VOL. 4, NO. 3, MAY 2009 ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

IN VIVO ESTIMATION OF CARCASS COMPONENTS FROM LIVE BODY MEASUREMENTS OF THE JAPANESE QUAIL (*Cortunix cortunix japonica*)

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ABSTRACT

Breast and thigh weights of mature Japanese quails were estimated *in vivo* from live body measurements using regression equations. Mean live weight obtained in this study was 113.16g while breast and thigh percent were 34.40 and 24.02% respectively. Live weight(r = 0.85 and 0.78), chest girth(r = 0.63 and 0.60) and chest width(r = 0.62 and 0.60) had high, positive and significant (P<0.01) correlations with breast and thigh weights while they were low and non significant (P>0.01) with breast and thigh percents. Equations D (R^2 = 0.83, MS_E = 4.95, SD_E = 2.22), I (R^2 = 0.85, MS_E = 4.89 SD_E = 2.22), J (R^2 = 0.85, MS_E = 5.05, SD_E = 2.24) and K (R^2 = 0.87, MS_E = 4.97, SD_E = 2.23) for breast weight estimation and 4 (R^2 = 0.68, MS_E = 2.29, SD_E = 1.51), 6 (R^2 = 0.67, MS_E = 2.29, SD_E = 1.51) and 11 (R^2 = 0.77, MS_E = 2.24, SD_E = 1.30) for thigh weight estimation had higher R^2, lower MS_E and SD_E compared to the other equations. Thus, they produced a better goodness of fit and greater accuracy in prediction of carcass components. Under field conditions, depending on the ease of measurement, these equations can be used to predict carcass components.

Keywords: Japanese quails, live body measurements, breast weight, thigh weight, regression equations.

INTRODUCTION

Japanese quail belongs to the order Galliformes and family Phasianidae and like chicken can be used for meat production. It is the smallest avian species farmed for meat and egg; and has the distinct characteristic of reaching table weight at 6-8 weeks and coming into lay at about the same age. (Panda and Singh, 1990). Cooper (1989) reported that the Japanese quail can be bred for meat and egg production. Thus, it has the potential to serve as an excellent and cheap source of animal protein for Nigerians (NVRI, 1996). The percent content of edible meat in Japanese quail is high. Ozbey *et al.* (2006) reported a dressing percentage of 69.57% in Japanese quail. Vali *et al*. (2004) observed that breast and thigh amounts to 63% of the carcass with breast making up 40.43% and thigh 22.66%.

Studies on water fowls, turkeys and broilers indicate high correlations between body weight and carcass lean content (Bochno *et al.,* 2000b, Michalik *et al.,* 2002) while breast weight in ducks (Rymkiewiez and Bochno, 1998) and geese (Bochno *et al.,* 2000a) is best predicted based on body weight and chest girth. Bochno *et al.,* (1988) proposed body weight and breast bone crest length as a set of independent variables for the *in vivo* prediction of duck meatiness.

Literature provides scant information on selection directed towards increasing the weight of breast and thigh muscles in quails. In addition, *in vivo* prediction of carcass components based on a single trait is usually imprecise, thus, Wawro, (1990) proposed that more accurate results can be obtained when several parameters are used as independent variables in multiple regression equations. The aim of this study was to derive multiple regression equations for *in vivo* estimation of breast and thigh weights in Japanese quails raised in a semi arid environment.

MATERIALS AND METHODS

This study was carried out at the livestock unit of the University of Maiduguri Livestock Teaching and Research Farm, Maiduguri, Borno State. Maiduguri, the Borno State capital is situated on latitude $11^0 5'$ N and longitude $13^0 09'$E (Encarta, 2007) and at an altitude of 354 metres above sea level. The area falls within the Sahelian region of West Africa, which is noted for its great climatic and seasonal variation. It has very short period (3-4 months) of rainfall giving 645.9mm/annum with a long dry season of about 8-9 months. The ambient temperature could be as low as 20^0C during the dry cold (Oct.-Jan.)Season and as high as 44^0C during the dry hot (Feb-May) season. Relative humidity is 45% in August which usually lowers to about 5% in December and January. Day length varies from 11-12 hours.

