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EFFECTS OF DIVERGENT SELECTION FOR 35-DAY BODYWEIGHT ON REPRODUCTIVE TRAITS OF JAPANESE QUAIL IN NIGERIA

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A study was conducted to determine the effect of divergent selection for 35-day body weight on some reproductive traits of Japanese quail. A total of 1,500 chicks obtained from the National Veterinary Research Institute in Vom, Plateau State served as the base population from which 'High Line' and 'Low Line' were established based on individual body weight at 35-days of age. A random sample of the base population was maintained as the Control Line. Random mating was made within Line at the ratio of one male to three females and eggs were collected for incubation to produce subsequent generations using the same selection procedure. Data obtained on age at first egg, body weight at first egg, fertility and hatchability over five generations of selection were analysed within and between Lines using One-way Analysis of Variance procedure. The High body weight Line attained sexual maturity at a significantly (P<0.05) lower age (40.56 days) than the Low body weight Line which reached sexual maturity at 59.78 days. Body weight at sexual maturity was highest in the High body weight Line (143.63g) followed by the Control (133.64g) and lowest in the Low body weight Line (113.33g). Percentage fertility of incubated eggs showed no significant (P>0.05) differences among experimental lines in all generations except generation four. Over the five generations of selection, the Low weight lines had the highest fertility (86.07%). Percent hatchability over the five generations of selections in the three lines showed no significant (P>0.05) differences though the High body weight line had the highest mean value (44.37%). Mean hatchability of fertile eggs for the five generations of selection was highest in the High Body Weight line (53.18%) though not significantly (P>0.05) higher than the Control (50.86%), and the Low line (43.49%). Hatch weight increased with progress in selection. At the end of five generations, mean hatch weight differed significantly (P<0.05). Mean values were 6.42g, 6.08g and 5.79g for the High Control and the Low lines respectively. Chick: Egg weight ratios were not significantly (P>0.05) affected in all generations, though there was an increase with progress in selection in the High line. The results showed that selection for high 35-day body weight is desirable to improve the hatchability, chick weight and age at sexual maturity in Japanese quail.

Keywords: Age at sexual maturity, bodyweight at sexual maturity, fertility, hatchability.

Japanese quails have been employed as a pilot animal in quantitative genetic studies because of its short generation interval and lesser resource requirement (Anthony *et al*. 1996). Selection for live weight has been reported to affect age and body weight at sexual maturity (Shalan *et al.* 2012; Reddish *et al.* 2003; Karabag *et al.* 2010; Sadeghi *et al.* 2013). Oruwari and Brody (1988) have reported an inseparable interaction between chronological age, body weight and body composition for the onset of sexual maturity. An important attributes of parent stock performance are fertility and hatchability. Selections for increased growth rate in the avian species have been reported to result in depressed egg production, fertility and hatchability of the birds (Marks, 1979; Siegel and Dunnington, 1985). Selection for traits beside reproductive fitness often results in a negative correlation between the selected trait and reproductive fitness, this negative correlation has been shown to be true between growth rate and reproductive traits such as female fertility and egg traits (Bunan and Pym, 1991). In the Japanese quail, wide differences have been reported for fertility and hatchability values and these differences have been attributed to the amount of water loss during incubation and other environmental differences (Vasconcelos *et al.* 2008). Nazligul *et al*. (2001) had reported the proportional increase of fertility and the hatchability of fertile eggs with egg weight. Higher hatchability in heavier birds than in medium and light weight birds have also been reported (Ipek *et al*. 2004). There is however, paucity of records on the possible effects of divergent selection for body weight on reproductive traits of Japanese quail in Nigeria. Limited reports (Ojo *et al.* 2012; Okeniyi *et al*. 2013) showed that the performance of these birds is lower in sub-Saharan African countries like Nigeria. The study therefore examines the effect of short term divergent selection for 35-day body weight on reproductive traits of Japanese quail birds in Nigeria.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Poultry unit of the Department of Animal Production, Faculty of agriculture, University of Ilorin. All experiments were implemented in accordance with Institutional guidelines on the care and use of animals for scientific studies, and in compliance with generally accepted rules of best practice worldwide.

