

ASSESSING SIZE AND CONFORMATION OF THE BODY OF NIGERIAN INDIGENOUS TURKEY

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ABSTRACT

Body measurements, wing length, neck length, shank length, thigh length, body length, beak length, head length, keel length and chest circumference of 110 twenty weeks old Nigerian indigenous turkeys reared under semi intensive system were subjected to principal component analysis. The objectives of the study were to assess variability among body shape characteristics, deduce components that describe these traits, quantify the sex difference in size and shape, and predict live weight at that age from both original and orthogonal traits. Variation was noted between male and female turkey, in favour of the male as an expression of sexual dimorphism for all traits. Pair wise correlation between body weight and body measurements in both sexes ranged from 0.41 - 0.97 in males and 0.34 - 0.99 in females, respectively. Eigen values and share of total variance of the principal component analysis for the first 3 PCs were 80.25, 9.85 and 3.11% for males, and 78.03, 11.61 and 7.77% for females, respectively. The first factor in both sexes accounted for the greatest percentage of the total variation and was representative of general size. Independent body shape characters derived from factor scores accounted for 97% and 96% of the variation in the live weight in male and female turkeys, respectively.

Key words: size, conformation; body weight; principal component; indigenous turkey

INTRODUCTION

Turkey is not common among poultry growers in Nigeria: a number of farms are beginning to breed the bird at commercial level owing to increasing interest as a provider of meat complementing chicken. They are mostly located in urban areas and are gradually spreading even to village farms. The fast growth in the industry requires an intensive research approach to boast its production especially considering the potentials associated with it. The first approach in livestock characterization apart from evaluation of its production performance is the evaluation of body size and conformation (Ibe, 1989). The important criteria for judging market broilers are body size and body conformation or type. A quantitative measure of conformation will no doubt enable reliable genetic parameters for the traits to be estimated but also

make it possible to include conformation in breeding programme. Body weight has been commonly used to measure body size. Assessment of body weight and linear body measurements have been found useful in quantifying body size and shape (Ibe and Ezekwe, 1994). Linear body measurements have also been used to predict live weight in poultry (Chhabra *et al.*, 1972; Monsi, 1992; Gueye, 1998). The multitude of different body measurements available has lead several researchers to use multivariate techniques to simultaneously examine the relationship among body measurements and production traits (Brown *et al.*, 1973). Use of principal component analysis to examine the relationship between measurement of size and shape in poultry have been reported in chicken (Ibe, 1989; Yakubu *et al.*, 2009) and duck (Shahin, 1996; McCracken *et al.*, 2000; Ogah *et al.*, 2009). This multivariate procedure describes the total variation in a large system of

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body measurements in terms of a few artificial varieties.

The objectives of this study are (1) to examine the interdependence between different conformation traits in Nigerian indigenous turkey and their relationship with body size (2), to determine appropriate quantitative measure of body size and conformation using various linear traits and also determine whether such measures are affected by sex.

MATERIALS AND METHODS

Location of study, experimental birds and their management

The study was carried out in Lafia, Nasarawa State, located at humid savanna zone of north central Nigeria. It lies between $07^{\circ} 52' N$ and $08^{\circ} 56' N$ latitude, and $07^{\circ} 25'$ and $09^{\circ} 31' E$ longitude, respectively. One hundred and ten adult birds of twenty weeks age, made up of 42 males and 68 females, managed under semi intensive system at Gamos poultry farm were used for experimental purpose. The birds were fed commercial feed purchased from market and water supplied *ad libitum*.

Parameters measured

Body measurements taken were as suggested by Gueye *et al.* (1998) and Solomon (1996). The weight of the birds was obtained using a 20kg weighing scale in kilogram, while a measuring tape was used for body measurements in centimetre. Wing Length was taken from the shoulder joint to the extremity of terminal phalanx; while Neck Length was considered as the distance between the occipital condyle and the cephalic borders of the caracoids. Shank Length (SL) was measured from the hock joint to the tarsometatarsus digit-3 joint. Thigh Length (TL) was taken as the distance between the hock joint and the pelvic joint. Body Length (BL) was measured as length of the body from the base of the neck to the base of the tail around the uropigial gland. Beak Length was measured as distance between the rectal apterium to the end of the maxillary nail; Head Length from the end of the neck to start of beak. Keel Length (KL) was taken as the length of the cartilaginous keel bone or metasternum, and Chest Circumference was taken under the wing at the edge of the sternum.

