



ZOOMETRICAL MEASUREMENTS OF JAPANESE QUAILS (*COTURNIX JAPONICA*) IN A SEMI-ARID AREA OF NIGERIA

RAJI AO* • ALADE NK • MEDUGU CI

Department of Animal Science, University of Maiduguri, Maiduguri, Borno State, Nigeria

Corresponding Author's e-mail: razrajpearl@yahoo.com

ABSTRACT: This study was conducted to determine the effects of season, sex, color and hatch weights on the body measurements of Japanese quails in a semi-arid area of Nigeria. Mean values of chest width at 4, 5, 6, 7, 8, 12 and 20 weeks of age were 2.33, 2.45, 2.56, 2.64, 2.73, 2.82 and 2.86 cm, respectively. The corresponding values for shank length were 2.22, 2.33, 2.43, 2.51, 2.66, 2.78 and 2.22 cm and drum stick lengths; 4.56, 4.67, 4.77, 4.90, 4.93, 5.06 and 5.14 cm. Wild type (Normal) Japanese quails had wider chest and, longer shanks and drumsticks than light brown at all ages. Chest width and shank length measurements of wild type quails ranged from 2.35 to 2.85 cm and 2.22 to 2.85 cm compared to 2.24 to 2.74 cm and 2.21 to 2.55 cm respectively for light brown. Drum stick length of wild type quails ranged from 4.61 to 5.27 cm while the light brown had a range of 4.24 to 4.35 cm. It was observed that chest width of quails with high hatch weights were superior at early ages but inferior at older ages. While low weight groups at hatch had higher shank length especially at older ages. Quails in hatch weight categories of ≤ 4 , 4.1 – 5.0 and 5.1 – 6 g consistently had longer drum sticks than those that weighed 6.1 – 7 and >7 grams at hatch. Thus, as hatch weight increased at the different ages, body length also increased.

Key words: body measurements, color, hatch weight, sex, Japanese quail

1. INTRODUCTION

Quail is a collective name for several genera of midsized birds in the pheasant family *Phasianidae* (Wikipedia 2008). The Japanese quail belongs to the order; Galliformes, genus; *Coturnix* and species; *japonica*. The scientific designation for the Japanese quail is *Coturnix japonica* which differs from the common quail *Coturnix coturnix*. Thear (1998) reported that the Japanese quail was a sub species of the *Coturnix coturnix* before being conferred species status. Thus, it is common for some authors to refer to the it as *Coturnix coturnix japonica*. The ancestral wild species of the quail is widely distributed over much of Europe and Asia, and parts of North Africa (NRC 1991). Though domestic quails are now available almost everywhere, including Nigeria, Japan is probably the world leader in commercial quail production (Cooper 1989). It is also popular as a laboratory animal because of its small body size, low feed consumption and rapid maturity.

Body growth in livestock may be evaluated with body components such as live weight and body measurements

(Saatci and Tilki 2007). Chineke *et al.* (2002) reported that the relationship existing among body characteristics provide useful information on performance, productivity and carcass characteristics of animals and that these quantitative measures of size and shape are necessary for estimating genetic parameters in animal breeding programmes. Shank length has been reported to have effect on live weight of Japanese quails (Dikmen and İpek 2006). Raji *et al.* (2009) indicated that carcass components can be predicted with precision, based on body measurements, in Japanese quails. Furthermore, chest measurements are regarded as reliable criteria to evaluate the body weight of most livestock (Szabone 1997). In addition, Latshaw and Bishop (2001) developed models for the prediction of body composition and live weight of chickens using various body measurements.

Analysis of body dimensions in poultry bird at different ages shows that body, keel, drum stick and shank lengths increased with age (Kozaczyoski *et al.*, 1999). The authors also reported significant increase of chest circumference in males and females, sternum length in

males and keel length in females. There is a dearth of information on body dimensions of Japanese quails in Nigeria. The aim of this study was to evaluate the effects of season, sex, color and hatch weight on body measurements of Japanese quail in a semi-arid area of Nigeria.

