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Prediction of Testicular Weight in Local Chickens Using Linear Body Measurements

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Abstract: *The study was conducted in Muda-Lawal Market Bauchi, Bauchi state from June to August, 2016. A total of 400 matured cocks (357 normal feathered, 23 naked neck and 20 frizzled) were used to obtained the following measurements: comb height, comb length, wattle length, neck length, wingspan, trunk length, body length, girth circumference, drumstick length, shank length and testicular weight. Data generated were subjected to analysis of variance, Pearson correlation analysis and prediction models using simple and multiple linear regression. The mean comb height, comb length, wattle length, neck length, wingspan, trunk length, body length, girth circumference, drum stick length, shank length andtesticular weight were 4.93 cm, 7.53 cm, 3.98 cm, 13.61 cm, 47.50 cm, 21.80 cm, 45.24 cm, 32.70 cm, 14.38, 11.05 cm and 14.41g, respectively. Strain had significant effect on comb height ($P<0.01$) and length ($P<0.05$), neck lengths ($P<0.001$) and testicular weight ($P<0.05$) while influence of comb type on height and girth circumference ($P<0.001$) was evident. Correlation between the body measurements (comb length, wattle length, neck length, wingspan, trunk length, body length, girth circumference, drumstick length and shank length) and testicular weight were low to moderate, positive and significant ($P<0.01$). Comb height and length and, wattle length were found to have the highest correlation coefficient (R) values of 0.493, 0.534 and 0.480 and coefficient of determination (R^2) of 0.241, 0.285 and 0.230, respectively. The coefficients of determination of the combine traits (comb height and length and, wattle length) was 0.420. Moreover, this study indicated that secondary sexual characters (comb and wattle parameters) are good predictors of testicular weight in local chickens.*

Key words:*Correlation, Prediction, Testicular weight, Local chicken*

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I. Description of Problem

Indigenous chicken is a general terminology used to describe birds kept in a certain location under extensive management; scavenging the free-range,indescript, multi-purposed and unimproved (Horst, 1989). In Africa, they are also referred to as family chickens, bush chickens, African hens, bush hens or Sahel chickens (Gueye and Bessei, 1998). These highly adapted creatures are found throughout the regions of Nigeria and in every culture. Indigenous chickens formpart of the agricultural activities among rural communities, although farmers regard them as secondary to the otheractivities such as crop, cattle, sheep and goat production. Therefore, indigenous chickens are mostly under the management of women (Tadelle and Ogele, 2001). Research reports from different parts of Nigeria indicated that, the local chicken exhibit less than optimum productivity (slow growth rate, late maturity, few egg yield, small sized eggs, extended reproduction cycle and inter-clutch and high mortality) (Nwosu*et al*., 1985). On the other hand, they have several desirable traits including,thermo tolerance, disease resistance, productivity at minimal feed supplementation, high quality eggs and meat flavour, hard egg shells, high fertility, hatchability and dressing percentage (Aberra, 2000).Local chickens and eggs are preferred by most consumers because they are tastier and suitable for traditional sauces due to the deep yellow coloured yolks (Moges *et al.,* 2010).

Some of the animal production improvement procedures namely, management, nutrition and disease control (as alluded to) have therefore been fairly well assessed. Reproduction which is an aspect in the life cycle of animals that ensures availability and continuity of stock both improved and unimproved has been fairly neglected. It has not been adequately assessed in local chickens experimentally, on farm and in the field.chickens like fish and amphibian are oviparous.Embryonic and foetal developments take place outside the body. The avian male reproductive system however is inside the body.The male chicken possesses two testes, located along the backbone, near the top of the kidneys (Ahemen*et al*., 2010). The testes are elliptical and light yellow in colour and sperms remain viable at body temperature but quality decline with age.The vas deferens are the main sperm storage area.Each vas deferens opens into a small bump, or papilla, which is on the back wall of the cloaca. The papillae serve as the mating organ. The incorrectly named rudimentary copulatory organ is used to classify the sex of chicks.Fertility is affected by both the male and female.Testes development which is associated with those of other parts of the body is critical for achieving and maintaining fertility within a flock. Testes size is highly correlated with fertility; poor fertility is also often associated with small testes (Abor Acre, 2008).

Chicken reproductive studies especially in the field will give general idea of their capacity in this aspect. This will guide farmers on reproductive performance improvement. Even for the scientist the measurement of chicken reproduction, particularly the male, on the field is tasking. A farmer would require easily measureable attributes to aid the selection of a breeding rooster. Testicular size has been the common field measure of reproductive ability of animals. Its internal location in the rooster's body however complicates assessment. If strong and positive relationships could be established between body measurements and testicular size, the former could be used to indicate the latter and hence semen production.

