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Body Characteristics, Development of Reproductive Organs, Carcass Composition and Onset of Sexual Maturity in the Female Japanese Quail

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ABSTRACT. *Day-old female Japanese quails (Coturnix coturnix japonica) were fed with a diet containing 24% crude protein and 3000 kcal kg^{-1} metabolic energy up to 42 days of age. Individual body weights were measured weekly. Quails were slaughtered at 14, 21, 28, 35 and 42 days of age and their live weights, physical attributes and weight of the reproductive organ were recorded. The carcass composition was also analysed.*

Live weight of quails significantly increased up to 42 days of age. The quails commenced egg laying around 42 days of age at a body weight of around 169 g. Tibia length was found to increase up to 28 days of age. Weights of breast muscle and liver increased up to 35 days while weight of carcass increased up to 42 days of age. Total amounts of carcass protein and ash increased from 14 days of age while total amount and % of carcass fat abruptly increased from 28 days of age. A rapid development of oviduct and ovary took place at 28 and 35 days, respectively. Body, ovary and oviductal weights were found to be greater in mature quail than in immature counterparts.

The quail line investigated belongs to a line that has intermediate live weight. Weekly live weight gains increased up to 28 days of age and decreased up to 42 days. The skeletal development was completed by 28 days while the lean body growth was completed by 35 days. Total amounts of carcass protein and ash increased while their percentages remained constant with increasing age. A rapid deposition of body fat, which commenced at 28 days of age, coincided with the growth of the ovary and oviduct. Attainment of sexual maturity in the female Japanese quail appears to be due to a combined effect of several factors.

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INTRODUCTION

Female Japanese quail which are widely used in poultry research, grow at an increasing rate up to 3 (Mishra *et al.*, 1993) or 4 (Oguz *et al.*, 1996; Vohra and Roudybush, 1971) weeks of age and at a decreasing rate thereafter to reach sexual maturity at about 6 weeks (Steigner *et al.*, 1989; Wilson *et al.* 1961). It has been reported that a considerable variation exists in live weights among the different lines of quail (Anthony *et al.*, 1986; Anthony *et al.*, 1993; Mishra *et al.*, 1993; Oguz *et al.*, 1996). A remarkable increase in the weights of the ovaries of quails has been observed after 30 (Kobayashi and Wakiya, 1966) and 35 (Yannakopoulos *et al.*, 1995) days. Yannakopoulos *et al.* (1995) reported a strong positive and a negative relationship of carcass fat and protein with age, respectively. However, others have reported different trends between age and carcass composition in Japanese quail (Edwards, 1981; Marks, 1993). These findings indicate that Japanese quail lines which have been derived from divergent selection for live weights show marked variations in growth rate, live weight, reproductive organ weight and carcass composition among their lines. Age, live weight, body composition (Oruwari and Brody, 1988), carcass fat (Yannakopoulos *et al.*, 1995) and multiple threshold traits associated with growth and body composition (Zelenka *et al.*, 1984) are critical for the onset of sexual maturity in female Japanese quail.

Therefore, this experiment was conducted to investigate body growth, physical attributes, development of reproductive organs and carcass composition during the juvenile growth phase in female Japanese quail.

MATERIALS AND METHODS

Stock management and feeding

Day–old female Japanese quail (*Coturnix coturnix japonica*) chicks hatched at a commercial hatchery (Tokaikigyou Co., Toyohashi, Japan) were maintained in an electrically heated battery brooder. The brooder temperature was maintained at 33–36°C during the initial 7 days and gradually reduced to room temperature. At 14 days of age individual live weights were measured and 80 birds within ±22% of the average live weight were randomly selected for the experiment. Corn–soybean meal diet containing 24% crude protein (CP) and 3000 kcal kg^{-1} metabolizable energy (ME) was formulated (Table 1) to meet or exceed the minimum nutritional requirements for growth of quail (NRC, 1984) and was supplied *ad libitum* from 1 to 42 days of age. To identify the birds more precisely at the onset of lay, they were assigned to

individual cages at 28 days of age. Throughout the experimental period, a light (L) : dark (D) regime of 16 h : 8 h was maintained.

Table 1. Composition of the experimental diet.

Ingredient	Composition (kg/100kg)
Corn	58.26
Soyabean meal	28.31
Fish meal	10.01
Corn oil	1.82
DL–Methionine	0.01
Choline	0.04
NaCl	0.22
$Ca_3(PO_4)_2$	0.33
$CaCO_3$	0.60
Vitamin premix[1]	0.25
Mineral premix[2]	0.15
Proximate composition	
Crude protein (%)	24.18
Ether extract (%)	4.42
Estimated ME (kcal kg^{-1})	3002

[1] Vitamin premix provided per kg of diet: vitamin A 12500 IU; vitamin D 3000 IU, DL-∝-tocopherylacetate 62.50 mg; menadione 5.0 mg; riboflavin 10.0 mg; thiamin 5.68 mg; D-pantothenic acid 40.95 mg; cyanocobalamine 0.01 mg; niacin 500.0 mg; D-biotin 0.08 mg; folacin 2.5 mg; pyridoxin 9.13 mg.
[2] Mineral premix provided per kg of diet: $MnSO_4.5H_2O$ 265.5 mg; $ZnSO_4.7H_2O$ 49.3 mg; $CuSO_4.5H_2O$ 8.0 mg.

