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The Effects of Parental Age and Mating Ratio on Egg Weight, Hatchability and Chick Weight in Japanese Quail

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Abstract : This experiment was carried out to determine the effects of parental age and male to female ratio on egg weight, chick weight and hatchability on Japanese quails. In this study, quails were separated in to two groups on basis of age 10 weeks of ages (1. group) and 20 weeks of ages (2.groups). 1168 eggs were gathered from both groups during a week. The birds were caged 40x30 cm in size and 2 mating ratio 1 male to 2 female (1. group) and 1 male to 3 female (2. group). The effects of parental age on egg weight was statistically important ($P<0.001$). However it was not important for chick weight. The effects of mating ratio on egg weight and chick weight was statistically important at different degree ($P<0.001$, $P<0.05$ respectively). The effects of parental age on fertility, hatchability of fertile eggs (%) and hatchability of eggs set (%) and embryonic mortality was not statistically important. The effects of mating ratio was statistically important only on fertility ($P<0.05$). The effects of mating ratio on hatchability of eggs set for 1 group of age and on fertility for 2. group of age were statistically important ($P<0.001$). At the result, this study showed that egg weight increased with parental ages. However hatchability traits and chick weight were not affected by parental ages. Compare with 1 male to 2 female mating ratio 1 male to 3 female mating ratio had better egg weight, chick weight and hatchability (10 week of age group).

Key words: Parental age, male to female ratio, chick weight, hatchability, quail

Introduction

The parental ages are an important factor on egg weight, egg quality, hatchability and chick quality (Flatether *et al.*, 1983 and Narahari *et al.*, 1988). Most researchers reported that egg weight increases progressively with age (Shanawany, 1984; Uluocak *et al.*, 1995; Erensayin 2000 and Silversides and Scott, 2001).

In a research, egg weights were found 10.88 g in young quail group and 10.51 g in old quail group. The difference between age groups was statistically important (Esen and Ozcelik, 2002). Increasing of quail chick weights with parental ages was reported by many researchers (Tserveni-Gousi 1986, Yannakapoulus and Tservesi-Gousi, 1987). However, Yildirim and Yetisir, (1998) were reported, 7.70 g and 7.75 g chick weight from 22 and 65 weeks of quail respectively. The difference between ages was not statistically important.

In different researchers reported on 8 to 52 weeks of ages Japanese quail the fertility, hatchability of fertile eggs, hatchability of eggs set and embryonic mortality were between 48.00-94.00 % (Woodard and Alplanalp, 1967, Sandikcioglu and Sengor, 1981, Kumar *et al.*, 1990; Dixon *et al.*, 1992; Inal *et al.*, 1996 and Erensayin 2002), 40.00-70.34% (Kumar *et al.*, 1990; Dixon *et al.*, 1992; Inal *et al.*, 1996 and Erensayin 2002), 69.44-74.72% and 15.28-20.56% (Erensayýn 2002) respectively. Quail on 12-14 weeks ages have the best fertility ratio (Narahari *et al.*, 1988). Fertility and hatchability decreases (Narahari *et al.*, 1988; Elibol *et al.*, 2002 and Esen and Ozcelik, 2002) and chicks death increases with parental ages (Novo *et al.*, 1997 and Elibol *et al.*, 2002).

Breeding parental flocks to improve of the species or produce marketable hybrid vigour is not practiced in Turkey, because, the egg production of quail is economically suitable for the producers at the same time the procedure is very expensive and has difficulties. That is why the marketing production flocks are usually used as parental flocks as well. For as to maintain the optimum male to female mating ratio optimum numbers of male has to be kept in the flock (Erensayin, 1995). Differences between male to female mating ratio is not statistically effects the egg weight (Baser *et al.*, 2002).

