the 2nd generation, heterosis was calculated as 6.50 and 7.31% in R_3S_5 and S_5R_3, respectively, higher than the 1st generation. At the end of the 2 generations, R_3S_5 had higher heterosis than S_5R_3. BW increase was similar in the 2 selection methods. Heritability of BW in the individual lines was 0.27 and 0.73 in the 1st and 2nd generation, respectively. In the reciprocal selection, heritability of BW was estimated as 0.37 and 0.19 in the 1st generation and 0.17 and 0.27 in the 2nd generation for R_3S_5 and S_5R_3, respectively. As a result, at the end of the 2 generations of selection, an improvement in BW increase was obtained in both selection methods. If selection is continued in these lines, this may be important especially with regards BW.

Key words: Japanese quail, different selection, body weight, heterosis

INTRODUCTION

Japanese quail (*Coturnix coturnix japonica*) are used as pilot animals for research usually done with chickens and turkeys, because they require less time and space, are easier to handle and have low feed requirements, more rapid growth, earlier sexual maturity, greater laying ability, shorter time of hatching and are more resistant to diseases compared with chickens (Wilson *et al*., 1961; Sadjadi and Becker, 1980). The short generation interval (4 or more generations year^{-1}) and similarity of the genetic parameters with domestic fowl are the main advantages of Japanese quail. Besides this, in spite of the small body size of the Japanese quail, its meat and eggs are widely consumed all over the world. Commercially produced quail are reared mainly for meat in Europe and for eggs in Japan and are often bred as dual-purpose birds in other Asian countries (Minvielle, 1998). Recently, meat quail have begun to attract the interest of quail producers, but most producers find it difficult to obtain superior quality parents.

Selection has an important role in genetic improvement in animal production. Individual selection is particularly indispensable in selection experiments for BW in poultry. In such experiments, high heritability of body weight provides major benefits.

Many researchers have reported that the heritability of BW in Japanese quail is moderate to high (Marks and Lepore, 1968; Collins *et al*., 1970; Kesici *et al*., 1998; Darden and Marks, 1988; Marks, 1989; Kocak *et al*., 1995).

Selection experiments with different selection methods in different environments have been performed, but most involved individual selection and used BW at the 3rd-5th weeks of age as the criterion.

Experiments using selection methods have also been carried out to obtain heterosis. Reciprocal recurrent selection, which involves 2 types of selection in favour of additive and nonadditive genetic variation, is an important breeding method to obtain heterosis and to achieve stable lines. First developed by Comstock *et al*. (1949), this method enables to be developed with selection that will be done within own with regards combination capability of lines. That is to say, reciprocal

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recurrent selection designed to increase genetic distance between lines should eventually achieve maximum heterosis.

There are many experiments demonstrating significant genetic improvement and heterosis in selection experiments for BW in Japanese quail. Woodard *et al.* (1973) conducted an experiment using mass selection over 29 generations for 6 weeks BW and demonstrated higher (70%) BW increase in the selected line compared to the unselected line. Darden and Marks (1988) reported that different environment selection continued for 11 generations based on 4 weeks BW in Japanese quail, which resulted in higher increases (48.9 and 49.7%) in selected lines in comparison to the control line. Marks (1989) also reported that the BW increase was 31, 44 and 51% from the 27th-70th generation. Kesici *et al.* (1998) selected Japanese quail for high 5-weeks BW and found genetic improvement in the 1st generation, with a heritability for BW of 0.62 in females and 0.38 in males. Camci (1992) reported that 5 generations of selection for high 5-weeks BW in Japanese quail resulted in increases in BW in the 1st and 3rd generation, but this increase was steady during 3rd and then started to increase. An experiment on different quail genotypes was conducted and found that groups selected by BW showed higher performance than control groups and that the crossbred genotype was superior to the pure genotype (Testik *et al.*, 1993). Uluocak *et al.* (1997) reported that 5 generations of selection for 5-weeks BW in Japanese quail led to higher BW in the following generation. Baylan and Uluocak (1999) explained that 2 generations of selection for high 3rd-5th weeks BW in Japanese quail produced an increase in BW especially in the 4 and 5th weeks selection groups.