The experimental materials were 200 male Japanese quails obtained from the National Veterinary Research Institute (NVRI), Vom, Jos, Plateau state. They were housed in a deep litter pen and provided feed and clean drinking water *ad libitum*. They were fed a commercial broiler starter ration containing 2800kcal/kg of energy and 23% crude protein. At 10 weeks of age, 60 males were selected at random and slaughtered. Birds for slaughter were starved overnight but water was provided *ad libitum*. The birds were weighed before slaughter and the following body measurements obtained: chest width, chest girth, breast bone length and drumstick length. After slaughter, plucking and evisceration, the empty carcass was weighed to obtain the carcass weight. The carcass was then divided in to major parts like breast, thigh and others consisting of the back, neck, wing etc. These were weighed to obtain the breast and thigh weights. All weights were obtained in grams with a sensitive digital scale. The live measurements were obtained as follows:

Chest girth (in centimeters) as the circumference of the body behind the wings, through the anterior border of the breast bone crest and the central thoracic vertebrae.
Breast bone crest length: this is the distance between the anterior and posterior border of the breast bone crest.
Chest width: the distance between the medial protuberances of the humeral bones. It was obtained with a vernier caliper.
Drumstick length: this is the length from the knee joint to the hock.
Shank length: length between the genu and the regiotarsalis.
Body length: length between the base of the neck and the tip of the cauda (tail without feathers)
Wing length: length between the base and the tip of the wing.
Carcass percent was obtained as: $\frac{\text{Carcass weight}}{\text{Live weight}} \times 100$
Breast and thigh percent were obtained as percentages of the carcass weight.
All data collected were subjected to the correlation and regression procedure of SPSS 11.0 using the following model:

$Y_{ij} = a + b_iX_i + e_{ij}$
Y_{ij}= body weight
A = intercept
Bi = regression coefficient
X_i = independent variables
e_{ij} = random error

To determine the best fitted regression equation and verify accuracy of estimation, statistical parameters : coefficient of determination (R^2), D {(R^2) x 100}, residual mean square (MS_E), and error standard deviation (SD_E) were used for evaluating and comparing different regression models.

RESULTS

Descriptive statistics of the live body measurements and carcass components are presented on Table-1. Mean live weight was 113.16g, while carcass, breast and thigh weights were 76.9, 26.42 and 18.40g respectively. The percent carcass, breast and thigh were 67.82, 34.41 and 24.01% respectively.

Live weight was closely correlated with weight of breast and thigh (r=0.85 and 0.78; Table-1). In addition, breast and thigh weights were highly correlated with chest girth (0.63 and 0.60 respectively) and chest width (0.62 and 0.60 respectively). The coefficient of simple correlation between the percentages of body components and body weight were generally low and statistically non significant (P>0.01). Breast Percent had a low, negative and significant correlation (P<0.01) with wing length (-0.28) and shank length (-0.26) while breast bone crest length (-0.24) and drum length (-0.11) were not significant (P>0.01). Thigh Percent also had low, negative and significant (P<0.01) correlations with body length (-0.28) and chest width (-0.26).

Tables, 2 and 3 presents regression equations for *in vivo* estimation of breast and thigh weights in the live body weights of the Japanese quail. Equations A, B and C on Table-2 for prediction of breast weight with live weight, chest width and chest girth respectively as the independent variables yielded R^2 values of 0.65, 0.27 and 0.28 respectively. On Table-3, equations 1, 2 and 3 with the same set of independent variables for prediction of thigh weight yielded R^2 values of 0.56, 0.23 and 0.26 respectively. The two independent variables in equation D, E and F developed to predict breast weight in quails are live weight + bbl, live weight + chest width and live weight + chest girth respectively. These equations gave R^2 values of 0.83, 0.77 and 0.77 respectively. Similarly, equations 4, 5 and 6 on Table-3 with same set of independent variables gave R^2 values of 0.68, 0.66 and 0.67 respectively. Equation G and H on Table-2 and 7,8 and 9 on Table-3 with 3 independent variables each, yielded R^2 values of 0.84, 0.78, 0.69, 0.67 and 0.68 respectively. The other equations I, J and K on Table-2 and 10 and 11 on Table-3 with four or more independent variables yielded R^2 values of 0.85, 0.85 0.87, 0.69 and 0.77 respectively. Equations A to K and 1 to 11 gave high values of coefficient of multiple correlation (R=0.52 to 0.93 and 0.40 to 0.88) between the independent variables and the sets of independent variables.

Tables, 4 and 5 shows the statistical parameters viz; coefficient of determination (D), residual mean square (MS_E), F value, error standard deviation (SD_E) and coefficient of variation (CV). The CV for breast and thigh weight was 8.36 to 13.24% and 7.07 to 10.37% respectively. The F values were highly significant (P<0.01) for both dependent variables. The residual mean square for breast weight ranged from 4.89 to 10.92 with equation I and G having the least and C the highest. For thigh weight, it ranged from2.24 to 3.73 with equation 11 having the least and 2 the highest value. Coefficient of determination was highest in equation K (87%) for breast weight and least (27%) in equation B. Similarly, for thigh weight, equation 11 had the highest value of 77% while equation 2 had the least (23%). Thus, the more independent variables in the equation, the higher the coefficient of determination.