II. Materials and Methods

Location

Most of the study was conducted at Muda-Lawal market in Bauchi Local Government Area of Bauchi State, Nigeria from June to August, 2016.The remaining was carried out at Abubakar Tafawa Balewa University Research and Teaching Farm. Bauchi state occupies a total land area of 49,119 km^2 representing about 5.3% of Nigeria's land mass and is located between latitude 9° 3' and 12° 3' north and longitude 8° 50' and 11° east (Abubakar, 1974).

Climate and vegetation

The rainfall in Bauchi state ranges between 1300 mm per annum in the south and only 700 mm in the extreme north (Muhammad, 2003). The average relative humidity, daily sunshine hours and temperature values range between 35 - 94 % for months of February and August, 5.0 - 10.0 hours in August and November and 36.6 – 12.8^{0}C during April and December, respectively.It spansthree vegetation zones, namely, northern guinea, Sudan and Sahel savannahs (Abubakar, 1974). The northern guinea savannah consists of thick barked trees of medium height dominated by *Isoberliniaspp* and short grasses mainly *hyperrhenia*/*Andropogon spp*. The sudan savannah is essentially grass land vegetation with a few scattered short trees. *Combinbretum cacia* and *Comphoraspp* are the most common trees while *Andropogongayanus* is the dominant grass. The sahel savannah also known as semi-desert extend from the middle to extreme north of the state (Abubakar, 1974).

Data collection

Cocks with fairly developed spurs brought for slaughter at the Muda-Lawal market abattoir were used for this study. However, only normal feathered chickens were available, therefore the frizzled and naked were sourced directly from the village markets. Before slaughter cocks were tagged using a masking tape and permanent marker to obtain the linear body measurements.

Linear body measurements

A total of 400 matured cocks were available for this study out which, 357 were normal feathered, 23 naked neck and only 20 frizzled. The number used was determined according to the following expression by Yamane (1967).

$$n = \frac{N}{1 + N(e)^2}$$

n = Sample size
N = Population size
E = Level of precision

$$n = \frac{100,000}{1 + 100,000(0.05)^2}$$

n = 398

If the population size ranged between 100,000 to ∞, the sample size will be = 400 (Yamane, 1967)
The following quantitative traits were measured, namely; body length, body girth, shank length, drumstick length, back length, wing span, comb height, comb length, wattle length and testicular weight. On the other hand, strain (genotype) and comb type were observed.

Gonadal sperm/spermatid reserve determination

The weights of fifty pairs of testicles from normal feathered chickens were measured. Sperm and spermatid reserves were thereafter determined according to the method of Igboeli and Rakha(1971) and Rekwot*etal.* (1994). Eachpair was homogenized using an electric blender in 20ml of normal saline with antibiotics, the homogenate was centrifuged at 24 x gravity. After centrifugation, 5ml of the supernatant was stored overnight at 5^0C to allow sperm cells and spermatids to ooze out of the tissues. The gonadal sperm/spermatid concentrations were then determined using a haemocytometer according to the method of Coles (1974).

III. Data analysis

Data generated were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of SPSS, version 22 (2013). Significantly different means were compared using the least significance difference (LSD). The model utilized was as follow:

$\mathbf{Y}_{ij=}\mathbf{U} + \mathbf{G}_i + \mathbf{C}_j + \mathbf{e}_{ij}$

$\mathbf{Y}_{ij=}$ Observation on dependent variables

$\mathbf{U}_=$ Common Mean

$\mathbf{G}_{i=}$ effect of i^{th} genotype (1, 2, 3)

$\mathbf{C}_{j=}$ effect of j^{th} comb type (1, 2)

$\mathbf{e}_{ij=}$ random error term

The relationships among testicular weight and linear body measurements were determined using the Pearson's product moment correlation. Predictions of testicular weight using some body measurements (those with high correlation with testicular weight) were carried out using the following models:

$Y_{1\,=}a + bx_{1\text{-------}}$ simple regression model

$Y_{1=}a + b_1x_1 + b_2x_2 + \ldots + b_kx_{k\text{--}}$ multiple regression model

Where $Y_{1\,=}$ dependent variable (testicular weight)

$a_=$ the Intercept

$b`s_=$ the slopes

$x`s_=$independent variables

For prediction of gonadal sperm reserve from testicular weight, four most used models were utilized.