Origin and management of experimental birds

A total of 1,500 day-old Japanese quail chicks obtained from a random-bred population maintained at the National Veterinary Research Institute (NVRI), Vom, Plateau state, Nigeria served as the base population. Chicks were weighed on arrival and transferred into electrically-heated brooder pens. All chicks received a starter ration of 24% Crude Protein and 2800Kcal/kg of metabolizable energy and breeder rations of 19% Crude Protein and 2700Kcal/kg of metabolizable energy as recommended by the NVRI. Feed and water were provided *ad libitum* throughout the experimental period. At 35 days of age, 1,331 birds were wing-tagged, visually-sexed by plumage colour and weighed. Selection was based on individual body weight at 35 days of age. High (H) and Low (L) 35-day body weight (BW) lines were established based on individual body weight at that age. The H Line consisted of all individual birds having body weight greater than one standard deviation above the population mean weight (Pop mean + 1σ) while all individuals which had body weight less than one standard deviation below the population mean (Pop mean -1σ) were designated as the Low line. A random sample of the base population was maintained as the Control (C) Line for estimating environmental effects and genetic improvements. Selection was not changed at any time during the experiment in the two selected lines. The selected populations and the Control line were grown inter-mingled in order that temperature, humidity, light intensity and other variables would be as similar as possible among populations.

Egg collection, storage, incubation and selection in subsequent generations

Random mating was maintained at a ratio of one male to three females in the appropriate body weight direction to propagate the first filial generation. From the different Lines, eggs were collected daily, weighed and incubated weekly after storing at room temperature of 12 – 15^{0}C. Eggs were incubated in separate trays based on the selection line using a natural draught kerosene incubator. Eggs were incubated at 37.5^{0}C and at an accurate percentage of relative humidity for 17 days. During incubation, eggs were turned manually three times daily until the 14th day. At the end of the incubation period, all unhatched eggs were checked for fertility. At hatch, chicks were weighed and managed under identical conditions as described for the base population. At 35 days of age, birds in each Line were visually sexed by plumage colour and weighed. Selection method used in establishing Generation One parents from the base population was repeated to obtain the parents for subsequent generations maintaining the same ratio of male to female. Each line was kept in separate pens for data collection.

Age at First Egg was taken as the number of days to sexual maturity. That is, average of three consecutive days from hatch to the day on which eggs were sighted in each Line (Ayorinde *et al.* 1988).

Body Weight at Sexual Maturity was measured in grams as the average weight of the birds in the pen at first egg.

Percent fertility was obtained from the equation = (Number of fertilized eggs / total number of eggs placed in the incubator) X 100.

Hatchability of egg set was calculated in percentages as (Number of hatched chicks / Total number of Eggs Set) X 100.

Hatchability of fertile eggs was obtained as (Number of hatched chicks / Number of fertilized eggs placed in Incubator) X 100.

Chick Weight to Egg Weight ratio was obtained from the equation: Average weight of chicks / Average weight of egg set x 100.

Statistical analysis

All data obtained were analysed within and between Lines using the One-Way Analysis of Variance procedure of SPSS Version 16 (IBM SPSS, 2008). Any significant differences among means were separated by use of the Duncan's Multiple Range procedure option in SPSS 16 (SPSS IBM). Means were calculated within and between lines for all measured variables.