It is important to find out the optimum male to female mating ratio on quail for optimum fertility and production of suitable eggs for hatching (Erensayin, 1995). It was found that fertility, hatchability of incubated eggs, and hatchability of fertile eggs in quail eggs were found 73.78 % - 95.00% (Woodard and Alplanalp, 1967; Janda 1975; Panda *et al.*, 1980; Sandikcioglu and Sengor, 1981; Sreenivasaiah and Ramappa, 1985 and Asasi and Jaafar, 2000), 54.00%- 67.84% (Sreenivasaiah and Ramappa, 1985 and Asasi and Jaafar, 2000), and 76.87%-82.40% (Janda 1975 and Panda *et al.*, 1980) for 1 male:2 female ratio, respectively, while those parameters were 61.4%-95.4% (Woodard and Alplanalp, 1967; Janda 1975; Panda *et al.*, 1980; Sandikcioglu and Sengor, 1981; Sreenivasaiah and Ramappa, 1985 and Asasi and Jaafar, 2000), 49.00%-69.97% (Sreenivasaiah and Ramappa, 1985 and Asasi and Jaafar, 2000), and 79.90% (Panda *et al.*, 1980) for 1 male:3 female ratio, respectively.

Some researchers reported that there was no significant difference between mating ratios of 1male: 2 female and 1male: 3 female in fertility (Wilson and Holland, 1974; Hughes *et al.*, 1980 and Narahari *et al.*, 1988), hatchability of incubated eggs (Hughes *et al.*, 1980 and Narahari *et al.*, 1988), and hatchability of fertile eggs (Wilson and

Holland, 1974 and Baser *et al.*, 2002) in quail eggs. The optimum mating ratio of male to female was 1:3 for fertility and hatchability of fertile eggs reported by Baser *et al.* (2002) However, there was no significant difference for hatchability of eggs set between groups.
The purpose of this study was to determine the effects of parental ages and different male to female mating ratio on egg weight, chick weight, fertility, hatchability of fertile eggs and hatchability of eggs set and embryonic mortality.

Material and Methods

The research was carried out in Quail Breeding Unit of Firat University, Faculty of Veterinary Medicine and Department of Zootechnia in 2003.
80 male and 200 female quail were separated into two groups on basis of age, 10 weeks of age (1. group) and 20 weeks of ages (2. group). The quails were raised in floor pens and fed conventional starter and grower diets until 6 wk of age. The quails were housed in cages (40x30 cm). Water and standard layer diet (20 % protein and 3.0 % calcium) were given *ad libitum*. A lighting schedule of h light/day was used. 1168 eggs were gathered daily during a week. And each age group were divided in two subgroups; first subgroup was placed 1 male and 2 female and sub second group was placed 1 male and 3 female.
Eggs were weighted individually by a digital sensitive scale (0.01). Eggs were classed into 2 groups according to parental ages and each group was divided into two subgroups according to male to female ratio. Pre-incubation storage was at 15-18 °C and humidity was 70-75 %. Throughout the incubation period (1-15. days) the incubator was operated at 37.7 °C and relative humidity was maintained 55-60 % and then kept under 37.5 °C with the humidity of 75-80 % at releasing stage. Eggs were turned automatically 4 times in a day. The air circulation, temperature and humidity controlled automatically.
At the end of the hatch all unhatched eggs were cracked and infertile eggs were recorded. By this way, the number of fertile eggs and hatched chick were found and fertility, hatchability of fertile eggs (%) and hatchability of eggs set (%) were calculated by the following methods.
Fertility (%): (the number of fertile eggs/the number of total eggs) X 100
Hatchability of eggs set (%): (the number of hatched chicks/the number of total eggs) X 100
Hatchability of fertile eggs (%): (the number of hatched chicks/the number of fertile eggs) X 100
Unhatched fertile eggs were classed according to time of embryonic deaths such as early incubation period (1-6 days), middle incubation period (7-15 days) and late incubation period (16-17 days).The percentage of embryonic deaths to total eggs number was estimated.
All results were used to estimate the effects of parental ages and male to female ratio on egg weight and chick weight by using General linear Model and ANOVA (Snedecor and Cochran, 1980). The data were analyzed according to the following linear model:

$$Y_{ijk} = \mu + a_i + b_j + ab_{ij} + e_{ijk}$$

Where;

Y_{ijk} = the ijk th observation on chick weight, μ = the population mean, a_i = i the effects of dams age (i= 1,2), b_j = j the effects of the mating ratio (j=1,2), ab_{ij} = the effects of the interaction, e_{ijk} = the error term (0, δ^2_e).