To ensure accuracy, each measurement was taken twice and the mean was used in subsequent analysis. All the measurements were taken by the same person.

Statistical Analysis

The data were analysed to obtain mean, standard errors, minimum and maximum, and coefficient of variation for body weight and body measurements. Pearson correlation and effect of sex was determined using the general linear model (GLM). From the correlation

matrix, data were generated for the principal component factor analysis. Anti image correlation, Kaiser-Meyer-Olkin measures of sampling adequacy and Bartlett's Test of Sphericity were computed to test the validity of the factor analysis of the data sets. The appropriateness of the factor analysis was further tested using communalities and ratio of cases to variables. According to Everitt *et al.* (2001), principal component analysis is a method for transforming the variables in a multivariate data set into new variables, which are uncorrelated with each other and accounted for decreasing proportions of the total variance of the original variables. The components themselves are merely weighted linear combinations of the original variables. The varimax criterion of the orthogonal rotation method was employed in the rotation of the factor matrix to enhance the interpretability of the principal components.

The stepwise multiple regression procedure was used to obtain models for predicting body weight from body measurements (a) and from factor scores (b)

$$BWT = a + B_1 X_1 + \dots + B_k X_k \dots \quad (a)$$

$$BWT = a + B_1 FS_1 + \dots + B_k FS_k \dots \quad (b)$$

where,

BWT is the body weight , a is the regression intercept, B_i is the i-th partial regression coefficient of the i-th linear body measurement, X_i or the i-th factor scores(FS).

Cumulative proportion of variance criterion was employed in determining the number of principal components to extract. The factor programme of SPSS (2004) statistical package was used for the principal component analysis.

RESULTS AND DISCUSSION

The descriptive statistics outlining means \pm standard error, minimum, maximum and coefficient of variation estimate of body weight and linear body measurements of the indigenous turkey by sex are presented in Table 1. Sexual dimorphism was in favour of the male ($P<0.05$), as expressed in all traits studied, with the males being significantly heavier (3.38 ± 0.07) than the females (2.65 ± 0.02). The values were lower than those reported by Kodinetz (1940) and Muzic (1990) from Zagorje turkey at same age (6.01 kg for male and 3.97 kg for female, respectively). However, the values for chest width, shank length and drumstick length were similar to the findings of Janjecic and Muzic (2007), and Oblakova (2007). The relatively low body weight in the present study compared to the respective traits found in temperate region may have been due to the unfavourable

Table1: Descriptive statistics of body weight and linear body measurements of indigenous turkey by sex

| Variable | sex | mean±standard error | minimum | maximum | cv |
|-------------------------|--------|---------------------|---------|---------|-------|
| Body weight (kg) | Male | 3.38±0.07 | 2.80 | 4.20 | 9.93 |
| | Female | 2.65±0.02 | 2.50 | 2.80 | 4.05 |
| Wing length (cm) | Male | 26.85±0.40 | 24.00 | 32.00 | 6.89 |
| | Female | 24.57±0.49 | 22.00 | 28.00 | 9.15 |
| Neck length (cm) | Male | 25.52±0.61 | 20.00 | 31.00 | 10.99 |
| | Female | 20.28±0.35 | 18.00 | 23.00 | 7.97 |
| Shank length (cm) | Male | 12.52±0.35 | 10.00 | 17.00 | 12.78 |
| | Female | 9.14±0.22 | 8.00 | 11.00 | 11.09 |
| Thigh length (cm) | Male | 9.62±0.27 | 6.80 | 11.80 | 12.95 |
| | Female | 8.13±0.14 | 7.00 | 9.00 | 8.11 |
| Body length (cm) | Male | 35.05±0.71 | 28.00 | 40.00 | 9.27 |
| | Female | 31.86±0.33 | 30.00 | 34.00 | 4.69 |
| Beak length (cm) | Male | 5.02±0.10 | 3.80 | 6.20 | 9.61 |
| | Female | 4.20±0.09 | 3.80 | 5.00 | 9.76 |
| Head length (cm) | Male | 9.39±0.21 | 7.80 | 11.50 | 10.29 |
| | Female | 6.71±0.16 | 6.00 | 8.00 | 10.68 |
| Keel length (cm) | Male | 16.86±0.66 | 12.00 | 21.00 | 17.82 |
| | Female | 12.52±1.46 | 8.00 | 32.00 | 52.48 |
| Chest circumference(cm) | Male | 47.38±0.65 | 40.00 | 54.00 | 6.24 |
| | Female | 36.62±0.71 | 30.00 | 41.00 | 8.87 |