The predicted weight, difference between the actual and predicted weight in proportion and their correlation coefficients are presented in Tables, 6 and 7. The difference between the estimated and actual breast muscle weight ranged from 0.01 to 1.34 accounting for 0.037 to 4.99% of the actual weight. Correlation between the actual and estimated values was also high (0.745 to 0.820). The number of birds with deviations of the estimated value from the actual of 0-5% was highest for equations F and J while that with values greater than 10% of the actual was equation G. In thigh weight prediction, the difference ranged from 0.01 to 3.67 accounting for 0.054 to 18.53% of the actual weight. Coefficient of correlation between the actual and estimated values ranged from 0.633 to 0.753.

DISCUSSIONS

Mean live weight of quails (113.16g) in this study was lower than the 138.4g, 177.90g and 1.97g reported by

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Odunsi *et al.* (2007) Vali *et al.* (2005) and Adeogun and Adeoye (2004) respectively. Consequently, the breast (50.81g), thigh (27.62g) and carcass weights (125.90g) reported by Vali *et al.* (2005) were higher than the 26.42g, 18.40g and 76.91g respectively reported in this study. The difference in weight observed in this study compared with others could be due to the higher ambient temperature of the semi arid region which probably resulted in a lower feed intake and consequently lower body weight gain.

The suitability of the live body measurements for estimation of carcass components *in vivo* depends on the existence of correlation between them. The highest correlation was observed between body weight and the carcass components. Close correlation between live body weight and carcass components have been reported in quails (Vali *et al.,* 2005). They reported high correlation estimates between body weight and breast weight (0.79) and thigh weight (0.70). This suggests that body weight is a good indicator of carcass tissue composition in the quail. These authors also reported that in cortunix quail, breast weight had higher heritability than thigh weight (h^2 =0.482 and 0.278 respectively). Thus prediction based on live weight in quails may be an important part of selection aimed at improving meat production.

Apart from live weight, chest width and chest girth showed a high, positive and significant (P<0.01) correlation with carcass components (r=0.63 and 0.60 respectively for breast weight). Bochno *et al.* (1999b) obtained similar results in broilers, Kleczek *et al.* (2006) and Wawro and Szypulewska (1999) in Muscovy ducks and Bochno *et al.* (1999a) in Geese. The low and non significant correlation between body measurements and percentages of the carcass components indicates that these traits may not be considered reliable predictors of relative carcass meatiness in quails. Kleczek *et al.* (2006) made a similar observation in Muscovy ducks.

Kleczek *et al.* (2006) also reported high multiple correlation coefficients (0.77 to 0.80) between breast weight and body measurements (body weight, chest width and chest girth) in ducks. Wawro *et al.* (1985) and Bochno *et al.* (1988) made similar observation in Pekin ducks and geese. Wawro (1990) reported that breast muscle weight, leg weight and total meat weight can be predicted with somewhat accuracy in Turkey with live body weight. Though live weight had a high R^2 value when used alone to predict both dependent variables , the highest R^2 was obtained when all the body measurements were used in the regression equation suggesting that they could be estimated more accurately by combination of two or more measurements than live weight alone. This supports the assertion by wawro (1990) that more accurate results can be obtained when several parameters are used as independent variables in multiple regression equations.

As already observed, and corroborated by Wawro (1990) and Thiruvenkadan (2005), the R^2values increased as more independent variables are added to the regression. However, Snedecor and Cochran (1989) observed that the residual mean square was free from this disadvantage and may be used with SD_E as criteria for verifying prediction accuracy. Thus, prediction equations with independent variables having the smallest MS_E may be selected. Moreover Topal and Macit (2004) reported that larger R^2 and smaller MS_E produced better goodness of fit. From Table-4, equations I, G, D and K had the smaller MS_E and SD_E values with higher R^2 values. The same is true for equations 11, 6, 7 and 4 on Table-5 for predicting the thigh weights. These equations may predict the carcass components more accurately than the others because they produced a better goodness of fit.

In all the equations (Tables 6 and 7), there was little difference between actual and predicted weight except equations G (28.10%), 7(19.94%), 8 (13.8%) and 9 (18.53%). These equations also had lower correlations between the actual and predicted values. It was observed that equations with larger R^2 and smaller MS_E and SD_E showed smaller variation between the estimated and actual values. Thiruvenkanda (2006) made a similar observation. Relatively accurate results for meat weight estimation with regression equations in ducks and geese have been reported by Wawro *et al.* (1985) and Bochno *et al.* (2000b).