To determine the effects of parental ages and male to female ratio on eggs weight and chicks weight student-t test were used. Chi-square test was used to compare the hatching performance in and between groups (Snedecor and Cochran, 1980). All analyses were carried out by using SPSS (SPSS for Windows 1999).

Results

The effects of parental ages and male to female ratio on egg weight and chick weight and the average egg weight and chick weight were summarized in Table 1 and some hatching results were summarized in Table 2.
Egg weights differences were found significant statistically between parental ages groups ($P<0.001$). Egg weights were heavier in second age group (11.27 g) when compare with first age group (10.88 g). On chick weights, there was no significant difference between age groups. For hatching performance, there was no statistically important difference between age groups ($P>0.05$).
Male to female mating ratio effects on the egg weight were found significant statistically ($P<0.001$). Chick weight was statistically effected by male to female mating ratio ($P<0.05$).
In first age group there was statistically very important difference between male to female mating ratio subgroups on egg weight ($P<0.001$). In second age group there was statistically important difference between male to female

Table 1: The averages of egg weight and chick weight according to parental ages and male to female (M:F) Ratio Groups

Parental Age	M:F	n	Egg Weight (g) X ± Sx		n	Chick Weight (g) X ± Sx	
1	1	148	10.66	0.07	99	7.97	(1.08)
	2	297	10.99	0.06	211	8.16	0.05
	P		**			*	
Total		445	1088	0.05	310	8.10	0.04
2	1	230	11.19	0.04	167	8.12	0.06
	2	493	11.31	0.04	335	8.18	0.04
	P		*			-	
	Total	723	1127	0.03	502	8.16	0.03
Total	1	378	10.98	0.04	266	8.07	0.05
	2	790	11.19	0.04	546	8.17	0.03
General		1168	11.12	0.03	812	8.14	0.03
			P				
Parental Age			***			-	
Ratio of Male of Female			***			*	
Parental Age X Ratio of Male of Female			-			-	

P: Probability -:Not significant (P>0.05), **: P<0.01, ***: P<0.001

Table 2: The hatchability traits according to maternal ages and male to female (M:F) ratio groups

Parental age	M:F	Number of total eggs	Number of fertile eggs	Number of hatched chicks	Fertility (%)	Hatchability of eggs set (%)	Hatchability of fertile (eggs)	Early Middle period embryonic Deaths (%)	Late period embryonic deaths (%)	period embryonic deaths (%)
1	1	148	124	99	8378	6689	79.84	6.45	7.26	6.45
	2	297	228	211	76.77	71.04	92.54	1.75	2.63	3.07
	P				-	-	**	-	-	-
	Total	445	352	310	79.10	69.66	88.07	3.41	4.26	4.26
2	1	230	215	167	93.48	72.61	77.67	11.16	7.91	3.26
	2	493	395	335	80.12	67.95	84.81	3.80	6.84	4.56
	P				**	-	*	-	-	-
	Total	723	610	502	84.37	69.43	82.30	6.39	7.21	4.10
General	1	378	339	266	89.68	70.37	78.47	944	7.67	4.42
	2	790	623	546	78.86	69.11	87.64	3.05	5.30	4.01
	P				*	-	-	-	-	-
General P		1168	962	812	82.36 -	69.52 -	84.41 -	5.30 -	6.13 -	4.16 -

mating ratio subgroups on egg weight (P<0.05).

Between the male to female mating ratio subgroups the heavier egg weight was found in second age group. Average egg weight was 11.19 g in second age group whereas it was 10.98 g in first age group. Subgroups that have the 1 male to 3 female mating ratios have the heavier eggs.

In first age group, chick weight was heavier in 1 male to 3 female mating ratio subgroups compare with 1 male to 2 female mating subgroups and the difference was statistically important.