Traits measured

Individual live weights of 1, 7, 14, 21, 28, 35 and 42 day–old quails were measured using a weighing balance. Eight birds were randomly selected at 14, 21, 28 and 35 days of age and sacrificed by bleeding through heart punch. Since some birds had commenced to lay eggs at 42 days of age, 5 sexually immature and 7 mature birds were slaughtered at this age. After

defeathering, the head, neck, feet, heart and gastro–intestinal tract were discarded. The liver, ovary and oviduct were removed and their weights were recorded immediately. During the evisceration process, the fat around the bursa of fabricius, cloaca and adjacent digestive organs up to the gizzard was designated as the abdominal fat and its weight was recorded. Carcass weight (including abdominal fat) was also measured and frozen at -28°C until analysed for carcass composition.

Carcass composition analysis

Five carcasses selected randomly from each category were thawed overnight at 4°C. Breast muscle weight and tibia length were measured. Then each carcass was minced, homogenized in a blender and replicate samples were taken to determine composition. As per AOAC (1990), each sample was analysed for carcass moisture (air–drying oven method), fat (ether extraction method), protein (macro Kjeldahl method) and ash (furnace method) contents.

Statistical analysis

Data were subjected to analysis of variance. Means of an equal and unequal replications were separated by the Duncan's new multiple range test (DNMRT), and the extension of multiple range test (Kramer, 1956), respectively.

RESULTS AND DISCUSSION

Growth and composition

Average live weights of the day–old and 7 day–old quails were 7.5 g and 20.4 g, respectively. Live and carcass weights significantly increased (Table 2) from 14 to 42 days of age ($P<0.05$). Weekly live weight gains increased up to 28 days of age and decreased thereafter. Others have also observed an increasing growth rate up to 3 (Mishra *et al.*, 1993) or 4 (Oguz *et al.*, 1996; Vohra and Roudybush, 1971) weeks of age and a decreasing growth rate thereafter. Average live weight of the quail at 42 days of age was 169 g. Under a similar feeding regime Vohra and Roudybush (1971) and Zelanka *et al.* (1984) observed an average live weight of 118 g at 42 days of age. However, Yannakopoulos *et al.* (1995) reported an average live weight of 229 g at 42 days, under an inferior diet. Thus, out of the different lines of

Table 2. Variation of physical attributes during the growth of female Japanese quail.

Variable	Age (days)					
	14	21	28	35	42[l]	42[m]
Live body weight (g)	49.4±1.58[a*]	82.6±2.09[b]	117.1±3.10[c]	136.3±2.05[d]	155.6±3.08[e]	169.4±6.03[f]
Liver[1]						
(g)	1.7±0.06[a]	2.6±0.05[b]	3.3±0.13[c]	4.9±0.34[d]	4.4±0.22[d]	4.8±0.32[d]
(%)	3.4±0.07[bc]	0.1±0.08[ab]	2.9±0.06[a]	3.5±0.21[c]	2.8±0.10[a]	2.8±0.10[a]
Abdominal Fat[1]						
(g)	-	-	0.2±0.03[a]	0.9±0.16[a]	3.2±0.65[c]	2.2±0.30[b]
(%)	-	-	0.2±0.02[a]	0.6±0.11[a]	2.0±0.40[c]	1.3±0.14[b]
Carcass[2]						
(g)	28.8±1.07[a]	55.2±0.92[b]	4.8±1.44[c]	87.9±1.16[d]	100.5±3.10[e]	9.5±4.60[e]
(%)	0.6±0.01[a]	0.6±0.01[b]	0.7±0.01[b]	0.6±0.01[b]	0.7±0.01[b]	0.6±0.01[a]
Breast Muscle[2]						
(g)	7.3±0.31[a]	16.3±0.89[b]	22.6±0.90[c]	28.7±0.55[d]	30.9±1.24[d]	30.4±1.07[d]
(%)	14.8±0.51[a]	18.8±0.87[bc]	19.7±0.83[c]	20.8±0.49[c]	19.8±0.73[c]	7.6±0.51[b]
Tibia (mm)[2]	33.2±1.06[a]	42.9±0.57[b]	48.0±0.85[c]	47.9±0.26[c]	49.1±0.63[c]	8.5±0.48[c]

[l,m] Sexually immature and mature birds.