Heterosis for 4-weeks BW in Japanese quail was observed in reciprocal crosses of 2 quail lines following 21 generations of selection for high 4-weeks BW under different environments (Marks, 1973). Wyatt *et al.* (1982) reported that heterosis values ranged from -5 to 4% adult BW (at 8 weeks) in quail. In diallel crosses of a small body size quail line and one that had undergone selection for large BW, percentage heterosis increased quickly to 8.4% at 7 weeks and then steadily decreased thereafter to insignificant levels, suggesting an age-dependent trend in heterosis (Gerken *et al.*, 1988). It should be emphasised that there was an important heterosis on BW in most experiments using reciprocal recurrent selection (Baik and Marks, 1993; Damme, 1994; Marks, 1995). In contrast, reciprocally crossing lines of high and low BW resulted in heterosis values approaching zero and also negative estimates (Darden and Marks, 1989; Marks, 1993).

The aim of this research was to investigate the effects on some genetic parameters of different selection methods for body weight in Japanese quail.

MATERIALS AND METHODS

The quail lines used were M_{55}, R_{33} and S_{55}. These lines were developed previously by selection for BW in our Research Unit. Details regarding the establishment of these lines can be found in Baylan (2003). Briefly, M_{55} was obtained after 9 generations of individual selection for 5-weeks BW. Lines R_{33} and S_{55} were obtained following 3 generations of individual selection based on 3 and 5-weeks BW at the beginning, respectively and followed by 3 generations of reciprocal recurrent selection.

In this study, line M_{55} was subjected to individual selection for 5-weeks BW, while reciprocal recurrent selection was applied to lines R_{33} and S_{55}. Selection lasted for 2 generations.

Individual selection was applied to M_{55} and 70 parents were selected from the quail population based on the sex ratio (3♀: 1♂) per generation. Eighty male and female pullets were obtained from each generation from lines R_{33} and S_{55} and these parents were transferred to individual cages in order to perform reciprocal crosses (80 pair-matings R_3S_5 and pair-matings S_5R_3) at the end of 5 weeks of age. One male and female were kept together in individual cages (100×25×20 cm). Hatchery management started when these parents were 13-weeks-old. Eggs were collected separately from individual cages and transferred to an incubator after the necessary sanitary management. After hatching, each cross offspring (R_3S_5 and S_5R_3) was identified humanely with an aluminium wing-tag and was reared for 5 weeks.

Individual data belonging to cross offspring were analysed using the Derivative Free Restricted Maximum Likelihood DFREML Ver 3.0 β programme under the individual Animal Model (AM) (Meyer, 1998). Based on the 5-weeks performance of cross offspring, the breeding values of parents were calculated and then superior male and female parents were selected (in the proportion 9:27). Thus, R_{33} and S_{55} parents were selected as the parents of the next generation (Fig. 1).

Offspring (M_{55}, R_3S_5 and S_5R_3) were tested for genetic improvement, presence and level of heterosis and heritability at the same point in each generation.

During the study, the quail were fed with grower diet containing 22% crude protein and 3000 kcal ME kg^{-1} for 0-5 weeks. After 5 weeks, they were fed with layer diet containing 17% CP and 2650 kcal ME kg^{-1}. Feed and water were provided *ad-libitum*. Light was provided for 24 h during the growing period (0-5 weeks) and for 16 h

