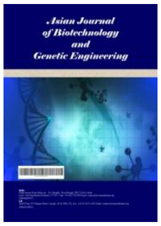

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Effects of Sexual Dimorphism on Phenotypic Traits of Anak ® Broiler Birds in the Cool Tropical Climate of Jos, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors OM, YB and U designed the study. Author NM performed the statistical analysis. Author PE wrote the protocol. Author JM managed the literature searches. Author AC managed the analyses of the study. Author WO managed the data cleaning. Authors ES and DS managed the proofreading of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Evaluation of sexual dimorphism is one of the important sources of information in the development of strategies to manage Anak broiler breeds in the cool tropical climate of Jos, Plateau State. While descriptive statistics and correlation analysis are utilized extensively, the use of principal component analysis (PCA) for this type of data analyses is unexplored. PCA was use to map the variations in male and female Anak® broiler birds. Data utilized for this study were obtained from

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male and female Anak broiler birds reared at National Veterinary Research Institute, Vom, Plateau State. Body weights showed sexual dimorphisms from six weeks through eight weeks and the males recorded significantly (P < .05) higher body weights than females. Our results showed that bodyweight is positive and strongly correlated to biometric in Anak® male and female broiler birds. Female birds showed higher response (97.38%) in variance than the male birds (93.5%) with two components extracted. Results of this study suggest that sexual dimorphism existed in biometric traits and decisions on the management of Anak® broiler birds should be handled separately.

Keywords: Sexual dimorphism; biometric; phenotypic traits; poultry industry.

1. INTRODUCTION

In the last decade, the poultry industry plays a major role in supplying the population with meat which is highly nutritious and popularly consumes [1]. The broiler chicken in Nigeria served as the major source of protein for the population. Despite their economic importance, the poultry production is continuously facing substantial and different challenges such as low adaptation of temperate breeds in the tropics, increase mortality and susceptibility to infectious diseases [2] Studies on performance characteristics of exotic strains in the hot humid environment in Nigeria have been conducted by several researchers [3]. [4] Reported that body linear measurement has heritable basis and have been identified to play a major role in the subsequent carcass yield of broiler strains [5]. Reported a direct and positive relationship between body weight and morphometric [6]. Opined that the knowledge of this relationship would help breeders organize selection in order to achieve an optimum combination of body weight and good conformation for maximum economic returns [7]. Opined that body weight, morphometric traits such as back length, shank length, keel length, wing span and head circumference are good indicators of growth and market value of broilers [8]. However, stated that the importance of evaluating interrelationships and productivity traits in poultry lies in their usefulness as predictors of characteristic like body weight. Such applications could speed up the assessment of traits through the involvement of simple measurement tools like ruler or tape.

A range of techniques are available to gain information about broiler mass and body conformation. Some of these techniques use simple and inexpensive equipment, while others required sophisticated and expensive equipment [7]. The most direct way to determine broiler's mass is to weigh it using scale. However, under some circumstances, a scale may not be available. An alternative is to measure a body part and relate the measurement to the body weight using multivariate techniques.
Therefore, our objective was to test the effect of sex on body weight and biometric traits at different ages and also to understand the pattern of relationship using correlation and principal component techniques.

2. MATERIALS AND METHODS

2.1 Study Location

This study was carried out at the National Veterinary Research Institute, Vom, Jos, Plateau State, Nigeria. The study area Plateau State of Nigeria derived its name from the geographical landscape that predominates in this part of the country. The Plateau highland stand at an average height of 1,200 meters above sea level. The State is covering about 5358 square kilometers with a population of 3,283,704. Plateau State is located in the middle belt zone of Nigeria between latitudes 8'22' and 10'24' North and longitudes 8'22' and 10'24' East. The congenial weather in Plateau makes results comparable to Europe easily attainable and desirable for poultry production [8].

2.2 Source of Experimental Birds

Commercial Anak® broiler strains were hatched at the National Veterinary Research Institute, Vom, Jos.

2.3 Experimental Birds and Management

A total of 60 unsexed day-old broiler chicks were reared from 0 to 8 weeks of age. Body weight was measured at 2, 4, 6 and 8 weeks of age during starter and finisher in both phases. Male and female birds were grouped separately.