$Y_{2=}a + bX_{2\text{------}}$simple regression model

$Y_{2=}aX^2_2 + bX_2 + c$ ---- quadratic model

$Y_{2=}ab^x$ -------exponential model

$Y_{2=}a + b\ln X_2$----logarithmic model

$Y_{2=}$ dependent variables (gonadal sperm reserve)

$X_{2=}$ independent variable (testicular weight)

Ln $_=$ natural logarithm

C $_=$constant

IV. Results

Average body measurements and testicular weight according tostrains and comb types are presented in Table 1. The GLM, revealed significant effect of strain on comb length ($P<0.05$) and height ($P<0.01$), neck length ($P<0.001$) and testicular weight ($P<0.05$). Normal feathered chickens had longer and higher combsand testicular weights while the Frizzled types had longer necks. Non-significant strain effect was detected on wing span, trunk length, shank length, drum stick length, girth circumference, body and wattle lengths.

There was significant comb type effect on girth circumference ($P<0.001$) and comb height ($P<0.001$). Rose comb chickens had higher girth circumference than the single (34.11±0.44 vs 31.30± 0.90 cm) while the later had higher comb height than the former (5.56±0.36 vs 4.30±0.45cm). Non-significant influence of comb type on wingspan, shank, drumstick, body, trunk, comb, wattle, neck lengths and testicular weight were however observed.

The correlation coefficients among the body measurements and testicular weight were as shown in Table 9. Phenotypic correlations among body measurements were in general positive and moderate to high except wingspan which had negative and low value (-0.06) with comb height.Correlation coefficients between testicular weight and body measurements ranged from 0.139 to 0.534. Comb length and height and, wattle length were found to have highest correlation coefficients with testicular weight (0.534, 0.493 and 0.480, respectively).

The linear Prediction equations using the body measurements (those with highest correlations with testicular weight) individually and combination as independent variables are shown in Table 3. When single characters were used alone CL had the highest coefficient of determination (R^2= 0.285) while the least was observed in WL (R^2 = 0.230). The multiple coefficient of determination of the combined traits (CH, CL and WL) however was higher (R^2= 0.42).

Four models for predicting sperm reserve using testicular weight are presented in Table 4. The quadratic type function had the highest coefficient of determination (R^2) of 0.942 whereas the exponential model had the lowest 0.705±0.173. Exponential model had the highest intercept, ***a*** (4991337.41±931397.81) whereas the quadratic function had the lowest, -21580379.14±4151455.07. On the other hand, the logarithmic model had highest ***b*** value (14898750.52±1614130.88) while the lowest was observed in quadratic type (-97849.62±1780.68). Furthermore, ***c***was only obtained for the quadratic function**.**

V. Discussion

The averagepaired testicular weight (14.41±1.81 g)observed in the present study is slightly similar to the overall mean valueof 16.50±1.12 grecorded by Ibrahim *et al*. (2018) among Isa Brown (ISB), Bovan Nera Black (BNB), ShikaBrown (SHB) and unimproved local strain, normal feather (NF) chickens. However, higher values of 23.20, 21.58 and 31.92 g were reported by Obidi*et al*. (2008), Orlu and Egbunike (2009) and Orlu and Egbunike (2010), respectively in Isa brown chicken while in 2007, Adeyemo*et al*. recorded lower mean of 11.44 g in same breed.The mean body measurements observed in the present study are similar to those reported by Aklilu*et al.* in 2013 (3.51±0.08, 21.84±0.27, 39.97±0.35, 30.47±0.32 and 11.32±0.10 cm for WL, TL, BL, GC and SHL, respectively), Guni*et al.* and Sri Rachma*et al*. also in 2013 with respective values of 47.60±0.26, 42.97±0.02 and 14.80±0.11 cm for WSP, BL and DSL and 4.70±1.50, 30.30±2.90, 14.40±1.30 and 10.20±1.10 cm for CL, GC, DSL and SHL. However, lower values of 2.76±0.09, 1.76±0.06, 37.04±0.13, 35.79±0.09 and 7.79±0.15 cm for CL, WL, WSP, BL and SHL and 2.08±0.03, 33.80±0.50 and 5.50±0.10 cm for CL, BL and SHL were reported by Getu*et al*. (2014) and Daikwo*et al*. (2011), respectively. Similarly, Fayeye*et al*. (2013) recorded values of 8.02±2.44 cm (WSP), 23.72±1.79 cm (BL) and 5.44±0.79 cm (SHL) among Isa brown and Ilorin ecotype cocks in Nigeria.