Table 2: Correlation coefficient of body weight and body measurements of male and female turkeys

| | BWT | WL | NL | SL | TL | BL | BKL | HL | KL | CC |
|-----|---------|---------|---------|---------|---------|---------|----------|---------|---------|---------|
| BWT | | 0.91*** | 0.85** | 0.97*** | 0.93*** | 0.93** | 0.86*** | 0.97*** | 0.41** | 0.89*** |
| WL | 0.91*** | | 0.85*** | 0.89*** | 0.85** | 0.82*** | 0.82*** | 0.90*** | 0.31 | 0.83*** |
| NL | 0.94*** | 0.90*** | | 0.78*** | 0.90*** | 0.90*** | 0.84*** | 0.84** | 0.43 | 0.76*** |
| SL | 0.88*** | 0.95*** | 0.89*** | | 0.88*** | 0.87*** | 0.85*** | 0.94*** | 0.29 | 0.85*** |
| TL | 0.95*** | 0.87*** | 0.96*** | 0.87*** | | 0.98*** | 0.90*** | 0.92*** | 0.56** | 0.85** |
| BL | 0.99*** | 0.92*** | 0.95*** | 0.91*** | 0.95*** | | 0.86*** | 0.91*** | 0.57*** | 0.81** |
| BKL | 0.89*** | 0.88*** | 0.95*** | 0.94*** | 0.90*** | 0.93*** | | 0.81*** | 0.45** | 0.78*** |
| HL | 0.81*** | 0.66** | 0.85*** | 0.68*** | 0.75*** | 0.80*** | 0.82*** | | 0.35* | 0.83*** |
| KL | 0.51** | 0.61** | 0.64** | 0.66*** | 0.50** | 0.52** | 0.67**** | 0.65*** | | 0.39* |
| CC | -0.34 | -0.52 | -0.54 | -0.53 | -0.41 | -0.32 | -0.50 | -0.48 | -0.72 | |

BWT = body weight, WL = wing length, NL = neck length, SL = shank length, TL= thigh length, BL= body length, BKL = beak length, HL = head length, KL = keel length, CC = chest circumference

*= $P<0.05$, **= $P<0.01$, ***= $P<0.001$

environmental conditions such as temperature, feed supply and non-selection characteristics of tropical animal genetic resources. The coefficient of variation (CV) for body weight and body measurements ranged from 4.05 - 17.82 except for keel length in females, thus

presenting an evidence that body dimensions and body weights are reliable indices of body size.

Pair wise correlation between body weight and body measurements in both male and female turkeys are presented in Table 2. In male turkeys all the morphometric

traits highly correlated ($P<0.001$ and $P<0.01$) with body weight, ranging from 0.41 for keel length to 0.97 for the shank length and head length. Similarly, relationships between all the traits were positive and significant. In females all the traits except chest circumference were positive and significantly correlated with body weight, ranging between 0.51 for keel length to 0.99 for the body length. Chest circumference negatively correlated with all the traits in the female, which is an indication of inverse relationship of chest circumferences with other traits. The high and significant correlation between body measurements and body weights in both sexes suggest

high predictability between the traits in both male and female turkeys. Bachev and Lalev (1990) recorded similar trend between body weight and principal body measurements in turkey, which means selection for body weight may lead to increase in other body measurements given that majority of genes influencing the body weight and body measurements of turkey are of common action. The implication here is that body weight can be estimated from body measurements except for the chest circumference in female turkey - this will be helpful as a selection criterion.