2.4 Brooding and Rearing

Chicks were brooded for four weeks in the restricted brooding section of the National

Veterinary Research Institute, Vom, Jos. Electric bulbs and charcoal stoves were used as source of heat. After brooding for four weeks, birds were transferred to the rearing house for another four weeks. All birds were vaccinated against common poultry diseases such as Marek, Newcastle, Infectious Bursal (Gumboro) and fowl pox.

2.5 Nutrition

Broiler starter and finisher diet was compounded and given to birds from day old to four weeks containing (2700 kcal of ME/kg and 23% CP) and from four week of age to eight weeks containing (2840 kcal of ME/kg and 20 CP/kg) respectively. All birds were given access to feed and water *ad libitum*.

2.6 Data Collection

2.6.1 Traits measured

The weight of the individual birds and body linear traits were recorded bi-weekly, early in the morning (8:00hr) before administration of feed as described according to [9].

Body Weight (BW): Body weight (BW) was measured in grams (g) from day old to eight (8^{th}) weeks using digital weighing scale.

Shank Length (SL): Shank length was measured using tailor's tape (in cm) from the hock joint to the base of the three toes.

Breast Width (BRW): Breast width was taken as the circumference of the breast around the deepest region of the breast using tailor's tape.

Body Length (BL): Body length was taken as the distance between the base of the neck and cloaca using tailor's tape.

Height at withers (HW): Height at withers was measured as the distance from the floor to the withers.

2.7 Statistical Models

2.7.1 Principal COMPONENT ANALYSIS PROCEDURES

The correlation coefficients of body weight and the biometric traits measurements were also determined. From the correlation matrix, data for the principal component factor analysis were generated. According to [10], principal component analysis is a method for transforming the variables in a multivariate data set x_1, x_2, ---, xp, into new variables, y_1, y_2,---, yp which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$y_1 = a_{11}\, x_1 + a_{12}\, x_2 + \text{------------------} + a_{1p}x_p$$

$$y_2 = a_2\, x_1 + a_{22}\, x_2 + \text{-------------------} + a_{2p}x_p$$

$$y_p = a_{p1}\, x_1 + a_{p2}\, x_2 + \text{------------------} + a_{pp}x_p$$

with the coefficients being chosen so that y_1, y_2, --, y_p account for decreasing proportions of the total variance of the original variables, x_1, x_2, --, x_p. In matrix form:

$$Y_1 = a'x$$

The a_{ji} are scaled such that $a_1'a_1$=1. Y_1 accounts for the maximum variability of the p variables of any linear combinations. The variance of Y_1 is $\lambda_{1.}$ The next, principal component Y_1 is formed such that its variance, λ_2 is the maximum amount of the remaining variance and that it is orthogonal to the first principal component. That is,

$$a_i'a_2 = 0$$

Components are extracted until some stopping criteria are encountered or until principal components are formed. The weights used to create the principal components are the eigenvectors of the characteristic's equation:

$$(R- \lambda_1 I)\, a = 0$$

Where R is the correlation matrix. The λ_1 are the Eigen values, the variances of the components. The Eigen values are obtained by solving $(R- \lambda_1 I)$ a = 0 for $\lambda_{1.}$

During the evaluation, factors were rotated with Varimax rotation of Kaiser. The aim of the Varimax rotation is to maximize the sum of variances of a_{ij}^2 quadratic weight. Anti-image correlations, 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.

2.8 Data Analysis

Body weight and biometric data were analyzed using a T-test to test the effect of sex on body weight and body linear measurement. Significant differences were separated using Least Significant Difference (α = 0.05) for multiple comparisons through R least square means (version 2.30-0) [11] and R multcomp (version

1.4-10) [12] packages. Correlation and principal component analysis were performed using PROC CORR and PROC PRIN procedures of Statistical Analysis System version 9.0.

3. RESULTS AND DISCUSSION

Average body weights and body measurements measured at starter and finisher phase are presented in Table 1. Body weights showed sexual dimorphisms from six weeks on wards to eight weeks and the males recorded significantly (P < .05) higher body weights than females. The biometric traits in male and female were statistically similar (P > .05) from two weeks to eight weeks. The coefficient of variation at different ages from 2 to 8 weeks for bodyweight was above 10%. This implies that improvement of body weight will progress faster during selection. The sexual dimorphisms observed in the present study in this period were in agreement with the findings of [13]. The body weights observed in male and female birds were in agreement with the reports of [14] in Vanaraja male chicks. The shank length observed in the present study at 8 weeks of age in female was higher than both Vanaraja and Gramapriya backyard poultry varieties as observed by [13]. The shank length observed in the present study at 8 weeks of age in female was lower than the report in purelines PD1 [14].

