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Principal Component Analysis of Different Economic Traits in Layer Chicken

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ABSTRACT

Background: Principal component analysis is a multivariate technique that transforms a number of possibly correlated variables into smaller number of uncorrelated variables leads to dimension reduction. Various economic traits of layer chicken are used for selection of parent birds which need to adjust for selection strategies to augment the genetic improvement.

Methods: The data was collected from 2020-2021 which includes weekly body weight (g) from 0 day to 20th week and 40th week, Body weight (g) at first egg production, age at sexual maturity (days), weight of first egg (g), egg numbers at 40th week, egg weight at 40th week (g), egg numbers at 52nd week, egg weight at 52nd week (g). The least squares mean was estimated considering three different genetic groups of layer chicken (N=450, 150 each group). The main focus of this study was to identify the principal components for economic traits in layer chicken. Further varimax rotation method was applied for the transformation of components to approximate simple structure.

Result: The genetic group Desi cross 1 performed better than Desi cross 2 followed by Punjab Red layer chicken. A total of three principal components were obtained which explained a total variance of 75.524%. Principal component 1 had high loads on body weight 10th week to 20th week (BW 10-BW 20) and BWSM and had a variance of 38.892%. Similarly, PC2 and PC3 explained variance of 27.072% and 9.560% respectively and had high loads on 1 week body weight to 9-week body weight (BW1-BW9) and age at sexual maturity, 40-week egg production, 52-week egg production respectively. From this study it was included that PCA can be used for selecting the economic traits for breeding purpose of layer chicken.

Key words: Age at sexual maturity, Body weight, Egg production, Layer chickens, Principal component analysis.

INTRODUCTION

Principal component analysis is a mathematical procedure that transforms a number of possibly correlated variables into smaller number of uncorrelated variables. It can be used for simplification of data, data reduction, data classification, variable selection and many more (Wold *et al.,* 1987). The main function of principal component analysis is to extract the important information from the data and to express this information as a set of summary indices known as principal components. Since there is a higher demand for eggs, PCA has been successfully used to describe the economic traits (productive and reproductive traits) of chickens. PCA will improve not only bird management, but also the selection of multiple economic features and the preservation of unique biodiversity. (Yunusa *et al.,* 2013). The main benefit of implementing principal component analysis is to minimize the variance in least square sense and maximize the variance of projection coordinates. It is one of the most prevalent types of vector analysis since it decreases the dimension of the original data set and explains its variation.

Yamaki *et al.* (2009) used principal component analysis to study meat type chicken production traits and concluded that principal components can be used in prediction of production traits in chicken. Paiva *et al.* (2010) assessed the possibility of discarding production variables in laying hens (White leghorn) by principal component analysis to eliminate unnecessary and difficult to measure characteristics and found that eight of the eleven principal components showed variance lower than 0.7 (eigenvalue lower than 0.7), suggesting eight variables to discard. And only three variables *viz.* egg production rate between 26th to the 58th week of age, individual mean weight at the 34th week of age and egg mean weight at the 58th weeks of age were recommended for use in future experiments. Saikhom *et al.* (2018) used the principal component analysis to reconnoitre the interdependence in the original eight morphometric traits in Haringhata Black chickens at 22nd week of age, out of which only five traits namely body weight, breast girth, keel length, body length, ornithological measurement, beak length, beak width and back length had the highest loading factors for first principal component (PC1) which explained the maximum variability of size and shape of this breed.

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Punjab Red is a layer variety of chicken which is commonly used as backyard poultry in Punjab. Desi Cross 1 and 2 were developed using RIR and Punjab red with crossing of local backyards birds for the improvement in production performances. Egg production is considered as most important parameter in layer chicken. All three genetic groups produce brown shell eggs. Keeping this in view, the current study was designed to identify the main components and comprehend the relationship between various economic traits in layer chicken.

MATERIALS AND METHODS

The present experiment was conducted at Poultry Research Farm of Directorate of Livestock Farms, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana from 2020-2021. Data were collected from 450 brown shelled egg producing layer birds from three genetic groups: Desi cross 1, Desi cross 2 and Punjab Red (150 birds per genetic group). Desi cross1 was developed by crossing of Rhode Island Red with local backyard birds, Desi cross 2 was developed by crossing of Punjab Red with local backyard birds of Punjab state and Punjab Red was previously developed and maintained at the poultry research farm. The birds having incomplete data were removed from analysis. A total of 25 traits viz. weight from 0-20th week of age (BW 0-20) and 40th week (BW 40), body weight at first egg (BWSM), age at sexual maturity (ASM), egg production at 40th week (EP 40), egg production at 52nd week of age (EP 52) were included. All the birds were produced from single hatch and hatch effect was not taken for mean comparison of among genetic groups. All of the birds included in the study received similar feeding and management practices. Electronic weighing balance was used for the measurement of different traits.