Between the male to female mating subgroups only fertility was found statistically important (P<0.05). Fertility was higher in 1 male to 2 female mating ratio subgroups. Where as in first age group hatchability of eggs set was statistically very important (P<0.001) between the male to female mating ratio subgroups. In second age group fertility was statistically very important between the male to female ratio subgroups.

Discussion

The parental age had important effect on egg weight. The average of egg weight in first and second age groups was 10.88 g and 11.27 g respectively. Egg weight increased with quail ages. These results were similar to the

findings of Erensayin *et al.*, (2002a) who reported egg weight on different ages of quail. As observed in this study, some researcher recommended egg weight increases with parental ages (Shanawany 1984; Uluocak *et al.*, 1995; Erensayin 2000 and Silversides and Scott, 2001).

In this study, on 10 weeks and 20 weeks of age groups, the chick weight was found 8.10 g and 8.16 g respectively. Chick weight slightly increased with parental ages. However this was not found statistically important. This results were similar with Yildirim and Yetisir, (1998) who reported no significant differences of chick weight, using 22 and 65 weeks old quail and with Shanaway (1981), who reported similar results. Whereas, those results were different than many researcher, who recommended the increasing of chick weight with parental ages in Japanese quail (Tserveni-Gousi 1986, Yannakapoulus and Tservesi-Gousi, 1987, Erensayin *et al.*, 2002a). Which might be there was not big parental age differences in this study. Apart form this; it might be the food conversion was good enough for embryonic developments for all groups as recommended by some researcher (Yildirim and Yetisir, 1998).

In this study, the fertility in 10 weeks and 20 weeks of age groups were 79.10 % and 84.37% respectively. Fertility, hatchability of fertile eggs and late period embryonic deaths were found in low percentage on old parental age group. However, the difference was not statistically important. Erensayin (2002) reported; in 10 weeks of age and 20 weeks of age quails, fertility 77.53 % and 63.47 %, hatchability of eggs set 70.34 % and 56.81 %, hatchability of fertile eggs 74.72 % and 69.44 %, early period embryonic deaths respectively. He found that, the effects of parental ages on hatchability (hatchability of eggs set) statistically important degree ($P<0.05$) and to use young males instead of old males increased the fertility and hatchability of eggs set on statistically important degree ($P<0.05$). In this study, some of the results were different than Erensayin's (2002) results who found that increasing of parental ages decreased fertility and late embryonic deaths in statistically important degree. However in same research Erensayin (2002) reported that, hatchability and early embryonic deaths were affected by increasing of parental ages, which were similar with our findings.

In this research, on 10 weeks of age group fertility was found similar with Woodard and Alplanalp, (1967) who reported the fertility 70-80 % on 8 weeks of age. Whereas, our results were lower than Sandikcioglu and Sengor, (1981) who reported 92.9 % fertility on 10-13 weeks of age quails; Dixon *et al.* (1992) who reported 87 % fertility on 11-13 weeks of age quails and Inal *et al.*, (1996) who reported 85-64 % fertility on Japanese quails. In this study, fertility on 20 weeks of age group was found similar with Kumar *et al.* (1990) who reported 71-81.4 % fertility on 20-24 weeks of age quails and Sandikcioglu and Sengor, (1981) reported 88.5 % fertility on 18-21 weeks of quails.

In this experiment, hatchability of eggs set on 10 weeks of age group was found lower than Inal *et al.* (1996) who reported 56.52 % hatchability of eggs set on 10-12 weeks of age. Whereas hatchability of eggs set on 20 weeks of age group was similar with Kumar *et al.* (1990) reported 51.1-57.7 % hatchability of eggs set) on 20-24 weeks of age quails.

In this experiment, hatchability of eggs set decreased and embryonic deaths (on early and middle incubation period) increased with increasing of parental ages. These results were similar for hatchability of eggs set with many researchers (Narahari *et al.*, 1988, Elibol *et al.*, 2002) and for embryonic deaths with many researchers (Novo*et al.*, 1997, Elibol*et al.*, 2002). Whereas the results for fertility was different with some researchers (Narahari*et al.*, 1988, Elibol*et al.*, 2002). Which might be related with increasing of egg weight with parental ages. Many researchers (Soley and Sarica, 1995 and Salyam, 1999) recommended that egg weights affect the hatchability. Heavier eggs hatched better than average of all fertile eggs.