Figs. 1-4 showed the scatterplot matrix of relationship between bodyweight and biometric traits female and male Anak® broiler birds reared from two to eight weeks. There were positive linear relationships between bodyweight and biometric traits in female and male Anak® broiler birds from two to eight weeks. Though some exceptions were observed: Negative and weak relationship between bodyweight and bodylength (-0.12) in female Anak® broiler birds at 4 weeks. At 6 weeks, in male birds, bodyweight and breast width (-0.44) were negative and strongly correlated while bodyweight and body length had low and negative correlations (-0.14). At 8 weeks, all the associations were positive and strong between body weight and biometric traits in Anak® broiler birds with the exception of body length in male birds. When the data from two weeks to eight weeks were pooled to increase the number of observations for the analysis, our results showed that bodyweight is positive and strongly related to body measurement in Anak

Table 1. Bodyweight and biometric traits of female and male Anak® broiler birds (2-8 weeks)

Age/Traits	Female	Male	C.V	P-value
		2 weeks		
Bodyweight	342.51±47.82	334.18±49.78	28.9	0.725
Shank length	8.55±0.31	8.17±0.44	6.95	0.062
Body length	13.37±1.16	13.41±0.71	9.26	0.454
Height	16.76±1.72	16.71±1.41	5.84	0.552
Breast width	12.50±0.79	12.66±0.89	12.4	0.242
		4 weeks		
Bodyweight	1251.97±208.48	1211.50±169.02	14.3	0.779
Shank length	11.19±0.79	11.24±0.91	3.77	0.411
Body length	18.68±1.55	19.06±1.66	8.79	0.199
Height	18.18±1.01	18.49±0.71	16.3	0.114
Breast width	27.99±2.77	28.67±2.36	9.88	0.167
		6 weeks		
Bodyweight	2599.70±467.23^{b}	2986.13±593.34^{a}	40.4	0.015*
Shank length	13.95±0.93	14.52±1.52	8.79	0.099
Body length	29.11±3.00	26.23±3.99	9.78	0.717
Height	22.74±1.97	23.40±1.94	6.34	0.147
Breast width	37.46±3.15	39.23±3.10	7.10	0.077
		8 weeks		
Bodyweight	3297.53±393.16^{b}	3451.00±432.51^{a}	32.24	0.204
Shank length	15.52±1.45	14.91±1.33	4.85	0.827
Body length	27.38±1.58	27.79±2.20	11.9	0.308
Height	25.26±1.26	25.14±1.14	9.50	0.586
Breast width	41.52±1.14	41.78±2.38	7.22	0.821

Values are least squares means ± standard error; means within rows sharing no common superscript were significantly different ($P < 0.05$); N = number of samples, CV % = Coefficient of Variation broiler birds which was in agreement with the report of [15,16]. This implies that selection targeted to improve bodyweight will lead to corresponding increase in biometric traits. The implication of this in livestock management is that the bodyweight of Anak broilers can be predicted from the body measurement characteristics and thus providing the livestock managers extra information needed to make decision on Anak® broiler birds resilience on the Jos Plateau, State. These metric results indicated that all models resulted in close match and good agreement between bodyweight and biometric values.

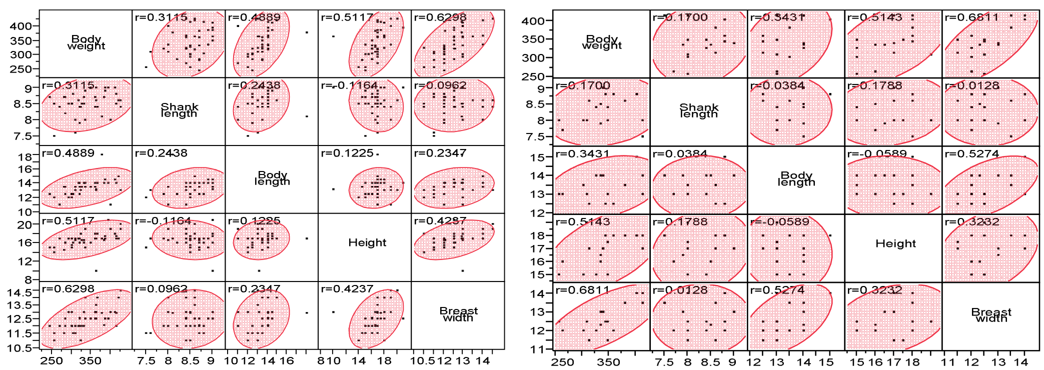

Fig. 1. Scatterplot matrix of relationship between bodyweight and biometric of two weeks female and male Anak® broiler birds

