



Principal Component Analysis of morphological traits of synthetic White Leghorn chicken

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ABSTRACT

The aim of present study was to assess the relationship among morphological traits and identify the components that define body conformation in a synthetic White Leghorn strain using multivariate procedure principal component analysis. Data were collected from the records of synthetic White Leghorn strain maintained at Poultry Breeding Farm, LUVAS, Hisar. A total of 12 different morphological traits, viz. 40 week body weight, beak length, comb length, keel length, body length, breast girth, breast angle, radius-ulna length, shank length, shank circumference, back length and tail length were recorded and statistical analysis revealed the means for corresponding traits as 1972.65 g, 2.25 cm, 10.74 cm, 12.61 cm, 33.10 cm, 31.40 cm, 55.19 degree, 13.28 cm, 8.37 cm, 4.33 cm, 26.58 cm and 22.94 cm, respectively. Phenotypic correlations among considered body measurements were found to be positive and highly significant varying from 0.394 (breast angle-back length) to 0.965 (body length-back length). All body measurements taken into the study showed high correlation with 40 week body weight indicating the possible use of body measurements in predicting body weight in synthetic White Leghorn strain. The extracted single component explained 75.307% of the total variability in the original parameters and had high loadings for all the considered traits except breast angle. Communalities estimates varied from 0.313 (breast angle) to 0.900 (body length) in present study. Further, low communality estimate for breast angle observed in this study indicated that breast angle is frail in elucidating the total variation in body measurements of synthetic White Leghorn strain.

Keywords: Breast angle, Morphological traits, Principal component analysis, Synthetic white leghorn strain

The population of poultry in India is 851.81 million with an increase of 16.8% over the previous census as per 20th Livestock Census (2019). In Indian agriculture, poultry sub-sector is growing at a very fast rate and the country ranks among top three egg producing countries in the world (19th livestock census). White Leghorn chicken strains play a vital role in achieving higher growth rate in egg production. The progress made in poultry industry has significantly contributed to provide livelihood to millions of people.

Lanari *et al.* (2003) reported that first approach for sustainable use of animal genetic resources is characterization of a livestock breed. The knowledge related to variation of morphological traits in the available genetic resources is most important for characterization (Delgado *et al.* 2001). Further, for measuring the growth in chicken, body weight as well as body conformations are important parameters. Univariate analysis may lead to wrong interpretations as growth traits are biologically related to each other due to pleiotropy and linkage (Rosario *et al.* 2008). Therefore, multivariate analysis is used for analyzing

and interpreting complex traits.

Principal component analysis (PCA) is an interesting tool for evaluating and understanding the total variability in a group of correlated traits which allows a drastic reduction in number of traits to be considered while constructing selection index for poultry (Pinto *et al.* 2006). Earlier different researchers (Udeh and Ogbu 2011, Saikhom *et al.* 2017) have utilized principal component analysis to describe the relationship between body measurements in chickens. Udeh and Ogbu (2011) used PCA in three broiler strains (Arbor acre, Marshal and Ross) in order to explain the relationship among body measurements. Saikhom *et al.* (2017) utilized this technique for characterization of Haringhata Black chicken using different morphological traits. Morphometric variables that contribute to the body conformation of F1 crossbred of exotic broilers with local chickens of Nigeria were investigated by using PCA (Akporhwarho and Omoikhoje 2017). Till date, there is no report regarding characterization of synthetic layer strain maintained at Poultry Farm, LUVAS using multivariate analysis. Therefore, present study was undertaken with the aim to assess the relationship among body measurements and identify the components that define the body conformation in synthetic White Leghorn strain using multivariate procedure principal component analysis.

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MATERIALS AND METHODS

Data: Records of synthetic White Leghorn strain maintained at Poultry Breeding Farm, LUVAS, Hisar were utilized in the present study. This strain has been developed as a result of selection over the generations in White Leghorn population and is being maintained at the farm since 1977. A selection criterion for genetic improvement of the strain is combined selection based on 40 week egg production and egg weight. In the present study, body measurements of a total of randomly selected 200 birds were taken and data were pooled for both the sexes.