In this study, egg weight was found 10.98 g on 1 male to 2 female mating ratio and 11.27 g on 1 male to 3 female mating ratio subgroups. The differences between subgroups were statistically important. This results was different than the findings of Asasi and Jaafar, (2000). The effect of sex ratio on egg production who found 11.00 g and 11.63 g egg weight on 65-95 weeks of age and 1 male 2 female and 1 male to 3 female mating ratio quails and who did not reported any significant egg weight differences between the groups.

The results of this study different than some researchers, who did not report any significant effect on egg weight within mating ratio groups in Japanese quails (Baser *et al.*, 2002). Which might be attributable to the number of egg collected from age groups and mating ratio subgroups were not equal in those studies.

In this study fertility was found 89.68 % and 78.86 % on 1 male to 2 female and 1 male to 3 female subgroups respectively. Those results were similar with some researchers, who reported higher fertility on 1 male to 2 female mating ratios in Japanese quails (Sandikcioglu and Sengor, 1981, Panda *et al.*, 1994).

As observed in this study, Woodard and Abplanalp, (1967) reported 82.4% and 62.5% fertility on 1 male to 2 female and 1:3 female mating ratio groups. The findings of this study on fertility were different than Baser *et al.*, (2002) who reported better fertility in 1 male to 2 female and 1 male to 3 female mating ratios. However the

hatchability of fertile eggs and hatchability of eggs set findings of the same researchers on 1 male to 3 female ratio was similar with this research result.

As observed in this study, Asasi and Jaafar, (2000) reported 92.00 % and 62.00 % fertility in 65-95 weeks of ages on 1 male to 2 female and 1 male to 3 female mating groups respectively. In this study, the results of fertility and hatchability of fertile eggs were comparable with the result of Panda *et al.*, (1980) who described 73.78 % fertility and 76.87 % hatchability of fertile eggs on 1 male to 2 female mating ratios

In this experiment, fertility differences were observed only between mating ratio groups, and hatchability of fertile eggs was observed different only on first age groups. These results were different than the finding of Erensayin *et al.*, (2002b) who reported different hatchability of eggs set than the results of this study. However, he reported similar results on hatchability of fertile eggs, early and late period embryonic deaths with this research. Apart from those, the same researchers found statistically important differences ($P<0.05$) on fertility, hatchability of fertile eggs and hatchability of eggs set, early and late period embryonic deaths in different mating ratios and in all ages group. This was different than the results of this study.

In this study, the findings of fertility on mating ratio subgroups different than some research findings (Wilson and Holland, 1974, Hughes *et al.*, 1980) and the findings of hatchability of fertile eggs in first age group different than findings of some researchers (Wilson and Holland, 1974; Sreenivasaiah and Ramappa, 1985 and Baser *et al.*, 2002).

In this study, fertility and hatchability of fertile eggs are similar with the findings of Janda (1975) who reported 82.1 % and 61.4 % fertility and 82.4 % and 79.9 % hatchability of fertile eggs on 1 male to 2 female and 1 male to 3 female mating ratio respectively. However, the same researcher reported lower hatchability of eggs set on 1 male to 3 female mating ratio than the findings of this research.

In this study, hatchability of fertile eggs 1 male to 2 female and 1 male to 3 female mating ratio were 70.37 % and 69.11 % respectively. Fertility on 1 male to 2 female mating ratio subgroups was comparable with Asasi and Jaafar, (2000) who reported 80-60% in first and 54-49% in second laying period. Apart from the findings of the same researcher in this study the difference between subgroups were not statistically important.