2. MATERIALS AND METHODS

The study was carried out at the Poultry Unit of the University of Maiduguri Livestock Teaching and Research Farm, Maiduguri, Borno State, Nigeria. Maiduguri, the Borno State capital is situated on latitude 11°5' N, longitude 13°09' E and at an altitude of 354 m above sea level. The area falls within the Sahelian region of West Africa, which is noted for great climatic and seasonal variations. It has very short period (3 – 4 months) of rainfall of 645.9 mm/annum with a long dry season of about 8 – 9 months. Three seasons are therefore identifiable: dry cold (October – January), dry hot (February – May) and wet (June – September). Relative humidity is 45% in August which usually lowers to about 5% in December and January. Day length varies from 11 to 12 hours.

Three hundred Japanese quails hatched from eggs collected from unselected and random mating parents were used for the study over three seasons. After hatching, the chicks were individually weighed and labeled according to color (light brown or wild type) and hatch weight (≤ 4.0 , 4.1 – 5.0, 5.1 – 6.0, 6.1 – 7.0 and ≥ 7.1 grams) before brooding for two weeks. Hatched chicks were fed commercial broiler starter ration containing 23% crude protein and 3000 kcal/kg of Metabolizable Energy to 6 weeks of age. The birds were then housed in cages (30x30x45 cm) fitted with improvised feeders and drinkers and fed breeders diet containing 18% crude protein and 2800 kcal/kg of Metabolizable Energy from 6 weeks of age. Birds were sexed according to plumage color and pattern at 3 weeks of age and had access to the feed and water *ad libitum* throughout the study period. All Chicks (males and females) were weighed in grams at hatch and the body measurements obtained in centimeters as follows:

Body length: length between the base of the neck and the tip of the cauda (tail without feathers).

Shank length was measured as the length of the tibiotarsus, that is, from the hock joint to the foot pad.

Chest width: the distance between the medial protuberances of the humeral bones. It was measured with a vernier caliper.

Drumstick length: this is the length from the knee joint to the hock.

Body, Shank and drumstick lengths were obtained using a measuring tape graduated in centimeters (cm).

The data generated was analyzed in a factorial design using the General Linear Model (GLM) procedure of SPSS 13.0 with season, color, sex and hatch weight as fixed factors. Significant means where applicable were separated by Duncan's Multiple Range Test. The model for the analysis was

$$Y_{ijklm} = A_i + B_j + C_k + D_l + e_{ijklm} \dots\dots\dots (1)$$

Where Y_{ijklm} = observation on individual measurements based on the $ijklm$ classification

μ = overall mean; A_i = effect of Season; B_j = effect of color; C_k = effect of sex; D_l = effect of hatch weight; e_{ijklm} = random error

3. RESULTS AND DISCUSSION

3.1 Chest width

Chest width measurements of the Japanese quail as affected by season, color, sex and hatch weight are presented in Table 1. The mean values of chest width at 4, 5, 6, 7, 8, 12 and 20 weeks of age were 2.33, 2.45, 2.56, 2.64, 2.73, 2.82 and 2.86 cm, respectively. Season had significant ($P < 0.001$) effect on chest width at different ages except at five ($P < 0.01$) and insignificant effect at six weeks. Chest width measurements were higher in the dry cold (2.40 and 2.47 cm) and rainy (2.58 cm) seasons which had similar values. This trend continued up to twenty weeks of age. Color had significant ($P < 0.001$) effect on chest width of Japanese quail from four to twenty weeks of age except at ten ($P < 0.05$) and twelve and twenty ($P < 0.01$) weeks. Wild type (Normal) Japanese quails had wider chest than light brown at all ages. Chest measurements of wild type quails ranged from 2.35 to 2.85 cm while those of light brown ranged from 2.24 to 2.74 cm. Sex did not significantly affect chest width except at four, five and six weeks of age. At these ages, males had wider ($P < 0.001$) chests than females. The chest width measurements of males and females at four, five and six weeks of age were 2.37 vs 2.29 cm, 2.49 cm vs 2.41 cm and 2.58 vs 2.54 cm respectively. The chest width of males increased as they approached maturity in preparation for mating. Hatch weight also had significant ($P < 0.05$) effect on chest width measurements of Japanese quail except at four ($P < 0.001$) and between seven and ten ($P > 0.05$) weeks of age. It was observed that those of high weight groups were superior at early ages but inferior at older ages.