RESULTS AND DISCUSSIONS

Age at sexual maturity

The mean age at first egg in five generations of quails divergently selected for 35-day body weight is shown in Table 1. Divergent selection for body weight in this study resulted in significant differences in average age at sexual maturity among selected Lines. Average age at first egg was significantly ($P<0.05$) lower in the High body weight line in all generations than the Low body weight line. Though the High body weight line attained sexual maturity at an earlier age than the Control in all generations, the differences were not significant ($P>0.05$) except at the base population. The Low body weight lines reached sexual maturity at 12, 19, 17, 22.67, 32 and 12.66 days later than the High body weight line in the base population and at Generations one, two, three, four and five, respectively. On the average, the High line reached maturity 3.83 and 19.22 days earlier than the Control and Low lines respectively. Within experimental lines across generations, age at sexual maturity though increasing with progress in selection, showed no significant differences in the Control and Low body weight lines. However, in the High body weight lines, age at sexual maturity was significantly ($P<0.05$) higher by 7.67 days in the fifth generation of selection than the base population. This is in consonance with the reports of Gunes and Cerit (2001) and Reddish *et al.* (2003) who reported that quails that grew quickly reached the age of sexual maturity much earlier. This however, does not support the results of Dobalova *et al.* (1983) and Oguz *et al.* (2001) who reported delay in lines selected for High body weight in reaching age at sexual maturity. It also contradicts the findings of Sadeghi *et al.* (2013) who reported highest age in High Lines of Japanese quails selected divergently for 4-week body weight over nine generations. Average age at sexual maturity reported in this study for all experimental lines falls within the ranges reported by several authors for age at sexual maturity in the Japanese quail. Turkmut *et al.* (1999) had reported an average age of 46 days to onset of sexual maturity in Japanese quails selected for 4-week body weight over three generations while Gunes and Cerit (2001) reported an average of 45.9 days to sexual maturity, Thomas and Ahuja (1988) reported a range of 48.9 - 49.6 while Camci *et al.* (2002) and Drbohlav and Metodiev (1996) reported an average of 44.9 and 63.3 days to sexual maturity in unselected quails. A number of factors have been shown to contribute to the considerable variability observed in the onset of egg production in poultry birds. These have been thought to be a result of environmental, genetic and physiological factors including photoperiod, nutrition,

Table 1 Effect of divergent selection for 35-day body weight on age (days) at first egg (AFE)

	Lines		
Generations	High	Control	Low
0	$38.00\pm1.00^{c,xy}$	45.00 ± 1.00^{b}	50.00 ± 1.00^{a}
1	$41.67\pm3.51^{b,xy}$	45.00 ± 1.73^{b}	60.67 ± 3.06^{a}
2	$42.00\pm1.00^{b,yz}$	44.67 ± 2.52^{b}	59.00 ± 7.00^{a}
3	$39.00\pm2.65^{b,xy}$	42.33 ± 2.08^{b}	61.67 ± 4.04^{a}
4	$37.00\pm2.00^{b,xy}$	41.00 ± 1.00^{b}	69.00 ± 16.46^{a}
5	$45.67\pm1.53^{b,z}$	47.00 ± 1.00^{b}	58.33 ± 3.79^{a}
$\bar{x}$ AFE	40.56 ± 3.50^{c}	44.39 ± 2.28^{b}	59.78 ± 8.69^{a}

$^{a\text{-}c}$ Means in the same row having different superscripts differ significantly (P<0.05
, $^{x\text{-}z}$ Means in the same column having different superscripts differ significantly (P<0.05)

Table 2 Effect of divergent selection for 35-day body weight on body weight (g) at first egg (BFE)

	Lines		
Generations	High	Control	Low
0	$117.80\pm11.40^{a,w}$	$113.71\pm17.04^{ab,x}$	$108.10\pm13.79^{b,y}$
1	$128.02\pm14.37^{a,x}$	$122.72\pm19.81^{a,x}$	$109.86\pm16.89^{b,y}$
2	$165.34\pm9.64^{a,y}$	$149.35\pm22.04^{b,yz}$	$135.65\pm12.99^{c,z}$
3	$162.14\pm13.74^{a,yz}$	$146.55\pm13.08^{b,z}$	$137.12\pm9.69^{b,z}$
4	$163.14\pm10.68^{a,yz}$	$136.83\pm19.50^{b,y}$	$141.37\pm19.26^{b,z}$
5	$171.70\pm13.69^{a,z}$	$141.06\pm21.15^{b,yz}$	$121.07\pm8.11^{c,y}$
$\bar{x}$ BFE	143.63 ± 24.26^{a}	133.64 ± 22.91^{b}	113.33 ± 17.78^{c}

$^{a\text{-}c}$ Means in the same row having different superscripts differ significantly (P<0.05)
$^{w\text{-}z}$ Means in the same column having different superscripts differ significantly (P<0.05)