The significant effect of genotype on reproductive traits (comb height and length and testicular weight) and neck length observed in this study is inconformity with the work of Gala (2007) among local breeds (Fayoumi and Dandarawi) of chickens native to Egypt. The author recorded longer comb and wattle in naked neck than normal feather cocks.Working on three different genetic groups (Ermellinata di Rovigo, Robusta lionataand Robusta maculata) of chickens, Rizzi and Verdiglione (2016) detected significant effect of genotype on comb length and height, comb, wattle and testicular weights. Similar, Ibrahim *et al*. (2014) detected significant variation in comb and wattle lengths and widths among BNB, ISB, SHB and NF cocks. The authors attributed this to differences in the genetic architecture of the studied breeds. The considerable effect of comb type on height and girth circumference observed in the current study concur with the finding of Birteeb*et al.* (2016). For both traits, cushion comb chickens had the highest while the least was recorded in pea type (4.18±0.43 and 14.79±0.40 cm vs 2.20±0.50 and 13.38±0.79 cm).

The generally positive correlations among body measurements show that they can be used to indicate each other i.e. if one has high value so also will be the other. The high correlation between the body measurements in this study agree with the findings of several investigators (Momohand Kershima, 2008; Getu*et al*., 2014; Ukwu*et al*., 2014). In particular, the strong and positive correlations among some of the body measurements (shank, drumstick and body lengths and, girth circumference) agree with the findings of some investigators (Dana *et al*., 2011; Getu*et al.*, 2014). The positive but low to moderate phenotypic correlations between body measurements and testicular weight means that the variable may not indicate each other. Ndofor-Foleng*et al*. (2015) also found low to moderate phenotypic correlations between body measurements. Similar results were detected by Soneeda*et al*. (2013) among Thailand indigenous chickens. The negative correlation observed between wingspan and comb length shows that the magnitude of the variables is oppose if the value of one is high that of the other will be low. Abdl-El-Ghanny*et al*. (2011) however found positive correlation between wingspan and comb length.

The strong and positive correlation between the testicular weight and secondary sexual characters (comb height and length and, wattle length) observed in this study agrees with the reports of some investigators (Abd-El-Ghany*et al*., 2011;Ibrahim *et al*., 2014). The authors stated that there are usually strong and positive correlations between secondary sexual characters and semen volume in chickens. Similarly, Galal (2007) reported an R^2value of 0.656 when comb length was regressed against semen volume in Fayoumi chickens. This indicates that selective measureable improvement of secondary sexual characters will improve testicular weight and hence sperm production.

The coefficients of determination (R^2) obtained when comb height and length andwattle length (CH, CL and WL) were individually regressed against TW (testicular weight)agree with the findings of Udeh*et al.* (2011) among local chickens. In their study,CL and SHL predicted semen concentration and motility with respective R^2 values of0.360 and 0.342. Similarly, El- Sahn (2007) reported R^2 values of 0.27 and 0.28 for comb and wattle lengths regressed to semen volume, respectively. This indicates (contrary to correlation values) that the measureable secondary sexual characters were poor indicators of testicular weight. The multiple coefficient of determination (R^2) of 0.42 for the combine traits (CH, CL and WL) is inconformity with the finding ofUdeh*et* *al*. (2011). The author reported an R^2 of 0.47 when BW, SHL, BKL (beak length) CL and WL were used together to predict semen volume in local chickens. Galal (2007) also reported an R^2 of 0.705 whenBW (body weight), SL, CL and WL were used in the prediction of semen volume among Egyptian Dandarawi chickens. Thus, combinations of measureable secondary sexual characters give better prediction than one.

The prediction results using different mathematical growth models indicated that the quadratic function was best for predicting gonadal sperm reserve from testicular weight. On the other hand, the exponentialwas poorest. Seeker (2005) using similar models in chickens also found that the quadratic best predicted albumen weight with precision of 0.889 or 88.9% when egg weight was used as regressor. Similarly, Orheruata*et al*. (2010) found that quadratic best predicted rabbit weights at different ages with average precision of 0.997 (or 99.70%) when girth circumference and body length were used. However, Semakula and Kogunza(2011) reported that the power model had the highest R^2value (0.83) for growth in chicken when heart girth was used in the equation. Agaviezor and Amusan (2012) on the other hand detected that the Logarithmic function (semi and double Logs) had the highest R^2 value when egg weight was predicted from body weight oflocal pullets.

VI. Conclusion

Conclusively, strain and comb type had no effect on most body measurements. The low to moderate relationships between body measurements and testicular weight implies that it is difficult to use the former individually to indicate (predict) the latter. Testicular weight can best be predicted when all the secondary sexual characteristics (comb height and length, and wattle length) are included in the regression model. Of the all models utilized, quadratic function yielded highest precision in the prediction of gonadal sperm reserve from testicular weight.