3.2 Shank length

Shank length measurements of the Japanese quail as affected by season, color, sex and hatch weight are presented in Table 2. The mean values of shank length at 4, 5, 6, 7, 8, 12 and 20 weeks of age were 2.22, 2.33, 2.43, 2.51, 2.66, 2.78 and 2.22 cm, respectively. Shank length measurements reported in this study were lower than those reported by Adeogun and Adeoye (2004). The difference could be due to the higher body weight of quails in their study. Season had highly significant ($P<0.001$) effect on shank length at the different ages except six, seven and ten ($P<0.05$) five, eight and nine ($P>0.05$) weeks. At the ages where effect of season was significant, shank length was higher in the dry hot than the dry cold and rainy seasons. Color had highly significant ($P<0.001$) effect on shank length measurements at almost all the ages except at eighteen ($P<0.01$), five, nineteen and twenty ($P<0.05$) and four ($P>0.05$) weeks. The wild type Japanese quail consistently had higher shank length measurements than light brown quails. Shank lengths ranged from 2.22 to 2.85 cm for the wild type and 2.21 to 2.55 cm for light brown. Fajemilehin (2010) did not observe significant color effect on shank length of guinea fowls. Similarly, sex did not significantly affect shank length at all ages. The non significant effect of sex on shank measurements at all ages might indicate that equal shank length for males and females is a characteristic of the Japanese quail. Akpa *et al.* (2009) also reported non significant sex effect on shank length of Japanese quail. On the contrary, shank length was reported to be greater in males by Deeb and Lamont (2002) in chickens on the 8th week and by Lukaszewicz *et al.* (2008) in geese. Hatch weight significantly ($P<0.05$) affected shank length of Japanese quails except at six to twelve weeks of age when differences were not significant. Those of low weight group at hatch had higher shank length especially at older ages.

3.3 Drum stick length

Drum stick length measurements as affected by season, color, sex and hatch weight are presented in Table 3. The mean values of drum stick lengths at 4, 5, 6, 7, 8, 12 and 20 weeks of age were 4.56, 4.67, 4.77, 4.90, 4.93, 5.06 and 5.14 cm, respectively. Season had significant ($P<0.001$) effect on the drum stick length at all the ages studied. At 4-week old, drum stick lengths recorded for dry cold (4.28 cm) and rainy (4.28 cm) seasons were similar, but both were lower than dry hot (5.04 cm). This pattern continued up to 20-week. Color had significant ($P<0.001$) effect on drum stick lengths from 5th to 20th week of age. Wild type quails had longer drum sticks than the light browns at most ages except for the 4th week old.

Drum stick length of wild type quails ranged from 4.61 to 5.27 cm while the light brown had a range of 4.24 to 4.35 cm. In contrast, Fajemilehin (2010) did not observe significant color effect on drum stick length in guinea fowls. Sex did not significantly affect drum stick length in this study. The non significant sex effect on drum stick length at all ages might indicate that equal drum stick length for males and females is a characteristic of the Japanese quail and both may be said to have equal meat potential. In addition, they may not differ in meat value. However, hatch weight significantly ($P<0.05$) affected drum stick length. Quails in hatch weight categories of ≤ 4 , 4.1 – 5.0 and 5.1 - 6 g consistently had longer drum sticks than those that weighed 6.1 - 7 and >7 grams at hatch. The drum stick length measurements for quails with hatch weight of ≤ 4 g ranged from 4.60 to 5.34, 4.1 – 5.0 g; 4.57 to 5.21 cm, 5.1 - 6 g; 4.62 to 5.29 cm, 6.1 - 7 g; 4.44 to 4.77 cm and ≥ 7.1 g; 4.32 to 4.58 cm.