Table 3: Eigen values and shares of total variance along with factor loading after varimax rotation and communalities of the morphometric traits of turkey

| Male turkey | PC1 | PC2 | PC3 | communalities |
|---------------------|--------|--------|--------|---------------|
| Wing length | 0.664 | 0.667 | 0.077 | 0.89 |
| Neck length | 0.852 | 0.387 | 0.225 | 0.93 |
| Shank length | 0.605 | 0.752 | 0.073 | 0.94 |
| Thigh length | 0.747 | 0.525 | 0.366 | 0.97 |
| Body length | 0.734 | 0.515 | 0.388 | 0.96 |
| Beak length | 0.733 | 0.498 | 0.258 | 0.85 |
| Head length | 0.666 | 0.682 | 0.137 | 0.93 |
| Keel length | 0.200 | 0.116 | 0.967 | 0.99 |
| Chest circumference | 0.376 | 0.860 | 0.236 | 0.94 |
| Eigen values | 7.220 | 0.886 | 0.280 | |
| % of total variance | 80.225 | 9.845 | 3.108 | |
| Female turkey | | | | |
| Wing length | 0.900 | 0.355 | 0.131 | 0.95 |
| Neck length | 0.818 | 0.324 | 0.445 | 0.97 |
| Shank length | 0.884 | 0.388 | 0.159 | 0.96 |
| Thigh length | 0.884 | 0.165 | 0.349 | 0.93 |
| Body length | 0.902 | 0.165 | 0.407 | 0.99 |
| Beak length | 0.814 | 0.332 | 0.416 | 0.95 |
| Head length | 0.484 | 0.309 | 0.802 | 0.97 |
| Keel length | 0.298 | 0.796 | 0.373 | 0.86 |
| Chest circumference | -0.214 | -0.925 | -0.075 | 0.91 |
| Eigen values | 7.022 | 1.041 | .429 | |
| % of total variance | 78.025 | 11.605 | 4.769 | |

PC=Principal component

Table 3 presents eigen values and share of total variance along with factor loading after varimax rotation and their communalities for male and female turkeys' morphology. To determine whether true factor existed in the data, an anti-image correlation and Keiser-Meyer-Olkin measure of sampling adequacy from the diagonal

partial correlations were performed, and sufficient values were obtained to satisfy factorability of the data for both sexes. The overall significance of the correlation matrices tested with Bartlett's test of sphericity for the body measurements of male and female were Chi square 266.471 at $P<0.001$ and 120.537 at $P<0.001$, respectively,

thus providing the needed support for using factor analysis. Communalities range between 0.85 to 0.99 for the male and 0.86 to 0.99 for the female data. Principal component analysis revealed three principal components (PCs), only the first PC had eigen values greater than 1 for the male and two PCs with eigen values greater than 1 for the female. The first PC accounted for 80.225% of observed variance (eigen value 7.220) representing the overall body size in the male. The traits that had high loading for the first PC include neck length, thigh length, body length and beak length. In female, the first PC accounted for 78.025% of the total variation with eigen value 7.022 and loaded highest for all traits except head length, keel length and chest circumference.

The variation in factor loading in male and female observed here may indicate differences in association of each measurement with bone which varies with sexes (Salako, 2006). As the PC1 contrasted in terms of generalised body size, the subsequent factor presented patterns of variation for shape component. This finding is in line with reports in chicken (Pinto *et al.*, 2006; Yakubu *et al.*, 2009) and rabbit (Shahin and Hassan, 2000). The principal component obtained for both sexes can be an important tool for development of selection index for improvement purposes (Debut *et al.*, 2003).

Table 4: Step wise multiple regression of body weight on original body measurements and on their factor scores in male turkey

| Model | Explanatory variables | Predictors | Intercept | Reg. Coeff. | SE | R ² | VIF |
|---|-----------------------|------------|-----------|-------------|-------|----------------|------|
| Original body measurements as explanatory variable | | | | | | | |
| 1 | Head length | | 0.212 | 0.337 | 0.013 | 0.94 | 1.00 |
| 2 | Head length | | 0.422 | 0.180 | 0.027 | 0.97 | 8.30 |
| | Shank length | | 0.101 | 0.016 | | | 8.30 |
| 3 | Head length | | 0.364 | 0.156 | 0.024 | 0.98 | 8.90 |
| | Shank length | | 0.109 | 0.014 | | | 8.49 |
| | Keel length | | 0.011 | 0.003 | | | 1.44 |
| Orthogonal traits | | | | | | | |
| 1 | Factor score 2 | | 3.381 | 0.241 | 0.036 | 53 | 1.00 |
| 2 | Factor score 2 | | 3.381 | 0.241 | 0.014 | 0.93 | 1.00 |
| | Factor score 1 | | | 0.210 | 0.014 | | 1.00 |
| 3 | Factor score 2 | | 3.381 | 0.241 | 0.010 | 0.97 | 1.00 |
| | Factor score 1 | | | 0.210 | 0.010 | | 1.00 |
| | Factor score 3 | | | 0.066 | 0.010 | | 1.00 |