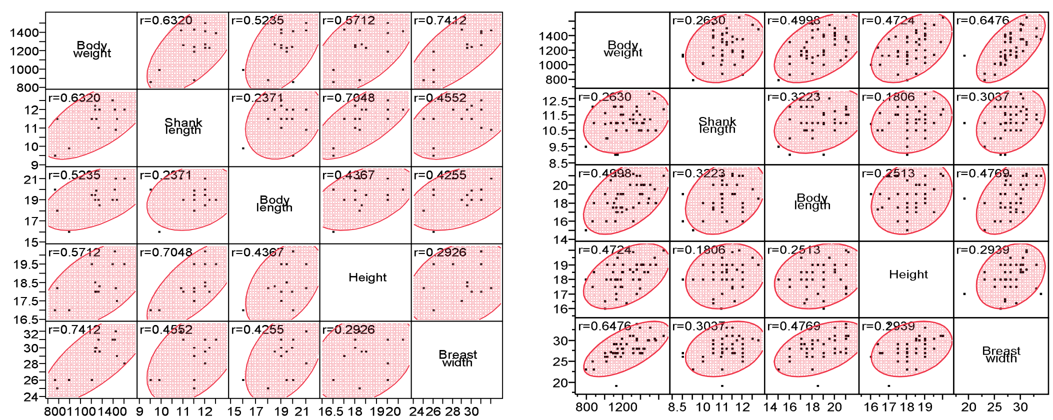

Fig. 2. Scatterplot matrix of relationship between bodyweight and biometric of four weeks female and male Anak® broiler birds

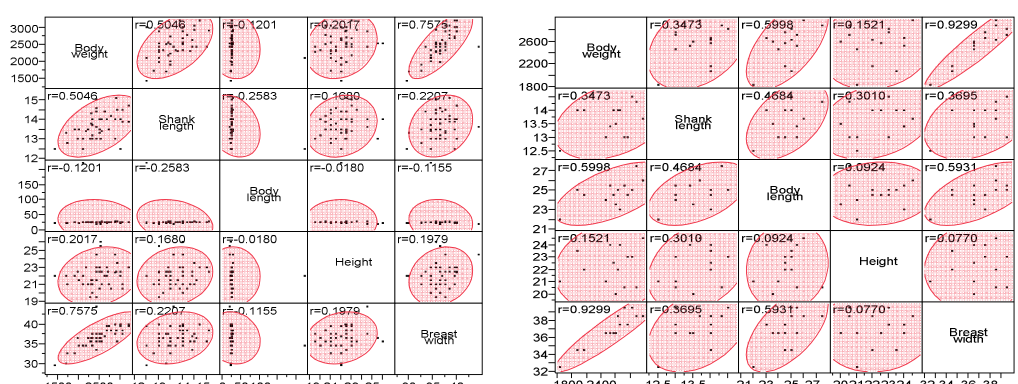

Fig. 3. Scatterplot matrix of relationship between bodyweight and biometric of six weeks female and male Anak® broiler birds