[*] Mean±SE.
Within each row means followed by the same letter are not significantly different (P=0.05).

[1] Number of birds used were 8 at 14,21,28 and 35 days of age and 5 and 7 in immature and mature groups.

[2] Number of birds used were 5

Japanese quail with widely varying growth rates, the line used in this study seems to have an intermediate live body weight.

A significant increase ($P<0.05$) in the weights of the oviduct and ovary were observed at 28 and 35 days of age, respectively (Table 3). Several reports also indicate the ovary growth rapidly takes place from 28 (Tanaka *et al.*, 1965), 30 (Kobayashi and Wakiya, 1996) and 35 (Yannakopoulos *et al.*,

1995) days of age in Japanese quail. Since some quails reached sexual maturity at 42 days of age, it seems that quail required at least 7 days for the development and maturation of ovarian follicle. Bacon *et al.* (1973) reported that Japanese quail hens required about 6 days for rapid development of ovarian follicles.

Table 3. Weight of the reproductive organs in the female Japanese quail at various growth stages.

Age	No of birds	Ovary wt.		Oviduct wt.	
		(g)	(%)	(g)	(%)
14	8	0.03±0.01 a	0.07±0.02 a	-	-
21	8	0.05±0.00 a	0.06±0.00 a	-	-
28	8	0.08±0.01 a	0.07±0.01a	0.07±0.02 a	0.06±0.02 a
35	8	0.43±0.14 a	0.31±0.10 a	1.64±0.47 b	1.19±0.34 b
42[i]	5	2.34±1.17 b	1.70±0.75 b	3.78±1.18 c	2.43±0.76 c
42[m]	7	8.74±0.85 c	5.21±0.57 c	6.44±0.41 d	3.78±0.14 d

Data presented as mean±standard error. Within each column, means followed by the same letter are not significantly different (p=0.05). [i, m] sexually immature and mature birds.

The significant increase in the length of the tibia ($P<0.05$) which reached a plateau at 28 days of age (Table 2) is an indication that skeletal development completes at 28 days. Yannakopoulos *et al.* (1995) have reported that shank length increased until 42 days of age. In the present experiment carcass ash % (Table 4) did not change significantly, however, the total amount of carcass ash increased significantly after 14 days of age ($P<0.05$). Previous studies have reported that carcass ash % of female quail reaches a plateau at 14 days (Marks, 1993) or 21 days (Edwards, 1981) of age.

Breast muscle weight significantly increased ($P<0.05$) up to the age of 35 days and reached a plateau (Table 2). This indicates that the completion

of lean body growth is reached by approximately 35 days of age. The total amount of carcass protein increased significantly ($P<0.05$) up to 42 days. However, carcass protein percentage showed no significant increase during this period (Table 4). Lepore and Marks (1971) also reported that the total amount of carcass protein increased with age. Although a negative relationship of carcass protein percentage with respect to age has been reported by Yannakopoulos *et al.*, (1995) others have reported that carcass protein percentage remained fairly constant from 14 to 42 days of age (Lepore and Marks, 1971; Edwards, 1981; Marks, 1993). The present results support the previous findings that the total amount of carcass protein increases with age while carcass protein percentage remains constant.

Several studies have indicated that a rapid increase of carcass fat percentage occurs during a specific period, between 21 and 42 days (Marks *et al.*, 1993) or between 35 and 42 days (Edwards, 1981) of age in the Japanese quail. In the present study, a significant increase ($P<0.05$) in the total amount and % of abdominal fat was observed between 35 and 42 days of age (Table 2). In addition, both the total amount and % of carcass fat were found to increase ($P<0.05$) rapidly from 28 to 42 days of age (Table 4). Lepore and Marks (1971) showed that the % as well as total amount of carcass fat started to increase rapidly at 4 weeks of age. Yannakopoulos *et al.* (1995) have also reported a strong positive relationship between carcass fat percentage and age in the female quail between 28 and 42 days of age. The results of present study confirm the observations of Lepore and Marks (1971) in that the phase of rapid deposition of body fat commences at about 28 days of age in female Japanese quail.

Sexual maturity

Yannakopoulos *et al.* (1995) reported that the live weight of sexually matured quail (at 42 days of age) was greater by 8.3% than that at 35 days of age. However, in the present study it was observed that there were both sexually matured as well as immature quail at 42 days of age. Compared with the 35 day–old quail, average live weight of the 42 day–old immature quail was greater by 14.2% while that of the mature quail was greater by 24.4%. The sexually mature quail were heavier ($P<0.05$) than the immature quail at 42 days of age (Table 2). Therefore it is clear that live body weight plays an important role in the initiation of sexual maturity in the female Japanese quail.

Table 4. Variation of carcass composition during the growth of female Japanese quail.