VIF=Variance inflation factor, SE=standard error, R²=regression coefficient

Table 4 and 5 presents the results of stepwise multiple regression of body weight on original body measurements and their factor score (orthogonal) for male and female. The interdependent original body dimensions and their independent principal component factor scores were used to predict body weight. In male the results showed that when only head length alone was used in predicting body weight it accounted for 94% of the total variation of body weight, while the inclusion of shank length, keel length and chest circumference further improved the accuracy of the prediction ($R^2= 98\%$). In female body length alone accounted for 97% variation, on inclusion of beak length the accuracy increases to

99%. The variation in body measurement traits used for weight prediction between sexes obtained in this study is similar to what McCracken *et al.* (2000) reported for musk duck.

Weight increase in poultry is one of the essential goals of improvement programmes, which requires adequate knowledge of correlated traits that can be considered when selection is to be applied, though some limitations can be anticipated due to multicollinearity that may exist when using linear traits which could render prediction unreliable (Ibe, 1989; Malau-Aduli *et al.*, 2004). This is evident in the present study in the case of female when beak length included in the variance inflation

Table 5: Stepwise multiple regression of body weight on original body measurements and on their factor scores in female turkey

| Model | Explanatory variables | Predictors | Intercept | Reg.coeff. | SE | R ² | VIF |
|---|-----------------------|------------|-----------|------------|-------|----------------|------|
| Original body measurements as explanatory variable | | | | | | | |
| 1 | Body length | | 0.390 | 0.071 | 0.002 | 0.97 | 1.00 |
| 2 | Body length | | 0.114 | 0.089 | 0.004 | 0.99 | 7.06 |
| | Beak length | | | -0.070 | 0.014 | | 7.56 |
| Orthogonal traits | | | | | | | |
| 1 | Factor score 1 | | 2.657 | 0.094 | 0.008 | 0.78 | .00 |
| 2 | Factor score 1 | | 2.657 | 0.094 | 0.004 | 0.95 | 1.00 |
| | Factor score 3 | | | 0.043 | 0.004 | | 1.00 |
| 3 | Factor score 1 | | 2.657 | 0.094 | 0.003 | 0.97 | 1.00 |
| | Factor score3 | | | 0.043 | 0.003 | | 1.00 |
| | Factor score 2 | | | 0.012 | 0.003 | | 1.00 |

VIF=Variance inflation factor, SE=standard error, R²=regression coefficient

factor (VIF) exceeded 10. Rook *et al.* (1990) stated that VIF in excess of 10 indicates severe collinearity which leads to unstable estimation of the associated least square regression coefficient. To overcome this limitation, the use of principal component factor scores which are orthogonal and not correlated is usually advocated (Keskin, 2007; Ogah *et al.*, 2009; Yakubu *et al.*, 2009). Combination of the factor scores 1, 2 and 3 reveals an improvement in the amount of variance explained by R²=53.93 and 97% for male, and R²=78.95 and 96 % for the female. Similar findings were reported by Shahin and Hassan (2000), and Keskin (2007).

The final regression equation for estimating live weight from independent factor scores for male and female is

$$\text{Male: body weight (kg)} = 3.381 + 0.241\text{FS2} + 0.210\text{FS1} + 0.066\text{FS3}$$

$$\text{Female: body weight (kg)} = 2.657 + 0.094\text{FS1} + 0.043\text{FS3} + 0.012\text{FS2}.$$

CONCLUSION

Principal component analysis has explored the interdependence in original body shape characteristics in the two sexes of indigenous turkey. The variability in independent variable used in weight estimation between sexes support the dimorphism expressed in descriptive analysis. The use of orthogonal body shape characteristics derived from factors' scores was more appropriate than

the use of original traits in body weight prediction as multicollinearity problems were eliminated.

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