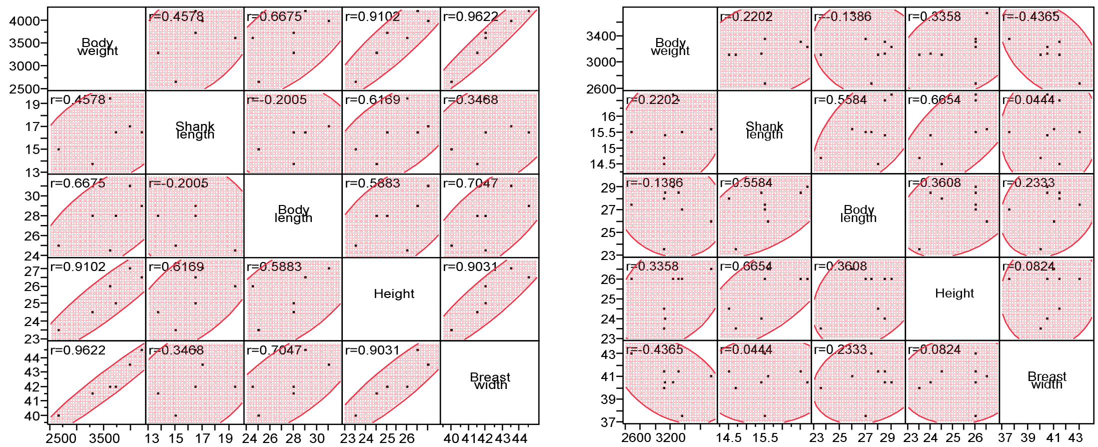

Fig. 4. Scatterplot matrix of relationship between bodyweight and biometric of eight weeks female and male Anak® broiler birds

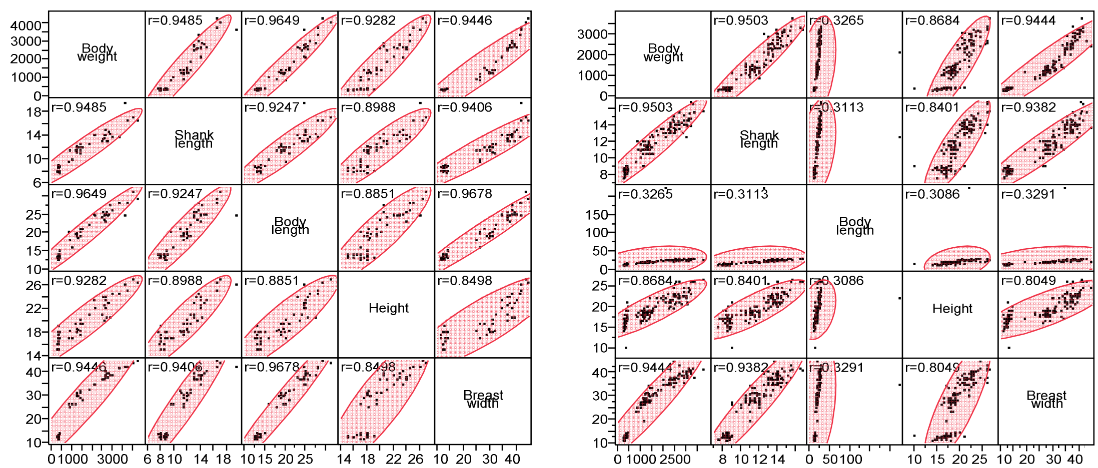

Fig. 5. Scatterplot matrix of relationship between bodyweight and biometric pooled data for female and male Anak® broiler birds

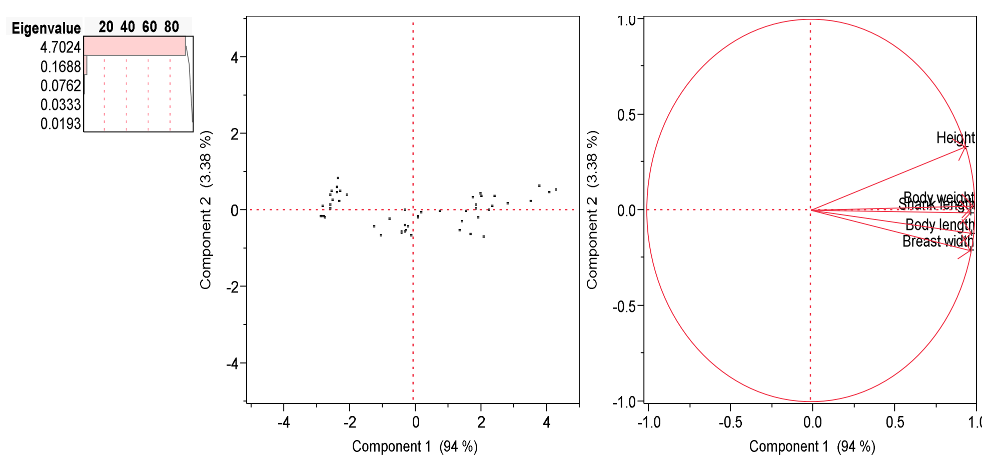

Fig. 6. Summary plots of principal component analysis for biometric traits of female Anak® broiler birds