Age	Carcass fat		Carcass protein		Carcass ash	
(day)	(g)	(%)	(g)	(%)	(g)	(%)
14	1.31±0.07*[a]	4.54±0.20[a]	5.45±0.21[a]	18.90±0.12[a]	1.01±0.06[a]	3.48±0.14[a]
21	2.16±0.07[a]	3.92±0.17[a]	10.76±0.26[b]	19.48±0.19[a]	2.02±0.05[a]	3.67±0.13[a]
28	3.63±0.21[a]	4.85±0.27[a]	14.89±0.31[c]	19.90±0.21[a]	2.87±0.08[b]	3.84±0.10[a]
35	7.80±0.99[b]	8.86±1.09[b]	17.16±0.37[d]	19.53±0.35[a]	3.09±0.11[b]	3.52±0.08[a]
42[i]	17.13±2.26[d]	16.97±1.96[c]	18.58±0.60[a]	18.51±0.46[a]	3.45±0.16[c]	3.43±0.10[a]
42[m]	14.78±2.29[c]	14.59±1.69[c]	18.77±0.50[a]	18.94±0.47[a]	3.49±0.14[c]	3.54±0.21[a]

Number of carcasses analysed per category are 5; * Data presented as mean±standard error; Within each column means followed by the same letter are not significantly different (p=0.05).

Significant differences (P<0.05) were not observed in carcass, liver or breast muscle weights between sexually immature and mature quail at 42 days of age. Moreover, abdominal fat weight was significantly less (P<0.05) in mature quail than in immature counterparts (Table 2). Weight of both ovary and oviduct were found to be greater (P<0.05) in the mature quail than in the immature counterparts (Table 3). Previous reports have showed critical effects of the minimum body weight on the initiation of sexual maturity in poultry (Brody *et al.*, 1984; Dunnington and Siegel, 1984; Oruwari and Brody, 1988). Oruwari and Brody (1988) observed that low body weight of immature quail is also associated with reduced ovary and oviduct weights. In the present study, it was observed that 65.5% (*i.e.* 9.06 g) of the extra body weight of 13.84 g of the mature quail (when compared to the immature counterparts) was due to their well developed ovaries and oviducts. Therefore, it is not only the attainment of the critical body weight that matters but also the growth of reproductive organs which ensure the formation of a complete egg, also play a critical role in the initiation of egg laying.

Liver weight increased up to 35 days of age and reached a plateau. The liver weight as well as its weight as a percentage of live weight in 42 day–old sexually immature quail were not different from those in mature quail (Table 2). However, Yannakopoulos *et al.* (1995) reported heavier liver

weights in the 42 day–old mature quail than in the 35 day–old immature quail. Brody *et al.* (1984) have also shown that the mature chicken had heavier livers than immature chicken.

Body fat contents were found to be greater in the mature Japanese quail than in the immature Japanese quail (Oruwari and Brody, 1988) and in chicken (Brody *et al.*, 1984; Zelenka *et al.*, 1986). Breast weight of laying hen was not different from that of nonlaying hen (Zelenka *et al.*, 1986). Breast muscle weight as a percentage of live weight has been shown to be higher in immature quail than in mature quail (Oruwari and Brody, 1988). The present study reveals that 42 day–old immature quail had greater ($P<0.05$) abdominal fat (Table 2) and carcass fat (Table 4) contents than those of mature quail. Significant differences were not observed in breast muscle weight (Table 2) and amount of carcass protein (Table 4) among the 42 day–old birds. The total amounts and percentages of carcass fat and protein in mature quail were greater than those of 35 day–old quail. Moreover, as part of the body reserves of mature quail has already been used for the growth of ovary and oviduct the data represent only the additional reserves. Thus, the present observations further justify the crucial role of body fat and protein in the initiation of sexual maturity. It is also evident that the deposition of the amounts of body fat and proteins do not necessarily induce the onset of egg laying.

Although some of the body weights and compositions reported in this study are different from those of others (Oruwari and Brody, 1988; Zelenka, 1984; Yannakopoulos *et al.*, 1995), the quail was found to commence egg laying at the age of 42 days, suggesting the role of minimum age for sexual maturity.

CONCLUSIONS

Divergent selection for live weight in different studies have resulted in considerable variations in the results obtained in the measurement of body growth and composition among the available lines of Japanese quail. The quail line investigated in the present study belongs to the line that has intermediate live weights. Live weight gain increased up to 28 days of age and decreased up to 42 days of age. Skeletal growth and lean body growth completed by 28 and 35 days, respectively. A rapid deposition of body fat, which commenced at 28 days, coincided with the rapid ovary and oviductal growth. The total amounts of carcass protein and ash increased while their percentages remained fairly constant with age. Live body weight, the growth

of ovary and oviduct, body composition and age seem to have a combined effect on sexual maturity.

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