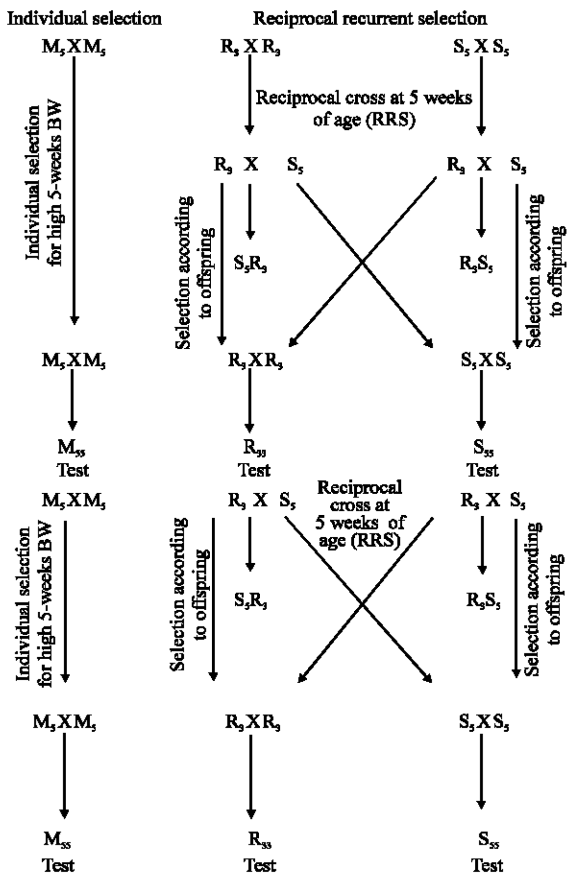

Fig. 1: Selection carried out

during the laying period. All hatched chicks were raised in the battery brooder until 2 weeks of age and were then transferred to growing cages until 5 weeks of age.

After this, line M_{55} was transferred into laying cages, while lines R_{33} and S_{55} were transferred into individual cages (a pair-mating in each individual cage) in order to perform the reciprocal cross (R_3S_5 and S_5R_3). In all lines, individual BW data were recorded weekly until 5 weeks of age. Estimated genetic parameters for BW were calculated by using the equation:

Individual selection:

- Realised genetic improvement was calculated with the equation (Duzgunes *et al*., 1996):

$$\Delta G_g = P_1 - P_0$$

where:

ΔG_g = Realised genetic improvement
P_0 = Mean body weight of parents' generation
P_1 = Mean body weight of offspring

- Superiority of selection

$$I = P_s - P_0$$

I = Superiority of selection
P_s = Mean body weight of selected from population
P_0 = Mean body weight of population

- Heritability was calculated from the selection results

$$\Delta G = I.h^2$$
$$h^2 = \Delta G/I$$

h^2 = Heritability
ΔG = Genetic improvement
I = Superiority of selection

Reciprocal recurrent selection

Heterosis: Heterosis was calculated based on 5-weeks-old quail in the cross (R_3S_5 and S_5R_3) which were obtained by reciprocal recurrent selection.

$$\text{Heterosis (\%)} = [\frac{F1\text{-}M}{M}] \times 100$$

F1 = Crossbred means
M = Parental means (Piao *et al*., 2004)

Heritability: Heritabilities were estimated by DFREML (Meyer, 1998) using an animal model with the animal's genetic effect as the only random factor.

RESULTS AND DISCUSSION

Individual selection

Realised genetic improvement: Realised genetic improvement in line M_{55} using individual selection was 3.7, 5.0 and 6.0 g for the 1st generation males, females and average, respectively. In the 2nd generation, genetic improvement was 15.1, 21.9 and 17.8 g, respectively; this was higher than for the 1st generation (Table 1). Females had higher values than males in each generation. The percentage deviation of body weight was 1.41, 1.73 and 2.19% in the 1st generation and 5.57, 7.44 and 6.29% in the 2nd generation males, females and mixed sex, respectively.

In contrast, Kesici *et al.* (1998) selected Japanese quail for high 5-weeks BW and found that genetic improvement in the 1st generation was higher. Camci (1992) reported that 5 generations of selection for high 5-weeks BW in Japanese quail showed increases in BW from the 1st-3rd generation, but later on this increase steady at the 3rd generation and then started to increase. Turedi and Duzgunes (1984) reported that body weight increase was 5.25 g in selection based on 6-weeks BW. Similar results for BW increase were reported by Marks (1980, 1996). Collins and Abplanalp (1967) reported that the BW of quail selected for 6-weeks BW was 20 g higher than the base population. Nestor and Bacon (1982) reported that 7 generations of selection for 4-weeks BW produced a 6, 10, 11, 11, 19, 20 and 26 g BW increase per generation, respectively. Tozluca (1993) also reported that the increase in 4-weeks BW was 18.95 g for males and 20.37 g for females. These results are consistent with our results. Oguz and Turkmut (1999) and Baylan and Uluocak (1999) obtained similar results related to BW increase, but they also obtained negative values for some groups.