CONCLUSIONS

It can be concluded from this study, that live body weight, chest girth and chest width had high, positive and significant (P<0.01) correlation with breast and thigh weight while they were low and non significant (P>0.01) with breast and thigh percent. Thus, they can be used as selection criteria for improving meatiness of the quail. Though live body weight alone can be used to predict breast and thigh weights, better results are obtained when two or more independent variables are combined in the equation. Equations with high R^2 and lower MS_E produced a better goodness of fit with higher prediction accuracy. Thus, equations D, I, J, K, 4, 6 and 11 can be used for predicting breast and thigh weights in the Japanese quail depending on ease of obtaining the sets of measurements under field condition.

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Table-1. Descriptive statistics and correlation coefficients of the carcass components and live body measurements.

	Descriptive statistics			**Simple Correlation coefficient**			
Variable	**Mean**	**SD**	**SE**	**Breast weight**		**Thigh weight**	
				(g)	(%)	(g)	(%)
Breastbone length	5.5380	0.8528	0.1206	0.18	-0.23	-0.06	-0.02
chest girth	14.460	0.8836	0.1250	0.63**	0.01	0.60**	-0.14
chest width	3.1100	0.2384	0.0337	0.62**	0.01	0.60**	-0.26
live weight	113.16	10.187	1.4406	0.85**	0.01	0.78**	-0.17
wing length	8.3180	0.8181	0.1157	-0.24	-0.08	-0.28	0.02
body length	17.796	1.1932	0.1689	0.12	-0.09	0.08	-0.28
shank length	2.913	0.8981	0.0513	-0.13	0.07	-0.26*	0.07
drum length	7.3020	0.7604	0.1075	-0.03	0.11	-0.11	0.11
thigh weight	18.400	2.0504	0.2900	NA	NA	1.00	NA
Breast weight	26.420	3.6089	0.5104	1.00	NA	NA	NA
carcass weight	76.917	7.6851	0.9921	NA	NA	NA	NA
% Carcass	67.821	6.5130	0.8156	NA	NA	NA	NA
% Breast	34.419	2.6980	0.3816	NA	1.00	NA	NA
% Thigh	24.016	1.5870	0.2240	NA	NA	NA	1.00

NA = Not available.
All widths and lengths are in centimeters and weights in grams
** Significant (P<0.01)

Table-2. Regression equations for prediction of breast weight in japanese quails.

No	**Predictor variable**	**Regression Equations**
A	Live weight (lwt)	Y_1= -3.460 + 0.264 Lwt
B	Chest width (chw)	Y_1=6.554 + 6.388 chw
C	Chest girth (chg)	Y_1=1.158+1.747 chg
D	Lwt x bbl	Y_1=1.689+0.277 Lwt-1.202 bbl
E	Lwt x chw	Y_1=-8.106+2.258 chw+0.243 Lwt
F	Lwt x chg	Y_1=-9.220+0.559 chg+0.243 Lwt
G	Lwt x bbl x chg	Y_1=-3.490+1.177 bbl+0.492 chg+0.259 Lwt
H	Lwt x chg x chw	Y_1=-12.14+0.456 chg+0.229 Lwt+1.932 chw
I	Lwt x chg x chw x bbl	Y_1=-5.195-1.124 bbl+0.444 chg+0.250 Lwt+0.955 chw
J	Lwt x chw x chg x bbl x wl	Y_1=-2.296+0.676 chw+0.428 chg+0.251 Lwt-1.060 bbl-0.241 wl
K	Lwt x chw x chg x bbl x wl x bl x dl	Y_1=-0.706+0.559 chw+0.520 chg+0.251 Lwt-1.354 bbl-0.486 wl -0.235 wl +0.699dl

Bbl - Breast bone crest length, wl-wing length, bl-body length, dl-drumstick length.

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Table-3. Regression equations for prediction of thigh weight in Japanese quails.

No	Predictor variable	Regression Equations
1	Live weight (lwt)	Y_2=3.026+0.135 Lwt
2	Chestwidth (chw)	Y_2=8.796+3.087 chw
3	Chest girth (chg)	Y_2=5.134+0.917 chg
4	Lwt x bbl	Y_2= 4.522+0.139 Lwt+0.349 bbl
5	Lwt x chw	Y_2=1.121+0.127 Lwt+0.926 chw
6	Lwt x chg	Y_2=-0.171+0.310 chg+0.124 Lwt
7	Lwt x bbl x chg	Y_2=1.456+0.128 Lwt+0.296 chg+0.334 bbl
8	Lwt x chg x chw	Y_2=-1.276+0.119 Lwt+0.732 chw+0.271 chg
9	Lwt x chw x bbl	Y_2=3.014+0.133 Lwt+0.311 bbl+0.653 chw
10	Lwt x chw x bbl x chg	Y_2=0.629+0.125 Lwt+0.464 chw+0.268 chg-0.308 bbl
11	Lwt x chw x bbl x chg x dl	Y_2=-5.911+0.874chw+0.369chg-0.647bbl+0.119lwt+0.864dl

Bbl-Breast bone crests length, dl-drumstick length.