Traits: A total of 12 different traits, viz. 40 week body weight (40BW), beak length (BeL), comb length (CL), keel length (KL), body length (BoL), breast girth (BG), breast angle (BA), radius-ulna length (RUL), shank length (SL), shank circumference (SC), back length (BaL) and tail length (TL) were considered in this study. Body weight of individual bird was measured at 40 weeks of age using electronic balance. Breast angle was measured with the help of goniometer and remaining traits were measured using measuring tape in centimeter.

The measurements were taken as suggested by different workers (Ceballos *et al.* 1989, Francesch *et al.* 2011 and Adeleke *et al.* 2011) for considered traits as beak length: from tip of beak to point of insertion of beak in skull; comb length: from insertion of comb in beak to end of combs' lobe; keel length: distance between vertices of sternum; body length: from the tip of beak to cloaca; breast girth: circumference of the breast around its deepest region; breast angle: from the extreme of the keel of sternum; radius-ulna length: from tip of olecranon process to the tip of styloid process; shank length: from the hock joint to the tarsus-metatarsus; shank circumference: width of shank; back length: from insertion of neck into body to cloaca; tail length: from the tip of a central rectrix to the point where it emerges from the skin.

In order to avoid between individual variations, all the measurements were taken by the same person.

Statistical analyses: Means, standard deviations and co-efficients of variation for different traits were calculated by using descriptive statistics of Statistical Package for Social Sciences, i.e. SPSS (2007). Pearson correlations among the considered traits were computed and correlation matrix was further utilized for carrying out principal component analysis. Kaiser Meyer-Olkin (KMO) test of sampling adequacy was used to test the validity of data set at 1% level of significance. Bartlett's test of Sphericity (Bartlett 1950) was performed to check whether the data set of 200 birds with twelve traits could be factored or not. Maxwell (1959) proposed that the test should be used prior to the application of factor analysis. SPSS (2007) was used for carrying out principal component analysis. The rotation of principal components was done using varimax rotation in order to maximize sum of variances of squared loadings.

RESULTS AND DISCUSSION

Means, standard deviations and co-efficients of variation

for different body measurements as observed are presented in Table 1. Average 40 week body weight of synthetic White Leghorn strain was found to be 1,972.65 g in this study. However, Tomar *et al.* (2015) and Churchil *et al.* (2019) reported comparatively lower 40 week body weight of White Leghorn strain. Higher body weight in the present study may be due to pooling of data for both the sexes. In the present study, body measurements were observed as 2.25, 10.74, 12.61 33.10, 31.40, 13.28, 8.37, 4.33, 26.58 and 22.94 (in cm) for beak length, comb length, keel length, body length, breast girth, radius-ulna length, shank length, shank circumference, back length and tail length, respectively with 55.19 degree breast angle. Saikhom *et al.* (2018) reported similar mean beak length (2.38 cm) in Haringhata Black chicken however, they observed comparatively lower keel length (9.80 cm). In this study, mean body length was found to be comparatively less than the findings of Bekele *et al.* (2015) in Indigenous chicken of Ethiopia (36.78 cm) and Egena *et al.* (2014) in indigenous Nigerian chickens (38.77 cm). Similar shank length (7.45 cm) and comparatively lower breast girth (26.38 cm) was reported by Abdel-Lattif (2019) in White Leghorn chicken. Present study revealed maximum variation in comb length (27.84%) while minimum variation was observed for breast angle (6.53%). In Haringhata Black chicken, maximum and minimum variability was found to be in comb width (59.29%) and ocular length (3.78%), respectively (Saikhom *et al.* 2017). Maximum co-efficient of variation was observed for shank thickness (38.53%) and minimum was for body girth (5.87%) in indigenous Nigerian chickens (Egena *et al.* 2014).