In a long-term selection, experiment carried out under a different environment for 4-weeks BW, the percentage deviation of body weight was 48.9 and 49.7% in selected lines (Darden and Marks, 1988). Marks (1989) reported values of 31, 40 and 51% in selected lines. Deviation in this experiment was 2.19 and 6.29%. Since percentage deviation of body weight can be observed to better, long-term selection experiments are suggested.

Heritability: Heritability was estimated based on realised genetic improvement (Table 2). Heritability in line M_{55} was 0.11, 0.43 and 0.27 in the 1st generation males, females and mixed sex, respectively. In the 2nd generation heritability was 0.52, 1.06 and 0.73, respectively. In the 2nd generation, females had a value higher than 1. This value is outside the theoretical range. The limit of deviation of heritability, however, ranges between $0 \le h^2 \le 1$ (Duzgunes *et al*., 1996). If heritability calculated according to phenotype is outside this limit, this condition may occur either due to environmental variation or inadequate representation of selected animals in the population. Falconer (1960) reported that heritability for a particular trait can take different values according to the population, the environmental conditions surrounding the animals and the calculation method. Tigli *et al.* (1997) reported that the heritability of hatch weight in Japanese quail was >1 and outside the theoretical range and that this condition may be due to maternal effects. Some researchers reported negative values for heritability (Kocak *et al*., 1995; Nestor *et al*., 1996; Nacar *et al*., 1999; Baylan, 2003).

Tigli *et al.* (1997) reported that heritability increased with age and was 0.15, 0.37 and 0.50 at the 3rd-5th weeks of age, respectively. Baylan and Uluocak (1999) also reported -0.28, 0.33 and 0.37 in the 1st generation and 0.06, 0.03 and 0.27 in the 2nd generation for the same ages. Chahil and Johnson (1974) estimated values of 0.44 and 0.24 for the 5th weeks of age for females and males, respectively. For the same age, Caron *et al.* (1990) estimated values of 0.30/0.22; 0.19/0.24 and 0.17/0.18 in the 1st-3rd lines for males and females, respectively. Marks (1996) estimated values of 0.32/0.42 for 28 days-old male and female Japanese quail. These results and values are similar to the values estimated in this study (Marks, 1989; Kavuncu and Kesici, 1992; Damme, 1994).

Table 1: Genetic improvement following individual selection (M_{55})

Generation	Sex	Parent	Offspring	ΔG	(%)
I	Male	261.5±2.27	265.2±3.63	3.7	1.41
	Female	287.4±2.99	292.4±3.73	5.0	1.73
	Mean	273.5±2.05	279.5±2.82	6.0	2.19
II	Male	270.7±2.38	285.8±2.42	15.1	5.57
	Female	294.3±2.42	316.2±4.04	21.9	7.44
	Mean	282.9±1.86	300.7±2.61	17.8	6.29

ΔG: genetic improvement

Table 2: Heritability based on individual selection (M_{55})

Generation	Sex	ΔG	I	h^2
I	Male	3.7	32.3	0.11
	Female	5.0	11.6	0.43
	Mean	6.0	21.9	0.27
II	Male	15.1	28.7	0.52
	Female	21.9	20.5	1.06
	Mean	17.8	24.2	0.73

ΔG: genetic improvement I: superiority of selection h^2: Heritability

In this study, heritabilities in the 2nd generation were higher than in the 1st generation. However, the results from three long-term selection experiments (Marks and Lepore, 1968; Marks, 1978, 1989, 1991; Nestor *et al*., 1996; Darden and Marks, 1989) indicate that the realised heritability of body weight declines with selection. The decline in heritability was more rapid when selection was for decreased rather than for increased 4-weeks BW (Marks, 1995; Nestor *et al*., 1996). In each of the 2 generations, females had higher heritabilities than males. However, Kwahara and Saito (1996) reported that males had higher heritabilities than females and that male birds had larger genetic variance of these traits than females.