3.4 Body length

Body length measurements of the Japanese quail as affected by season, color, sex and hatch weight are presented in Table 4. Season had significant ($P<0.001$) effect on body length at all the ages studied. Body lengths were significantly higher in the dry cold (10.17 cm) and rainy (10.20 cm) than the dry hot (7.53 cm) season at four and subsequent weeks of age. Color and sex, however, did not affect body length significantly. The non significant sex effect on body length measurements at all ages might indicate that equal body length for males and females is a characteristic of the Japanese quail. Akpa *et al.* (2009) also reported non significant color and sex effect on body length of Japanese quail. Similarly, Fajemilehin (2010) did not find any color effect on body length in guinea fowls. The effect of hatch weight (in this study) was significant ($P<0.05$) at all the ages except at 4 and 5 ($P<0.01$) weeks. As hatch weight increased at the different ages, body length also increased.

4. CONCLUSION

1. Season, color and hatch weight had significant effects on chest width, shank length, drum stick length and body length, while sex did not.
2. Male and female quails had similar values for chest width and, shank, drum stick and body length measurements and both may have equal meat potential.
3. Shank measurements of male and female Japanese quails at all ages are equal

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Table 1: Chest width measurements (cm) of Japanese quail at different ages as affected by season, color, sex and hatch weight

Factors	Age (weeks)															
	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20
Overall	2.33	2.45	2.56	2.64	2.73	2.76	2.79	2.82	2.85	2.87	2.88	2.89	2.86	2.86	2.87	2.86
Season	***	**	ns	***	***	***	***	***	***	***	***	***	***	***	***	***