Table 3 Effect of divergent selection for 35-day body weight on incubation characteristics (%) of Japanese quail eggs

	Fertility			Hatchability of Eggs Set			Hatchability **of Fertile Eggs**		
Gen	High	Control	Low	High	Control	Low	High	**Control**	**Low**
1	88.08 ± 2.70^{x}	90.10 ± 2.19	91.30 ± 1.27	37.73 ± 6.05^{x}	44.44 ± 1.98^{yz}	37.13 ± 7.80	42.95 ± 7.77^{x}	48.00 ± 2.46^{y}	40.59 ± 8.04
2	70.32 ± 4.55^{y}	71.87 ± 17.47	82.07 ± 9.97	35.51 ± 7.27^{x}	34.83 ± 7.76^{x}	30.27 ± 3.62	51.01 ± 13.24^{y}	49.72 ± 4.05^{y}	36.90 ± 1.51
3	89.66 ± 2.25^{y}	88.41 ± 2.42	84.07 ± 6.77	42.79 ± 7.64^{x}	39.18 ± 2.26^{xy}	42.75 ± 14.75	47.78 ± 8.73^{xy}	36.82 ± 6.05^{x}	49.62 ± 13.41
4	$85.51\pm0.51^{b,y}$	76.47 ± 0.50^{c}	88.34 ± 1.38^{a}	$44.75\pm3.82^{ab,x}$	$50.65\pm1.31^{a,z}$	41.94 ± 3.71^{b}	$52.37\pm4.78^{b,y}$	$66.24\pm2.14^{a,z}$	47.56 ± 4.94^{b}
5	85.73 ± 5.52^{y}	85.99 ± 1.13	84.56 ± 4.39	$61.05\pm13.44^{a,y}$	$46.11\pm4.66^{ab,yz}$	36.33 ± 6.47^{b}	$71.79\pm18.25^{a,z}$	$53.55\pm4.71^{b,y}$	42.79 ± 5.78^{b}
mean	83.86 ± 7.80	82.57 ± 9.99	86.07 ± 5.98	44.37 ± 11.64	43.04 ± 6.76	37.68 ± 8.44	53.18 ± 14.12	50.86 ± 10.43	43.49 ± 8.14

$^{a\text{-}c}$ Means in the same row having different superscripts differ significantly (P<0.05)
$^{x\text{-}z}$ Means in the same column having different superscripts differ significantly (P<0.05)
Gen- Generations

body composition and age of the birds (Zelenka *et al.* 1984). Since the different lines used in this study were reared under similar conditions, variation observed in onset of lay could therefore be of genetic origin. Relationships between chronological age, body weight, body composition, and sexual maturity have been reported to be complex with a minimum body fat threshold required for sexual maturity (Oruwari and Brody, 1988). The High weight line in this study must have been able to attain the

Table 4 Effect of divergent selection for 35-day body weight on hatch: egg weight ratio of Japanese quail

	Egg Weight (g)			Hatch Weight (g)			Hatch: Egg Weight Ratio		
Gen	High	Control	Low	High	Control	Low	High	Control	Low
1	9.34± 0.16^{a,x}	8.83± 0.06^{b}	8.77± 0.14^{b}	6.11± 0.09^{a}	5.44± 0.03^{b,x}	5.84± 0.30^{a,xy}	65.42± 1.58	61.61± 0.11	66.59± 4.47
2	9.86± 0.07^{a,z}	8.87± 0.09^{b}	8.97± 0.21^{b}	6.44± 0.27^{a}	5.83± 0.03^{b,y}	5.88± 0.30^{b,xy}	65.31± 2.38	65.73± 0.58	65.55± 4.01
3	9.73± 0.22^{a,yz}	8.96± 0.30^{b}	8.44± 0.18^{c}	6.47± 0.09^{a}	6.45± 0.03^{a,z}	5.55± 0.07^{b,x}	66.50± 2.46	71.99± 2.06	65.76± 0.74
4	9.48± 0.06^{a,xy}	9.42± 0.39^{a}	8.83± 0.25^{b}	6.43± 0.21^{a}	6.36± 0.16^{a,z}	5.55± 0.23^{b,x}	67.83± 2.27	67.52± 3.80	62.85± 2.12
5	9.67± 0.16^{a,yz}	9.21± 0.11^{b}	8.95± 0.29^{b}	6.66± 0.23^{a}	6.31± 0.22^{ab,z}	6.15± 0.20^{b,y}	68.87± 1.35	68.51± 2.79	68.72± 2.51
mean	9.62± 0.23^{a}	9.06± 0.30^{b}	8.79± 0.27^{c}	6.42± 0.25^{a}	6.08± 0.41^{b}	5.79± 0.31^{c}	66.74± 2.27	67.12± 4.06	65.87± 3.27