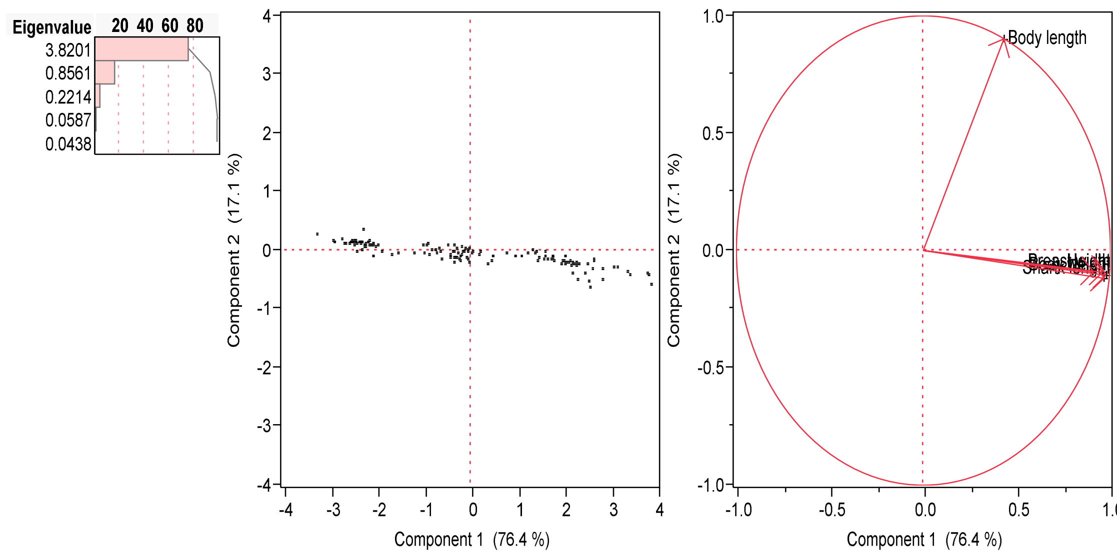

Fig. 7. Summary plots of principal component analysis for biometric traits of male Anak® broiler birds

Figs. 6 and 7 depicts the summary plots of principal component analysis for biometric traits of male and female Anak® broiler birds. The figures showed that only two components were extracted through varimax rotation in male and female Anak® broiler birds. Female birds showed higher response (97.38%) in variance with eigen value of 4.70 than the male birds (93.5%) with eigen value of 3.82. In this study, all the biometric traits showed effect in PC1 in both male and female Anak® broiler birds with the largest shared variance and is mostly described as the generalized form of broilers because most traits that describe the dimension of broiler birds are mostly clustered in PC1. PC1 had the largest share of the total variance and correlated highly with breast width, height and shank length in male Anak birds. In Female Anak® birds, PC1 was highly correlated with breast width, body length and shank length. In a principal component analysis of body measurements of broilers, [5] reported that PC1 had high positive loadings on body weight, breast circumference and thigh length of Arbor Acre and termed PC1 “form factor”. [6] reported that PC1 had the highest correlation with shank length, breast circumference and bodyweight of Ross 308 broilers. [5] reported that the first principal component accounted for the largest variance in the morphological traits of three Nigerian chicken genotypes. [16] presented data that showed PC1 accounting for the largest variance in the body measurements of ducks with high positive loadings on body width, bill width, shank length, body length, head length and neck length. [15] used PCA to analyze performance and carcass traits measured in a population of *Gallus gallus*. The authors reported that the five first principal components explained 93.30% of the total variation and the first component explained 66.00%. They called the first component generalized weight because the largest eigen vectors were associated with bodyweight at 35 and 42 days of age, liver, breast, wing and thigh weights.

4. CONCLUSION

From the results and discussion above it can be concluded that there is a linear relationship between bodyweight and biometric traits at different ages in male and female Anak® broiler birds. Sexual dimorphism existed in bodyweight at 6 and 8 weeks. Female Anak® broiler birds showed propensity for improvement in biometric traits than the male birds.

ETHICAL APPROVAL

The research was approved by National Veterinary Research Institute Ethics Committee.

DISCLAIMER

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country.

There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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