Correlation co-efficients among different morphometric traits are presented in Table 2. All the correlations were found to be positive as well as highly significant ($P < 0.01$) and varied from 0.394 (breast angle-back length) to 0.965 (body length-back length). Among all the correlations, correlation of breast angle with other body measurements was found to be least. Further, in the present study, all body measurements had high correlation with 40 week body weight in synthetic White Leghorn strain. Similarly, various

Table 1. Descriptive statistics of morphological traits in synthetic White Leghorn strain

Trait	Mean	Standard Deviation	CV (%)
40 week body weight (g)	1972.65	362.95	18.40
Beak length (cm)	2.25	0.50	22.22
Comb length (cm)	10.74	2.99	27.84
Keel length (cm)	12.61	1.25	9.91
Body length (cm)	33.10	4.82	14.56
Breast girth (cm)	31.40	2.05	6.53
Breast angle (degree)	55.19	3.24	5.87
Radius Ulna length (cm)	13.28	1.23	9.26
Shank length (cm)	8.37	0.73	8.72
Shank circumference (cm)	4.33	0.56	12.93
Back length (cm)	26.58	4.63	17.42
Tail length (cm)	22.94	4.69	20.44

Table 2. Phenotypic correlations* between different morphological traits in a synthetic White Leghorn strain at 40 weeks of age

Trait#	40BW	BeL	CL	KL	BoL	BG	BA	RUL	SL	SC	BaL	TL
40BW	1.00											
BeL	0.780	1.00										
CL	0.886	0.804	1.00									
KL	0.734	0.669	0.707	1.00								
BoL	0.901	0.801	0.892	0.731	1.00							
BG	0.680	0.639	0.652	0.617	0.769	1.00						
BA	0.432	0.502	0.442	0.502	0.423	0.482	1.00					
RUL	0.742	0.699	0.767	0.749	0.730	0.629	0.486	1.00				
SL	0.801	0.739	0.796	0.751	0.810	0.636	0.492	0.796	1.00			
SC	0.850	0.733	0.869	0.729	0.862	0.666	0.447	0.722	0.783	1.00		
BaL	0.896	0.813	0.901	0.724	0.965	0.710	0.394	0.725	0.800	0.843	1.00	0.0
TL	0.827	0.768	0.860	0.713	0.870	0.656	0.476	0.793	0.788	0.797	0.881	1.00

*All correlations were significant at 1% level of significance; #40BW, 40 week body weight; BeL, Beak length; CL, Comb length; KL, Keel length; BoL, Body length; BG, Breast girth; BA, Breast angle; RUL, Radius Ulna length; SL, Shank length, SC, Shank circumference; BaL, Back length; TL, Tail length.

researchers (Ajayi *et al.* 2008, Udeh and Ogbu 2011, Egena *et al.* 2014) observed high positive correlation of body weight with the body measurements indicating the possible use of body measurements in predicting body weight.

In the present study, Kaiser-Meyer Olkin (KMO) value was found to be 0.951 and Kaiser (1960) suggested a KMO value above 0.80 to be commendable. The overall significance of correlation tested with Bartlett's test of Sphericity for different morphological traits was significant (Chi-square value: 3079.34; $P = 0.000$) and provided enough support for the validity of factor analysis of used data set. Communalities, unique factor, eigenvalue and percent of total variance explained with rotated component matrix of considered traits at 40 week of age in synthetic layer strain are presented in Table 3.

The amount of variance explained by each factor out of total variance is depicted by eigenvalue. Kaiser Rule criterion (Johnson and Wichern 1982) led to the extraction of one component having eigenvalue >1 (Table 3). Scree plot is another criterion to select the actual number of components to be retained for further analysis. The components having eigenvalue up to the bent of elbow in scree plot are generally considered (Fig.1). The extracted single component accounted for 75.307% of the total variability present in the measured parameters and had high loadings for all the considered traits except breast angle. Highest loadings (0.949) were obtained for the body length and these findings were in agreement with the findings of Ogah *et al.* (2009) and Egena *et al.* (2014) as they observed high loadings of 0.766 and 0.814 on body length, respectively. The results obtained were also in correspondence with the findings of Yakubu *et al.* (2009 a, b) and Saikhom *et al.* (2018) as they also found that PC1 had high positive loadings on body length and body weight in different chicken breeds. However, in Arbor Acre chicken, Udeh and Ogbu (2011) extracted two principal components explaining 65% of total variation in original data set and first component was found to be highly correlated with breast width (0.930), wing length (0.897) and thigh length (0.789) in their study. Egena *et al.*