Dry cold	2.40 ^a	2.47 ^a	2.54 ^a	2.58 ^b	2.66 ^b	2.68 ^b	2.68 ^b	2.67 ^b	2.69 ^b	2.71 ^b	2.71 ^b	2.72 ^b	2.69 ^b	2.69 ^b	2.69 ^b	2.68 ^b
Dry hot	2.20 ^b	2.40 ^b	2.58 ^a	2.73 ^a	2.83 ^a	2.90 ^a	2.99 ^a	3.08 ^a	3.13 ^a	3.17 ^a	3.17 ^a	3.17 ^a	3.17 ^a	3.17 ^a	3.17 ^a	3.17 ^a
Rain	2.41 ^a	2.48 ^a	2.55 ^a	2.58 ^b	2.68 ^b	2.68 ^b	2.68 ^b	2.67 ^b	2.69 ^b	2.69 ^b	2.72 ^b	2.73 ^b	2.69 ^b	2.69 ^b	2.69 ^b	2.67 ^b
Color	***	***	***	***	***	***	*	**	***	***	***	***	***	***	***	**
Wild type	2.35 ^a	2.46 ^a	2.57 ^a	2.64 ^a	2.73 ^a	2.76 ^a	2.77 ^a	2.81 ^a	2.84 ^a	2.86 ^a	2.87 ^a	2.88 ^a	2.86 ^a	2.87 ^a	2.86 ^a	2.85 ^a
Light brown	2.24 ^b	2.31 ^b	2.44 ^b	2.49 ^b	2.59 ^b	2.61 ^b	2.68 ^b	2.70 ^b	2.67 ^b	2.69 ^b	2.68 ^b	2.69 ^b	2.69 ^b	2.71 ^b	2.73 ^b	2.74 ^b
Sex	***	***	***	ns	ns	Ns	ns	ns	ns	ns						
Male	2.37 ^a	2.49 ^a	2.58 ^a	2.64 ^a	2.73 ^a	2.76 ^a	2.78 ^a	2.78 ^a	2.80 ^a	2.82 ^a	2.84 ^a	2.85 ^a	2.82 ^a	2.83 ^a	2.82 ^a	2.81 ^a
Female	2.29 ^b	2.41 ^b	2.54 ^b	2.63 ^a	2.73 ^a	2.76 ^a	2.80 ^a	2.85 ^a	2.89 ^a	2.92 ^a	2.91 ^a	2.92 ^a	2.90 ^a	2.89 ^a	2.91 ^a	2.90 ^a
Hatch Weight(g)	***	*	*	ns	ns	Ns	ns	ns	*	*	*	*	*	*	*	*
≤ 4	2.17 ^c	2.29 ^b	2.44 ^b	2.54 ^a	2.66 ^a	2.69 ^a	2.76 ^a	2.84 ^a	2.89 ^a	2.91 ^a	2.90 ^a	2.91 ^a	2.90 ^a	2.90 ^a	2.90 ^a	2.89 ^a
4.1 – 5.0	2.31 ^b	2.44 ^a	2.57 ^a	2.64 ^a	2.74 ^a	2.77 ^a	2.82 ^a	2.82 ^a	2.87 ^a	2.88 ^{ab}	2.90 ^a	2.92 ^a	2.88 ^a	2.90 ^a	2.89 ^a	2.87 ^a
5.1 - 6.0	2.33 ^{ab}	2.46 ^a	2.58 ^a	2.66 ^a	2.75 ^a	2.80 ^a	2.84 ^a	2.86 ^a	2.90 ^a	2.93 ^a	2.94 ^a	2.94 ^a	2.91 ^a	2.90 ^a	2.91 ^a	2.91 ^a
6.1 – 7.0	2.38 ^{ab}	2.48 ^a	2.57 ^a	2.62 ^a	2.70 ^a	2.71 ^a	2.70 ^a	2.74 ^a	2.76 ^b	2.78 ^b	2.78 ^b	2.78 ^b	2.77 ^b	2.76 ^b	2.76 ^b	2.75 ^b
≥7.1	2.42 ^a	2.46 ^a	2.52 ^a	2.56 ^a	2.66 ^a	2.66 ^a	2.64 ^a	2.64 ^a	2.62 ^c	2.64 ^c	2.64 ^c	2.64 ^c	2.66 ^c	2.70 ^b	2.70 ^b	2.70 ^b
SEM	0.16	0.15	0.12	0.15	0.15	0.17	0.2	0.23	0.25	0.027	0.26	0.25	0.26	0.26	0.26	0.27