The observations on fertility and hatchability of eggs set in mating ratio subgroups were comparable with the findings of Sreenivasaiah and Ramappa, (1985) who reported 84.68 % and 86.72 % fertility and 67.84 % and 69.97 % hatchability of eggs set on 1 male to 2 female and 1 male to 3 female mating ratio respectively. As observed in this study, the same researchers recommended no statistically significant differences between 1 male to 2 female and 1 male to 3 female mating ratios in Japanese quail.

Apart from statistically important differences on fertility and hatchability of fertile eggs there was no significant difference between mating ratio subgroups in this study. These results were different than some reporters, who reported statistically important differences on mating ratio groups, which might be attributable to effects of strain, age, food conversation, egg storage time and condition in this study (Narahari *et al.*, 1988; Asasi and Jaafar; 2000 and Baser *et al.*, 2002).

In general findings of this research were different than the findings of some researchers, which might be attributable to the effects of inbreeding in those researches. Because some researchers (Sittman *et al.*, 1990) reported that inbreeding affect the hatchability.

Conclusion

At the result, this study showed that egg weight increased with parental ages. However hatchability traits and chick weight were not affected by parental ages. Compare with 1 male to 2 female mating ratio 1 male to 3 female mating ratio had better egg weight, chick weight and hatchability (10 week of age group). Embryonic deaths and fertility decreased with parental ages. Although the decreasing of fertility was found statistically imported, the decreasing of embryonic deaths was not statistically significant.

References

Asasi, K. and A. J. JAAFAR, 2000. The effect of sex ratio on egg production, fertility and hatchability of japanese quail. Pajouhesh-Va-Sazandegi, 4: 45: 128-131.

Baser, E., K. Kucukyilmaz, C. Erensayin and H. Orhan, 2002. The influence of mating interval and different sex ratio on reproductive performance and some yielding traits of japanese quail (Coturnix coturnix Japanese). J. Central Animal Research Institute, 12:2: 16-20.

Dixon, R. J., G. G. Arzey and P. J. Nickholls, 1992. Production, hatchability and fertility of eggs from breeding japanese quail (Coturnix coturnix Japanese) fed diets containing furazolidone. British Poultry Sci., 33: 835-845.

Elibol, O., S. D. Peak and J. Brake, 2002. Effect of flock age, length of egg storage, and frequency of turning during storage on hatchability of broiler hatching eggs. Poultry Sci., 81:945-950

Erensayin, C., 1995. Tavukçuluk. Cilt 3. (Sivas, Dilek Matbaasi).

Erensayin, C., 2000. Tavukçuluk. Cilt 2., 2.Baský. (Ankara, Nobel Yayin Dagitim).

Erensayin, C., 2002. Influence of parental age on fertility, embryonic mortality and hatchability in japanese quail (Coturnix coturnix Japanese). Journal of Central Animal Res. Institute, 12: 47-50.

Erensayin, C., E. Baser, S. Aktan and K. Kucukyilmaz, 2002a. Influence of male to female ratios on reproductive performance of japanese quail. J. Central Animal Res. Institute, 12: 51-54.

Erensayin C., H. I. Akcadag, A. N. Ozsoy, O. Koskan and S. Aktan, 2002b. Effects of the parent's age on production characteristics in japanese quails (Coturnix coturnix Japanese). S.D.U. Fen Bilimleri Enst. Derg, 6:2: 34-40.

Esen, A. and M. Ozcelik, 2002. The effect of age of parents, egg weight and shape index on hatchability in quails. Firat University J. Health Sci., 16:1:19-25.

Flatether, D. L., W. M. Britton, G. M. Pesti, A. P. Rahn and S. I. Savage, 1983. The relationships of layer flock and egg weight on egg component yield and solid contents. Poultry Sci., 62:1800-1805.

Hughes, B. L., J. E. Jones and W. D. Resseguie, 1980. Effect of male to female rations on reproduction of caged coturnix d1 breeders. Poultry Sci., 59:6:1339-1341

Inal, S., S. Dere and C. Tepeli, 1996. Japon bildircinlarinin (Coturnix coturnix Japanese) degisik yaslardaki canli agirliklarinin kalitim dereceleri. S.Ü. Vet. Fak. Derg,. Airi Basim.