$^{a-c}$ *Means in the same row having different superscripts differ significantly (P<0.05)*

$^{x-z}$ *Means in the same column having different superscripts differ significantly (P<0.05)*

Gen-Generation

threshold for the onset of sexual maturity earlier than the low Line due to its faster growth rate.

Body weight at first egg

Table 2 shows the effect of divergent selection for 35–day body weight on body weight at first egg in the Japanese quail. Among experimental lines, mean body weight at first egg was significantly higher (P<0.05) in the High body weight line than the Control except in Generations 0 and 1 and the Low body weight line in all generations. The Control and the Low weight lines also had similar (P>0.05) body weight at first egg except in Generations one, two and five. Overall mean for all generations showed statistical differences (P<0.05) with the High weight line having the highest body weight of 143.63g at first egg and the Low body weight line having the least (113.33g). Body weight at first egg in the Control was 133.64g. Within experimental lines, body weight at first egg improved significantly (P<0.05) in all lines as selection progressed and by the fifth generation of selection, body weight at first egg had improved by 53.90g, 27.37g and 12.97g in the High, Control and the Low body weight lines respectively. The differences in body weight at first egg in Generation One between the High and the Control and Low lines were 5.3g and 18.16g respectively but by the fifth generation, the differences had increased to 30.44g and 50.63g respectively. The significantly higher body weight at sexual maturity recorded for the High weight birds over the random-bred Control and the Low weight ones in this study is in agreement with the studies of Karabag *et al.* (2010) and Sadeghi *et al.* (2013) who also reported significantly higher body weight at sexual maturity in the High Lines than the random-bred Control and the Low Lines of Japanese quails selected divergently for five and four-week body weight respectively. Increase in body weight with progress in selection also agrees with the report of Oguz *et al.* (2001) who reported changes in body weight at sexual maturity in Japanese quails selected for four-week body weight. Kosba *et al.* (2003) had also indicated that improving body weight at six weeks of age had positive effect on increasing body weight at sexual maturity while Gunes and Cerit (2001) reported correlations between body weight at various ages and body weights at sexual maturity to be positive and significant.