Reciprocal recurrent selection

Heterosis: Heterosis of BW in the crossbred phenotype moved in a positive direction and was 3.22 and 1.95% in the 1st generation for R_3S_5 and S_5R_3, respectively; these values increased to 6.50 and 7.31% in the 2nd generation, respectively and were thus higher than in the 1st generation (Table 3). At the end of the 2 generations of selection, R_3S_5 had higher heterosis than S_5R_3.

In a previous study, heterosis was 7.34 and 2.12% for the same crosses (R_3S_5 and S_5R_3) (Baylan, 2003). Heterosis for 4-weeks BW in Japanese quail was observed in reciprocal crosses of 2 quail lines following 21 generations of selection for high 4-weeks BW under different nutritional environments (Marks, 1973). Diet influenced heterosis with means across diets ranging from 4.4% to

Table 3: Body weight of 5-weeks-old parents and crossbred genotype and heterosis

	Parents		Crossbred		Heterosis[1] (%)	
Generation	R_{33}	S_{55}	R_3S_5	S_5R_3	R_3S_5	S_5R_3
I	258.9±1.41	259.0±1.26	267.3±1.09	264.0±1.15	3.22	1.95
II	284.8±1.16	279.5±1.08	300.5±1.17	302.8±1.28	6.50	7.31

[1]Heterosis (%) = [(F1-M)/M] ×100; F1: Crossbred means, M: Parental means

9.5% for 4-weeks BW. In diallel crosses of a small body size quail line and one that had undergone selection for large BW, percentage heterosis increased quickly to 8.4% at 7 weeks and then steadily decreased thereafter to insignificant levels, suggesting an age-dependent trend in heterosis (Gerken *et al.*, 1988). Reciprocally crossing 2 quail lines selected for high 4-weeks BW under a different environment also resulted in a decline in heterosis with age (Baik and Marks, 1993). Heterosis declined from 10% at 1 week to 6% at 6 weeks of age. In contrast, heterosis increased from 5% at 1 week to 14% at 6 weeks in crosses of lines selected for low BW. Burke and Henry (1999) reported that the crossbred genotype obtained with reciprocal recurrent selection had high heterosis. Similarly, as shown in this study, many researchers have reported positive heterosis in reciprocal selection experiments (Sato *et al.*, 1989; Marks, 1993; 1995; Hussein *et al.*, 1996). In contrast, reciprocally crossing lines of high and low BW resulted in heterosis values approaching zero and also negative estimates (Darden and Marks, 1989). Marks (1993) and Moritsu *et al.* (1997) reported negative heterosis for BW in the LW× HW cross. Piao *et al.* (2004) recently reported that in the cross between a Large body weight Line (LL) and the RR line, the weight of the F_1 was intermediate between the parental lines and the mature body weight of F_1 had a negative heterosis. Overall, crosses between lines with very different body weight showed little negative heterosis primarily because selection for low body weight is associated with major dominant genes (Baik and Marks, 1993; Moritsu *et al.*, 1997).

Heritability: Heritability of 5-weeks BW in crossbred birds was estimated to be considered all relationship degree. In the analyses, sex and hatching were assumed to be fixed effects. The heritability of BW in the crossbred birds was 0.37 and 0.19 in the 1st generation for R_3S_5 and S_5R_3, respectively. These parameters were 0.17 and 0.27 in the 2nd generation. In the 1st generation, estimated heritability in the individually selected line was similar to these values. Heritability was higher (0.43 and 0.48) in this study than in the same crossbred genotype (R_3S_5 and S_5R_3) reported by Baylan (2003). The heritability estimates in this study were similar to those reported by Chahil and Johnson (1974), Eitan and Soler (1995), Nestor *et al.* (1996), Marks (1996) and Tigli *et al.* (1997), but were higher than those reported by Caron *et al.* (1990), Marks (1989), Kavuncu and Kesici (1992), Damme (1994) and Baylan and Uluocak (1999).

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