Janda, R., 1975. Some observations on the performance of japanese quail. Chovatel., 14:6:133-134.

Kumar, K. M. A., K. S. P. Kumar, B. S. Ramappa and V. Manjunath, 1990. Influence of parental age on fertility, hatchability, body weight and survivability of japanese quail (Coturnix coturnix Japanese). Poultry Adviser, 23:9: 43-47.

Narahari, D., K. A. Mujeer, A. Thangavel, N. Ramamurthy, S. Viswanathan, B. Mohan, B. Buruganandan and V. Sundararasu, 1988. Traits influencing the hatching performance of japanese quail eggs. British Poultry Sci., 29:101-112.

Novo, R. P., L. T. GAMA and M. C. SOARES, 1997. Effects of oviposition time, hen age and extra dietary calcium on egg characteristics and hatchability. J. Applied Poultry Res., 6:3:335-343.

Panda, B., S. D. Ahuja, M. Prakashbabu and D. P. Gulati, 1980. Evaluation of a quail line for some important economic traits. Indian J. Animal Sci., 50:518-520.

Sandikcioglu, M. and E. SENGOR, 1981. Effects of stimulatory light at different ages on the age of sexual maturity, body weight, egg production, egg weight and egg laying patterns of the quail (Coturnix coturnix Japanese). Doga Bilim Dergisi, Vet. Hay. Tar. Orm., 5:337-339.

Soley, F. and M. Sarica, 1995. The effects of hatching egg weights on the hatchability, growth and egg production traits of japanese quail (Coturnix coturnix Japanese). J. Agric. Fac. O.M.U., 10:19-30.

Saylam, S. K., 1999. The effects of egg weight and storage time on egg weight loss and hatchability traits in japanese quail. Tr. J. of Veterinary and Animal Sci., 23:367-372.

Shanawany, M.M., 1984. Inter-relationship between egg weight, parental age and embryonic development. British Poultry Sci., 25:449-455.

Shanawany, M.M., 1981. Hatching weight in relation to egg weight in domestic birds. World Poultry Sci., 45: 107-115.

Silversides, F. G. and T. A. Scott, 2001. Effect of storage and layer age on quality of eggs from two lines of hens. Poultry Sci., 80:1240-1245.

Sittman, K., H. Abplanalp and R. A. Fraser, 1990. Bobwhite Quail Production. Clemson University Extension Bulletin. U.S.A.

Snedecor, G.W. and W. G. Cochran, 1980. Statistical method. Seventh edition. (Ames, Iowa, U.S.A., The Iowa State University Press).

SPSS for Windows, 1999. Release 9.0., Standard version. Copyright SPSS Inc.

Sreenivasaiah, P.V. and B. S. Ramappa, 1985. Influence of mating ratio and pre-incubation storage on fertility and hatchability of japanese quail. World Review of Animal Production, 21:3-5:25-28.

Tserveni-Gousi, A. S., 1986. Relationship between parental age, egg weight and hatching weight of japanese quail. British Poultry Sci., 28:749-752

Uluocak, A. N., F. Okan, E. Efe, and H. Nacar, 1995. Exterior and interior quality characteristics of eggs and their variation according to age in japanese quail. Tr. J. Vet. Anim. Sci., 19:181-185

Wilson, H. R. and M. V. J. Holland, 1974. Male to female ratios for bobwhite quail breeders. Poultry Sci., 53:4:1571-1575.

Woodard, A. E. and P. H. Alplanalp, 1967. The effect of mating ratio and age on fertility and hatchability in japanese quail. Poultry Sci., 46:383-388.

Yannakapoulus, A. L. and A. S. Tservesi-gousi, 1987. Relationship of parent's age and hatching egg weight and shell quality to day old chick weight as influenced by oviposition time. Poultry Sci., 66:829-833.

Yildirim, I. and R. Yetisir, 1998. Effects of hatching egg weight and parental age on the hatching weight and 6th week live weight in japanese quail (Coturnix coturnix Japanese). Tr. J. of Veterinary And Animal Sci.., 22:315-319.