Fertility and hatchability characteristics

Table 3 shows the fertility and hatchability characteristics in five generations of Japanese quails selected divergently for 35-day body weight. The result on fertility of eggs set in all experimental lines showed fertility rates in Japanese quails to be high ranging from 70.32 to 91.30%. This falls within the range reported by Sadeghi *et al.* (2013) who also reported high percentage fertility (71 - 88%) in quails divergently selected for 4-week body weight over nine generations. Ojo *et al.* (2012) had earlier reported high percent fertility of 79.4 and 73.5 in large and medium-sized Japanese quail eggs. Khaldari *et al.* (2010), on the other hand, reported a lower fertility rate of 67% in five generations of selection for increasing six week body weight. The non-significant effect in percent fertility among lines was similar to the report of Nestor (1985) who found no significant effect in percent fertility of eggs in turkey selected divergently for 16-week body weight. The numerically lower fertility observed in the High body weight lines however agrees with the reports of Bunan and Pym (1991) that selection for increased growth rate in the avian species do result in depressed fertility of the birds. Anthony *et al.* (1996) have also indicated the negative effect of selection on fitness traits in the Japanese quail. Hatchability of incubated eggs showed no significant differences (P>0.05) among experimental lines except in the fourth and fifth generations when the Low body weight line had significantly (P<0.05) lower percent hatchability than the Control in Generation Four and the High line in Generation Five. Hatchability fluctuated greatly in successive generations in the three experimental lines. In the High body weight line, hatchability improved as generation progressed and by the fifth generation, hatchability of incubated eggs had improved significantly (P<0.05) from 37.73% in the first generation to 61.05% in the fifth generation. Average hatchability of incubated eggs for the five generations of selections in the three lines also showed no significant (P<0.05) differences though the High body weight line had the highest mean value (44.37%) followed by the Control (43.04%) with the Low weight line having the least (37.68%). Hatchability of fertile eggs also showed no significant differences (P>0.05) among the lines except in the fourth generation where the Control group had significantly (P<0.05) higher hatchability than both the High and Low body weight groups by 13.87% and 18.68% respectively, and in Generation Five when the High body weight line had significantly (P<0.05) higher value (71.79%) than the random bred Control and Low body weight. As generation progressed, selection for 35-day body weight significantly (P<0.05) improved hatchability of fertile eggs in the fifth generation of the High Line (71.79%) and in the fourth generation of the random-bred Control (66.24%). Average hatchability of fertile eggs for the five generations of selection among lines showed no significant differences (P>0.05). However High body weight line had the highest value (53.18%). Higher hatchability recorded in the High weight birds over the random bred Control and the Low weight birds is in line with the report of Ipek *et al.* (2004) who also observed higher hatchability in heavier birds than in the medium and the light weight birds. Selection for High body weight in this study was found to improve percent hatchability of total eggs significantly and hatchability of fertile eggs. This is in contrast to the reports of Sadeghi *et al.* (2013) and Marks (1996) who both reported that hatchability percent in selected lines were significantly lower than in Control lines. Egg weight was reported by Altan *et al.* (1995) to be critical to hatchability. Narahari *et al.* (1988) corroborated this and postulated that hatchability is directly proportional to egg weight. Better hatchability observed in the High body weight line in this study could therefore have resulted from the heavier eggs set for incubation.

Table 4 shows the effect of divergent selection for 35-day body weight on egg to hatch weight ratio of Japanese quail. The value for hatch weight reported in this study ranged between 5.44g and 6.66g and is similar to the report of Musa *et al.* (2008) who reported an estimate of 6.0g of body weight in both sexes at hatch. Marks (1995) however reported a range of 6.3g and 6.6g for body weight at hatch through random-bred population of Japanese quails. The significantly larger egg weight selected for incubation in the High weight birds than the Low and the random bred Control Lines also resulted in significantly larger hatchling weight of chicks. This agrees with the results of Farooq *et al.* (2001) and Petek *et al.* (2003) who both reported positive interrelation between egg weight and hatchling weight. Thus, smaller eggs would normally produce smaller chicks while bigger eggs would produce larger chicks. The ratio of the hatching chick weight to the weight of the egg set ranged from 61.59 to 72.03% and was similar to the value estimated by Wilson (1991), Murad *et al.* (2001) and Khurshid *et al.* (2004). These authors have reported a range of 62-76% for hatchling chick weight to weight of eggs set. The weight of chick as a percent of egg weight has been reported to be fairly constant across species, for instance Ayorinde *et al.* (1994) reported a value of 72.42 % in guinea fowl, while Murad *et al.* (2001) and Khurshid *et al.* (2004) reported 67.3% and 68.2% in Fayoumi chickens and Japanese quails, respectively. The non-significance of these values in all experimental lines also showed that weight loss during incubation was proportionate to egg size.

CONCLUSION

The results of this study revealed that selection for increased 35-day body weight results in reduction in age at which sexual maturity is reached while improving body weight at the time. Hatchability, hatch weight and chick to egg weight ratio of Japanese quails were also improved. This can be of help to breeders in decision making for breeding programmes in the Japanese quail.