Table-4. Statistical parameters for the equations predicting breast weight in Japanese quails.

Equation	F	MS_E	SD_E	R^2	D (%)	CV
A	59.99**	5.90	2.43	0.65	65	9.20
B	10.40**	10.92	3.50	0.27	27	13.25
C	10.75**	10.86	3.29	0.28	28	12.45
D	40.87**	4.95	2.22	0.83	83	8.40
E	31.27**	5.78	2.40	0.77	77	9.08
F	31.70**	5.82	2.41	0.77	77	9.12
G	28.08**	5.78	2.41	0.84	84	9.12
H	27.32**	5.77	2.40	0.78	78	9.08
I	20.88**	4.89	2.22	0.85	85	8.40
J	16.50**	5.05	2.24	0.85	85	8.48
K	12.31**	4.97	2.23	0.87	87	8.44

** = ($P<0.01$)

VOL. 4, NO. 3, MAY 2009 ISSN 1990-6145
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Table-5. Statistical parameters for the equations predicting thigh weight in Japanese quails.

Equation	F	MS_E	SD_E	R^2	D (%)	CV
1	40.17**	2.33	1.52	0.56	56	8.26
2	7.10**	3.73	1.90	0.23	23	10.33
3	8.89**	3.62	1.90	0.26	26	10.33
4	20.86**	2.29	1.51	0.68	68	8.21
5	20.45**	2.34	1.53	0.66	66	8.32
6	20.86**	2.29	1.51	0.67	67	8.21
7	14.69**	2.28	1.51	0.69	69	8.21
8	13.94**	2.34	1.53	0.67	67	8.32
9	14.69**	2.32	1.53	0.68	68	8.32
10	14.21**	2.33	1.53	0.69	69	8.32
11	11.53**	2.24	1.30	0.77	77	7.07

** = ($P<0.01$)

Table-6. Results of prediction of breast weight in Japanese quails with the regression equations from Table-2.

Equation	Value		Difference ($Y-\hat{Y}$)		Coefficient of correlation ($r_{Y\hat{Y}}$)	No. of birds with deviation of the estimated value from the actual in the range± (%)		
	Actual (Y)	Estimated ($\hat{Y}$)	(g)	% in relation to Y		0-5	5-10	>10
A	26.42	26.41	0.01	0.037	0.745	38	9	3
D	26.42	26.39	0.03	0.113	0.796	39	8	3
E	26.42	26.41	0.01	0.037	0.758	38	10	2
F	26.42	26.36	0.06	0.227	0.756	40	7	3
G	26.42	33.87	-7.45	28.10	0.615	2	4	44
H	26.42	26.37	0.05	0.181	0.764	39	9	2
I	26.42	26.26	0.16	0.605	0.806	37	10	3
J	26.42	26.52	-0.10	0.375	0.807	40	7	3
K	26.42	27.74	-1.32	4.996	0.820	35	10	5

VOL. 4, NO. 3, MAY 2009 ISSN 1990-6145
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Table-7. Results of prediction of thigh weight in Japanese quails with the regression equations from Table-3.

Equation	**Value**		**Difference** (Y- Ŷ)		**Coefficient of correlation** ($r_{Y\hat{Y}}$)	**No. of birds with deviation of the estimated value from the actual in the range±** (%)		
	Actual (Y)	**Estimated** (Ŷ)	(g)	**% in relation to Y**		0-5	5-10	>10
1	18.40	18.30	0.1	0.543	0.675	47	3	0
4	18.40	18.42	-0.02	0.108	0.633	40	10	0
5	18.40	18.37	0.03	0.163	0.682	45	5	0
6	18.40	18.34	0.06	0.326	0.686	45	5	0
7	18.40	22.07	-3.67	19.94	0.647	0	41	9
8	18.40	20.94	-2.54	13.80	0.690	15	30	5
9	18.40	21.81	-3.41	18.53	0.648	0	43	7
10	18.40	18.39	0.01	0.054	0.701	45	5	0
11	18.40	18.34	0.06	0.326	0.753	45	5	0