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Table 1: Average body measurements (cm) and testicular weight (g) by strain and comb type

Factors	CH	CL	WL	NL	WSP	TL	BL	GC	DSL	SHL	TW
Overall mean± SE	4.93±0.39	7.53±0.51	3.98±0.34	13.61±0.45	47.50±1.62	21.81±0.79	45.24±1.1	32.71±0.92	14.38±0.38	11.10±0.36	14.41±1.81
Strain	**	*	NS	***	NS	NS	NS	NS	NS	NS	*
Normal feather	5.36±0.38^{a}	8.02±0.50^{a}	4.12±0.34	12.67±0.45^{b}	48.73±1.61	20.19±0.78^{c}	44.78±1.08	32.96±0.97	14.19±0.38	11.03±0.36	16.23±1.80^{a}
Naked neck	4.61±0.42^{b}	7.32±0.55^{b}	4.12±0.37	13.83±0.49^{a}	46.00±1.75	23.29±0.85^{a}	45.44±1.17	32.81±1.05	14.45±0.41	11.37±0.39	14.00±1.95^{b}
Frizzled feather	4.82±0.50^{b}	7.25±0.66^{b}	3.69±0.44	14.33±0.59^{a}	47.70±2.12	21.94±1.03^{b}	45.50±1.42	32.34±1.27	14.50±0.49	10.76±0.47	12.99±2.37^{c}
Comb type	***	NS	NS	NS	NS	NS	NS	***	NS	NS	NS
Single	5.56±0.36	7.66±0.47	3.79±0.32	13.63±0.42	47.03±1.50	21.93±0.73	45.21±1.01	31.30±0.90	14.19±0.35	10.97±0.33	14.39±1.68
Rose	4.30±0.45	7.40±0.60	4.16±0.40	13.59±0.53	47.97±1.91	21.68±0.92	45.27±1.28	34.11±1.40	14.57±0.44	11.14±0.42	14.42±2.13

CH = Comb height, CL = Comb length, WL = Wattle length, NL = Neck length, WSP = Wing span, TL = Trunk length, BL = Body length, GC = Girth circumference, DSL = Drum stick length, SHL = Shank length, TW = Testicular weight, *** = P<0.001, ** = P<0.01, * = P<0.05 and NS = Non-significant.

Table 9: Correlation between body measurements (cm) and testicular weight (g)

Parameter	2	3	4	5	6	7	8	9	10	11
C H(1)	0.699**	0.599**	0.192**	-0.061ns	0.160**	0.321**	0.287**	0.186**	0.273**	0.493**
C L(2)		0.675**	0.179**	0.202**	0.171**	0.321**	0.394**	0.181**	0.295**	0.534**
W L(3)			0.268**	0.123*	0.209**	0.316**	0.461**	0.230**	0.328**	0.480**
N L(4)				0.147**	0.474**	0.504**	0.336**	0.420**	0.341**	0.143**
W S(5)					0.201**	0.250**	0.406**	0.325**	0.362**	0.139**
T L(6)						0.417**	0.397**	0.438**	0.348**	0.166**
B L(7)							0.493**	0.564**	0.541**	0.292**
G C(8)								0.506**	0.560**	0.374**
D L (9)									0.617**	0.165**
S L(10)										0.282**
T W(11)										1

CH = Comb height, CL = Comb length, WL = Wattle length, NL = Neck length, WSP = Wing span, TL = Trunk length, BL = Body length, GC = Girth circumference, DSL = Drum stick length, SHL = Shank length, TW = Testicular weight, *** = P<0.001, ** = P<0.01, * = P<0.05 and NS = Non-significant.

Table 11: Models for prediction of testicular weight (g)

Models	R^2
TW = 2.26 + 2.22CH	0.241
TW = -0.41 + 1.90CL	0.285
TW = 5.122 + 2.55WL	0.230
TW = -1.612 + 0.86CH + 1.01CL + 0.93WL	0.420

CL = Comb Length, CH = Comb Height, WL = Wattle length, TW = Testicular WeightR^2 = Coefficient of determination

Table 4: Constants for some prediction models of gonadal sperm (10^6/ml) reserve from testicular weight (g)

Model	A	b	C	R^2
Linear	758262.91±2047768.78	960665.63±144411.55		0.783
Quadratic	21580379.14±4151455.07	-97849.62±17580.68	4026502.12±555898.20	0.942
Exponential	4991337.41±931397.81	0.075±0.013		0.705
Logarithmic	24602188.77±4192840.00	14898750.52±1614130.88		0.875

a = intercept, b = slope, c = constant and R^2 = coefficient of determination

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