REFERENCES

1. Altan O., Oguz, I. and Settar P. (1995). Japon Bildircinlarinda Yumurta Agirlik Ile Ozgul Agirligin Kulucka Ozelliklerine Etkileri. *Turk J. Agric. Forest.* 19, 219-222.
2. Anthony N.B., Nestor K.E. and Marks H.L. (1996). Short-term selection for four-week body weight in japanese quail. Poult. Sci. 75, 1192-1197.
3. Ayorinde K.L., Atteh J.O. and Joseph K. (1994). Pre and post hatch growth of nigerian indigenous guinea fowl as influenced by egg size and hatch weight. Nig. J. Anim. Prod. 21, 55-59.
4. Ayorinde K.L., Toye A.A. and Aruleba O.A. (1988). Association between body weight and some egg production traits in a strain of commercial layer. Nig. J. Anim. Prod. 15, 119-121.
5. Bunan A.T. and Pym R.A.E. (1991). Proc. of Australian Poult. Sci. Symp. 3, 41-45.
6. Camci O., Erensaymn C. and Aktan S. (2002). Relations between age at sexual maturity and some production characteristics in quail. Arch Geflugelk, 66, 280-282.
7. Dobalova M., Bulla J. and Granat J. (1983). The effect of light on the growth and egg yield in three lines
8. of Japanese quails. Proc. 5th International Symp. Actualproblems of Avian Genetics, Piestany, Czeschoslovakia, March 21-24, 1983, Research Institute of Animal Production, Nitra, Czechoslovakia,
9. pp: 131-137.
10. Drbohlav V. and Metodiev S. (1996). Possibility of selection on laying intensity in Japanese quail (Coturnix coturnix japonica). Bulg. J. Agric. Sci. 2, 497-500.
11. Gunes H. and Cerit H. (2001). Interrelationships between age of sexual maturity, body weight and egg production in the Japanese quail (Coturnix coturnix Japonica). İstanbul Üniversitesi Veteriner Fakültesi Dergisi. 27, 191-198.
12. Farooq M., Aneela K., Durrani F., Mugarrab A.K., Chand N. and Khurshid A. (2001). Egg and shell weight, hatching and production performance of Japanese broiler quail. Sarhad J. Agric. 17, 289-293.
13. Ipek A., Sahan U. and Yilmaz B. (2004). The effect of live weight, male to female ratio and breeder age on reproduction performance

in japanese quails (Coturnix coturnix japonica). S. African J. Anim. Sci. 34, 130-134.
14. Khaldari M., Pakdel A., Yegane H.M., Javaremi A.N. and Berg B. (2010). Response to selection and genetic parameters of body and carcass weights in Japanese quail selected for 4-week body weight. Poult. Sci. 89(9), 1834-1841.
15. Khurshid A., Farooq M., Durrani F.R., Sarbiland K. and Manzoor A. (2004). Hatching performance of
16. Japanese quails. Livestock Res. Rur. Dev. 16. art. #2, from http://www.cipav.org.co/lrrd/lrrd16/1/khur161.htm. Accessed June 2012.
17. Karabağ K., Alkan S. and Balcioğlu M.S. (2010). The Differences in some production and clutch traits in divergently selected Japanese quails. *Kafkas* Üniversitesi Veteriner Fakültesi Dergisi, 16(3), 383-387.
18. Kosba M.A., Bahie El-Deen M. and Shalan H.M. (2003). Long-Term Selection for Body Weight in Japanese Quail under Egyptian Conditions 3-Correlated response of some egg production traits. Egypt. Poult Sci., 23, 961-975.
19. Marks H.L. (1979). Growth rate and feed intake of selected and non-selected broilers. Poult. Sci. 58, 269-274.
20. Marks H.L. (1995). Heterosis on overdominance following long-term selection for body weight in Japanese quail. Poult. Sci. 74(11), 1730-1744.
21. Marks H.L. (1996). Long term selection for body weight in Japanese quail under different environments. Poult. Sci. 75, 1198-1203.
22. Murad A., Farooq M., Mian M. A. and Muqarrab A.K. (2001). Hatching performance of Fayoumi Eggs. Sarhad J. Agric. 17(1), 1-6.
23. Musa U., Haruna E. S. and Lombin L. H. (2008). Quail Production in the Tropics. National Veterinary Institute Press, Vom, Nigeria.
24. Narahari D., Abdul Mujeeri K., Thangavel A., Ramamurthy N., Viswanathan S., Mohan B., Muraganandan B. and Sundararasu V. (1988). Traits influencing the hatching performance of Japanese quail eggs. Br. Poult. Sci., 29, 101-112.
25. Nazligul A., Bardakcioglu H.E., Turkyilmaz N.K. and Oral D.C. (2001). The effect of cage density on egg weight, egg production and feed consumption in Japanese quails. J. Fac.Vet. Med. Uni. 27(2), 429-438.
26. Nestor K.E. 1985. Genetics of growth and reproduction in the turkey. 10. Tandem selection for increased body weight and egg production. Poult. Sci., 64, 2221–2222.
27. Oguz I., Akbas Y. and Altan O. (2001). Relationship of body weight at sexual maturity and with body weights at various ages in lines of Japanese quail unselected and selected for four week body weight. Appl. Anim. Res. 19, 219-223.
28. Ojo V., Ayorinde K.L., Fayeye T.R. and Josiah B.O. (2012). Effect of egg weight on hatchability and growth performance of the Japanese quail in Nigeria. Nig. J. Gen. 26, 180- 185.
29. Okenyi N., Ndofor-Foleng H.M., Ogbu C.C. and Agu C.I. (2013). Genetic parameters and consequences of selection for short-term egg production traits in Japanese quail in a tropical environment. African. J. Biotech. 12(12), 1357-1362.
30. Oruwari B.M. and Brody T. (1988). Roles of age, body weight, and composition in the initiation of sexual maturation of Japanese quail (Coturnix coturnix japonica). Br. Poult. Sci. 29, 481–488.