Means in a column within a subset with different superscripts ^{a,b} are significantly different.

ns = not significant, * = P<0.05, ** = P<0.01, *** = P<0.001

Table 2: Shank length measurements (cm) of Japanese quail at different ages as affected by season, color, sex and hatch weight

Factors	Age (weeks)															
	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20
Overall	2.22	2.33	2.43	2.51	2.66	2.7	2.75	2.78	2.82	2.85	2.83	2.84	2.82	2.82	2.81	2.22
Season	***	ns	*	*	ns	Ns	*	***	***	***	***	***	***	***	***	***
Dry cold	2.28 ^a	2.35 ^a	2.38 ^b	2.45 ^b	2.66 ^a	2.67 ^a	2.70 ^b	2.70 ^b	2.70 ^b	2.68 ^b	2.65 ^b	2.65 ^b	2.63 ^b	2.63 ^b	2.60 ^b	2.60 ^b
Dry hot	2.14 ^b	2.32 ^a	2.50 ^a	2.59 ^a	2.66 ^a	2.73 ^a	2.82 ^a	2.92 ^a	3.01 ^a	3.13 ^a	3.13 ^a	3.13 ^a	3.13 ^a	3.13 ^a	3.13 ^a	3.13 ^a
Rain	2.26 ^a	2.31 ^a	2.39 ^b	2.46 ^b	2.66 ^a	2.68 ^a	2.71 ^b	2.72 ^b	2.73 ^b	2.70 ^b	2.67 ^b	2.69 ^b	2.66 ^b	2.66 ^b	2.64 ^b	2.64 ^b
Color	ns	*	***	***	***	***	***	***	***	***	***	***	***	**	*	*
Wild type	2.22 ^a	2.33 ^a	2.46 ^a	2.54 ^a	2.69 ^a	2.73 ^a	2.78 ^a	2.82 ^a	2.86 ^a	2.90 ^a	2.89 ^a	2.89 ^a	2.87 ^a	2.87 ^a	2.85 ^a	2.85 ^a
Light brown	2.21 ^a	2.28 ^b	2.23 ^b	2.29 ^b	2.48 ^b	2.51 ^b	2.54 ^b	2.57 ^b	2.58 ^b	2.51 ^b	2.49 ^b	2.53 ^b	2.52 ^b	2.54 ^b	2.55 ^b	2.55 ^b
Sex	ns	ns	ns	ns	ns	Ns	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Male	2.22 ^a	2.32 ^a	2.41 ^a	2.49 ^a	2.65 ^a	2.69 ^a	2.73 ^a	2.77 ^a	2.81 ^a	2.82 ^a	2.81 ^a	2.82 ^a	2.80 ^a	2.79 ^a	2.78 ^a	2.78 ^a
Female	2.22 ^a	2.33 ^a	2.45 ^a	2.52 ^a	2.67 ^a	2.71 ^a	2.76 ^a	2.80 ^a	2.84 ^a	2.88 ^a	2.86 ^a	2.85 ^a	2.85 ^a	2.85 ^a	2.83 ^a	2.83 ^a
Hatch Weight	*	*	ns	ns	ns	Ns	Ns	ns	*	*	*	*	*	*	*	*
≤4	2.08 ^b	2.24 ^b	2.37 ^a	2.43 ^a	2.57 ^a	2.61 ^a	2.66 ^a	2.76 ^a	2.84 ^a	2.86 ^a	2.86 ^a	2.89 ^a	2.87 ^a	2.87 ^a	2.87 ^a	2.87 ^a
4.1 – 5.0	2.22 ^a	2.31 ^{ab}	2.44 ^a	2.52 ^a	2.66 ^a	2.71 ^a	2.78 ^a	2.82 ^a	2.86 ^a	2.89 ^a	2.88 ^a	2.88 ^a	2.86 ^a	2.84 ^a	2.83 ^a	2.83 ^a
5.1 – 6.0	2.20 ^a	2.33 ^{ab}	2.44 ^a	2.52 ^a	2.66 ^a	2.70 ^a	2.74 ^a	2.78 ^a	2.82 ^a	2.87 ^a	2.87 ^a	2.87 ^a	2.87 ^a	2.86 ^a	2.85 ^a	2.85 ^a
6.1 – 7.0	2.32 ^a	2.39 ^a	2.43 ^a	2.51 ^a	2.68 ^a	2.72 ^a	2.76 ^a	2.78 ^a	2.80 ^{ab}	2.78 ^{ab}	2.74 ^{ab}	2.73 ^b	2.72 ^b	2.73 ^{ab}	2.70 ^b	2.70 ^b
≥7.1	2.23 ^a	2.26 ^b	2.36 ^a	2.42 ^a	2.62 ^a	2.64 ^a	2.66 ^a	2.66 ^a	2.66 ^b	2.64 ^b	2.62 ^b	2.66 ^b	2.60 ^c	2.66 ^b	2.62 ^b	2.62 ^b
SEM	0.01	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Means in a column within a subset with different superscripts ^{a,b} are significantly different.

ns = not significant, * = P<0.05, ** = P<0.01, *** = P<0.001

Table 3. Drumstick length measurements (cm) of Japanese quail at different ages as affected by season, color, sex and hatch weight