(2014) carried out principal component analysis of data related to body weight and five different body measurements of indigenous Nigerian chickens and found two components accounted for 66.4% of total variability in the original traits. Saikhom *et al.* (2017) obtained four components explaining

Table 3. Communalities, unique factor, eigenvalue and percent of total variance explained with rotated component matrix of considered traits at 40 week of age in synthetic White Leghorn strain

Trait	PC	Communalities	Unique factor
Body length (cm)	0.949	0.900	0.100
Back length (cm)	0.940	0.884	0.116
Comb length (cm)	0.932	0.868	0.132
40 week body weight (g)	0.926	0.858	0.142
Tail length (cm)	0.915	0.836	0.164
Shank circumference (cm)	0.903	0.815	0.185
Shank length (cm)	0.889	0.790	0.210
Beak length (cm)	0.864	0.747	0.253
Radius Ulna length (cm)	0.852	0.726	0.274
Keel length (cm)	0.830	0.689	0.311
Breast girth (cm)	0.780	0.609	0.391
Breast angle (degree)	0.560	0.313	0.687
Eigenvalue	9.037	—	—
% of the variance	75.307	—	—

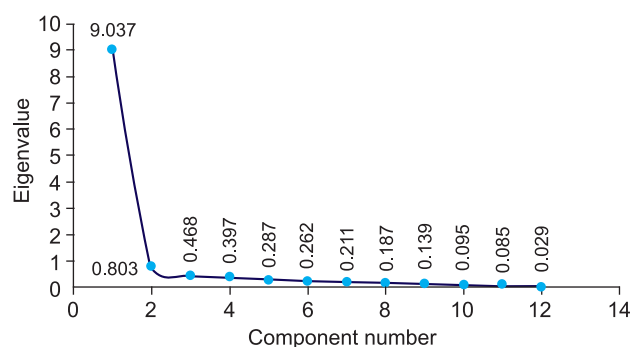


Fig.1. Scree plot showing component number with eigenvalues.

77.17% of total variation in 14 original variables considered in their study. They observed that PC1 explained 47.15% of the total variance and had high loadings on comb length (0.96), comb width (0.95), wattle length (0.96), wattle width (0.95), earlobe length (0.94) and earlobe width (0.84) which can be further utilized for characterization of indigenous Harringhata Black chicken. In the present study, estimated communalities varied from 0.313 (breast angle) to 0.900 (body length) and unique factors ranged from 0.100 (body length) to 0.687 (breast angle). Similar high communalities have been reported in different breeds of chicken by different researchers (Yakubu *et al.* 2009a, Udeh and Ogbu 2011, Ajayi *et al.* 2012). Breast angle which is an indicator of keel bone prominence was found to be smaller in layer hybrid as compared to commercial dual purpose hybrids (Mueller *et al.* 2019). Low communality estimate for breast angle observed in this study indicated that breast angle is weak in explaining the total variation in body measurements.

In conclusion, the interdependency of original measurements was explored by analyzing all the measurements at same time using principal component analysis. All body measurements had high positive and significant correlation with 40 week body weight indicating the possible use of body measurements in predicting body weight in synthetic White Leghorn strain. The present study revealed that extracted single PC had the largest share of total variance and explained 75.307% of total variability present in the original morphometric parameters besides having high loadings for all the considered traits except breast angle. Further, low communality estimate for breast angle observed in this study indicated that breast angle is frail in explaining the total variability in morphological traits of synthetic White Leghorn strain.

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