31. Petek M., Baspinar H. and Ogan M. (2003). Effects of egg weight and length of storage period on hatchability and subsequent growth performance of quail. S. African. J. Anim. Sci. 4, 242–247.
32. Reddish J.M., Nestor K.E. and Lilburn M.S. (2003). Effect of selection for growth on onset of sexual maturity in random bred and growth-selected lines of Japanese quail. Poult. Sci. 82, 187-191.
33. Sadeghi R., Pakdel A., Moradi Shahrbabak M. and Moradi Shahrbabak H. (2013). Divergent selection effect on reproductive trait in Japanese quails. Res. J. Poult. Sci. 6, 18-22.
34. Shalan H.M., Nadia A.E. and Rizk R.E. (2012). Estimates of genetic parameters for egg production and egg quality in local chicken strains. Egyptian Poult. Sci., 32(11), 399-411.
35. Siegel P.B. and Dunnington E.A. (1985). In: Poultry Genetics and Breeding Eds. W. G. Hill, J. M. Manson and D. Hewitt: 59-72. Longman Harlow.
36. SPSS 17.0. (2008). SPSS 17.0 Command Syntax Reference 2008, SPSS Inc., Chicago. http://www-01.ibm.com/software/analytics/spss/?prod_id=SPSS.
37. Thomas P.C. and Ahuja S.D. (1988). Improvement of broiler quails of cari through selective breeding. Poult. Guide, 25, 45-47.
38. Türkmut L., Altan Ö., Oguz I. and Yalçin, S. (1999). Effects of selection for four week body weight on reproductive performance in Japanese quail. Trin. J. Vet. Anim. Sci. 23: 229-234.
39. Vasconcelos T.G., de Moraes Moura Romao J., Evangelista da Silva E., Maciel Cardoso W., and Buxadé Carbó C. (2008). Incubation of Japanese Quail Eggs (Coturnix japonica) Stored in Domestic Refrigerator. Lives Res. Rur. Dev. 20(10). http://www.lrrd.org/lrrd20/10/vasc20164.htm.
40. Wilson H.R. (1991). Interrelationships of egg size, chick size, post-hatching growth and hatchability. World's Poult. Sci. J., 47(1), 5-20.
41. Zelenka D.J., Cherry J.A. Nir I. and Siegel P.B. (1984). Body weight and composition of Japanese quail (Coturnix coturnix japonica) at sexual maturity. Growth, 48, 16–28.