Factors	Age (weeks)															
	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20
Overall	4.56	4.67	4.77	4.9	4.93	4.99	5.03	5.06	5.1	5.12	5.25	5.13	5.14	5.14	5.14	5.14
Season	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Dry cold	4.28 ^b	4.33 ^b	4.34 ^b	4.43 ^b	4.43 ^b	4.43 ^b	4.46 ^b	4.46 ^b	4.48 ^b	4.46 ^b	4.45 ^b	4.46 ^b	4.47 ^b	4.47 ^b	4.48 ^b	4.47 ^b
Dry hot	5.04 ^a	5.27 ^a	5.45 ^a	5.62 ^a	5.71 ^a	5.87 ^a	5.94 ^a	6.01 ^a	6.09 ^a	6.17 ^a	6.55 ^a	6.22 ^a	6.22 ^a	6.22 ^a	6.22 ^a	6.22 ^a
Rain	4.28 ^b	4.33 ^b	4.43 ^b	4.53 ^b	4.53 ^b	4.53 ^b	4.55 ^b	4.55 ^b	4.57 ^b	4.55 ^b	4.54 ^b	4.55 ^b	4.55 ^b	4.55 ^b	4.56 ^b	4.55 ^b
Color	ns	*	***	***	***	***	***	***	***	***	***	*	*	**	**	**
Wild type	4.61 ^a	4.73 ^a	4.86 ^a	5.00 ^a	5.03 ^a	5.10 ^a	5.14 ^a	5.18 ^a	5.22 ^a	5.24 ^a	5.39 ^a	5.25 ^a	5.26 ^a	5.26 ^a	5.27 ^a	5.26 ^a
Light brown	4.24 ^a	4.29 ^b	4.21 ^b	4.29 ^b	4.29 ^b	4.29 ^b	4.31 ^b	4.31 ^b	4.34 ^b	4.33 ^b	4.33 ^b	4.35 ^b	4.36 ^b	4.34 ^b	4.35 ^b	4.34 ^b
Sex	ns	ns	ns	ns	ns	Ns	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Male	4.54 ^a	4.65 ^a	4.75 ^a	4.86 ^a	4.90 ^a	4.94 ^a	4.97 ^a	4.99 ^a	5.02 ^a	5.02 ^a	5.13 ^a	5.07 ^a	5.08 ^a	5.08 ^a	5.08 ^a	5.08 ^a
Female	4.57 ^a	4.69 ^a	4.79 ^a	4.93 ^a	4.96 ^a	5.03 ^a	5.08 ^a	5.12 ^a	5.17 ^a	5.20 ^a	5.35 ^a	5.18 ^a	5.19 ^a	5.19 ^a	5.19 ^a	5.19 ^a
Hatch weight (g)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
≤4	4.60 ^a	4.79 ^a	4.96 ^a	5.10 ^a	5.16 ^a	5.29 ^a	5.36 ^a	5.39 ^a	5.46 ^a	5.49 ^a	5.61 ^a	5.39 ^a	5.40 ^a	5.34 ^a	5.34 ^a	5.34 ^a
4.1 – 5.0	4.57 ^a	4.67 ^{ab}	4.81 ^a	4.93 ^a	4.94 ^a	5.01 ^b	5.07 ^b	5.10 ^b	5.15 ^b	5.18 ^b	5.30 ^b	5.20 ^a	5.21 ^a	5.21 ^a	5.22 ^a	5.21 ^a
5.1 – 6.0	4.62 ^a	4.76 ^a	4.87 ^a	5.00 ^a	5.04 ^a	5.09 ^{ab}	5.16 ^{ab}	5.19 ^{ab}	5.23 ^b	5.26 ^b	5.44 ^{ab}	5.28 ^a	5.29 ^a	5.29 ^a	5.29 ^a	5.29 ^a
6.1 – 7.0	4.44 ^{ab}	4.53 ^{bc}	4.54 ^b	4.66 ^b	4.68 ^b	4.74 ^c	4.72 ^c	4.73 ^c	4.76 ^c	4.75 ^c	4.82 ^c	4.78 ^b	4.78 ^b	4.77 ^b	4.78 ^b	4.77 ^b
≥7.1	4.32 ^b	4.38 ^c	4.48 ^b	4.58 ^b	4.58 ^b	4.58 ^c	4.58 ^c	4.58 ^c	4.54 ^d	4.58 ^c	4.56 ^d	4.54 ^b	4.54 ^b	4.58 ^b	4.60 ^b	4.58 ^b
SEM	0.06	0.06	0.08	0.08	0.09	0.08	0.07	0.07	0.07	0.07	0.07	0.09	0.1	0.09	0.09	0.09

Means in a column within a subset with different superscripts ^{a,b} are significantly different.

ns = not significant, * = P<0.05, ** = P<0.01, *** = P<0.001

Table 4. Body length (cm) measurements of Japanese quail at different ages as affected by season, color, sex and hatch weight

Factors	Age (weeks)															
	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20
Overall	9.22	9.47	9.8	10.04	10.23	10.24	10.37	10.49	10.56	10.62	10.62	10.62	10.61	10.62	10.62	10.62
Season	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Dry cold	10.17 ^a	10.43 ^a	10.61 ^a	10.80 ^a	10.91 ^a	10.71 ^a	10.75 ^a	10.75 ^a	10.78 ^a	10.79 ^a	10.79 ^a	10.79 ^a	10.79 ^a	10.79 ^a	10.79 ^a	10.79 ^a
Dry hot	7.53 ^b	7.77 ^b	8.14 ^b	8.46 ^b	8.80 ^b	9.17 ^b	9.48 ^b	9.80 ^b	9.94 ^b	10.08 ^b	10.07 ^b	10.07 ^b	10.07 ^b	10.07 ^b	10.07 ^b	10.07 ^b
Rain	10.20 ^a	10.45 ^a	10.86 ^a	11.06 ^a	11.17 ^a	10.96 ^a	10.99 ^a	10.99 ^a	11.03 ^a	11.03 ^a	11.03 ^a	11.03 ^a	11.03 ^a	11.03 ^a	11.03 ^a	11.03 ^a
Color	ns	ns	ns	ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Wild type	9.06 ^a	9.31 ^a	9.70 ^a	9.95 ^a	10.15 ^a	10.19 ^a	10.34 ^a	10.49 ^a	10.57 ^a	10.63	10.63 ^a	10.62 ^a	10.62 ^a	10.62 ^a	10.62 ^a	10.62 ^a
Light brown	10.23 ^a	10.51 ^a	10.46 ^a	10.65 ^a	10.75 ^a	10.56 ^a	10.56 ^a	10.54 ^a	10.55 ^a	10.55 ^a	10.56 ^a	10.57 ^a	10.56 ^a	10.57 ^a	10.57 ^a	10.57 ^a
Sex	ns	ns	ns	ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Male	9.45 ^a	9.69 ^a	10.04 ^a	10.27 ^a	10.44 ^a	10.37 ^a	10.44 ^a	10.55 ^a	10.62 ^a	10.66 ^a	10.66 ^a	10.66 ^a	10.66 ^a	10.66 ^a	10.66 ^a	10.66 ^a
Female	9.03 ^a	9.29 ^a	9.60 ^a	9.86 ^a	10.07 ^a	10.13 ^a	10.32 ^a	10.45 ^a	10.52 ^a	10.58 ^a	10.58 ^a	10.58 ^a	10.58 ^a	10.58 ^a	10.58 ^a	10.58 ^a
Hatch Weight(g)	**	**	*	*	*	*	*	*	*	*	*	*	*	*	*	*
≤ 4	8.43 ^d	8.69 ^c	9.04 ^c	9.33 ^c	9.54 ^d	9.66 ^c	9.91 ^c	10.16 ^b	10.34 ^b	10.41 ^b	10.41 ^b	10.44 ^b	10.43 ^b	10.44 ^b	10.44 ^b	10.44 ^b
4.1 – 5.0	9.07 ^c	9.31 ^b	9.71 ^b	9.96 ^b	10.17 ^{bc}	10.19 ^b	10.34 ^{bc}	10.53 ^{ab}	10.61 ^{ab}	10.68 ^{ab}	10.68 ^{ab}	10.67 ^{ab}	10.67 ^{ab}	10.67 ^{ab}	10.67 ^{ab}	10.67 ^{ab}
5.1 - 6.0	9.04 ^c	9.30 ^b	9.65 ^b	9.90 ^b	10.10 ^c	10.17 ^b	10.32 ^{bc}	10.44 ^{ab}	10.52 ^{ab}	10.57 ^{ab}	10.57 ^{ab}	10.57 ^{ab}	10.57 ^{ab}	10.57 ^{ab}	10.57 ^{ab}	10.57 ^{ab}
6.1 – 7.0	9.84 ^b	10.09 ^a	10.27 ^a	10.48 ^a	10.63 ^{ab}	10.49 ^{ab}	10.55 ^{ab}	10.55 ^{ab}	10.57 ^{ab}	10.60 ^{ab}	10.60 ^{ab}	10.59 ^{ab}	10.59 ^{ab}	10.59 ^{ab}	10.59 ^{ab}	10.59 ^{ab}
≥7.1	10.10 ^a	10.32 ^a	10.72 ^a	10.92 ^a	11.02 ^a	10.82 ^a	10.92 ^a	10.94 ^a	10.96 ^a	11.00 ^a	11.00 ^a	11.00 ^a	11.00 ^a	11.00 ^a	11.00 ^a	11.00 ^a
SEM	0.12	0.12	0.12	0.12	0.11	0.09	0.08	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06

Means in a column within a subset with different superscripts ^{a,b} are significantly different.

ns = not significant, * = P<0.05, ** = P<0.01, *** = P<0.001