Statistical analysis

Using Pearson correlation the phenotypic correlation was estimated between different economic traits (productive and reproductive traits). The highly correlated traits were subjected to a multivariate PCA. Rotation of principal components was done using varimax rotation for the transformation of components to approximate simple structure. At 1% level of significance the validity of data set was established by using Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and Bartlett's test of sphericity. principal component analysis as described by Everitt *et al*. (2001), is a method for transforming variables in a multivariate data set, x1, x2…xn into new uncorrelated variables y1, y2,……….yn which account for decreasing proportion of the total variance in the original variables specified as

y1= a11x1+a12x2+ ……+ a1nxn.

y2= a21x1+a22x2+……+ a2nxn.

yn= an1x1+an2x2+......+ annxn.

The principal components y1, y2…….yn account for decreasing proportions of the total variance in the original variables x1,x2,……xn. Variance maximizing orthogonal rotation was used in thelinear transformation of the factor pattern matrix in order to make the interpretation of the extracted principal components easier. The principal components analyses were performed using the factor program of SPSS 24 (2016) statistical package.

RESULTS AND DISCUSSION

Economic traits

The descriptive statistics for all traits for each genetic group and pooled are shown in Table 1. Desi cross 1 performed substantially better (P<0.05) than Desi cross2 and Punjab Red for egg production traits, especially egg production at 40th and 52nd week of age. For age at sexual maturity Desi cross1 (156.87±1.14 days) performed better than Desi cross2 (164.76±1.73) and Punjab Red (165.37±1.51 days) as lower age at sexual maturity is desirable trait in layer chicken. Desi cross 1 may be considered for rural poultry farming in Punjab and nearby states of the country. Kiani-Manesh *et al*. (2002) also suggested that age at sexual maturity, number of eggs, egg weight and body weight at eight weeks of age are the most important traits for improving the economic efficiency of rural chickens.

Phenotypic correlations

The magnitude of correlation coefficient ranges from -0.25 to 0.87. The values of all the correlation were found to be positive except between BW1-20 week and ASM is negative but it is desirable because sooner the bird attains sexual maturity, it becomes more productive. There is positive correlation between BW40 and ASM but negative correlation was observed between BW40 with EP40 and EP52 because less body weight leads to low egg production. Among all correlation, five (EP40-BW1, EP40-BW2, EP40-BW3, EP40-FEW and EP40-BW14) were highly significant (P<0.01). Similar trend was depicted by Nigussie *et al*. (2011) for the associations between the phenotypic performance of body weight growth and total egg production at 44 weeks of age in Horro chicken. The phenotypic correlation of age at sexual maturity was positive with FEW and negatively correlated with 40-week egg production (-0.479±0.03), 52-week egg production (-0.431±0.03), 40-week egg weight (-0.058±0.04), 52-week egg weight (-0.012±0.04) and body weight at sexual maturity (-0.013±0.04). However, contrary results were observed by Liu *et al*. (2019) for ASM with 40-week egg production and 52-week egg production.

Principal component analysis

Principal component analysis were applied to 25 economic traits of three different genetic groups (Desi Cross 1, Desi Cross 2 and Punjab Red). The measurement of sampling adequacy was found to be 0.95 which was estimated by Kaiser-Meyer-Olkin method. This value represents that whether each factor has enough data to give reliable results for PCA. The value should more than 0.6 and desirable value should be more than 0.8 (Tabachnick and Fitell, 2013). To maximize the sum of loading squares varimax rotation method (Fernandez, 2002) was applied. The overall

Table : 1. Mean with SE for different economic traits of crossbreds chicken

Traits	Desi cross 1	Desi Cross 2	Punjab Red	Pooled
N	150	150	150	450
BW0	36.54±0.22	36.73±0.37	36.63±0.38	36.63±0.19
BW1	58.99^{a}±0.90	60.99^{a}±0.88	56.15^{b}±0.78	58.71±0.50
BW2	99.19^{a}±1.80	100.65^{a}±1.78	91.05^{b}±1.40	96.96±0.98
BW3	146.27^{a}±5.15	144.63^{a}±2.79	126.33^{b}±2.20	139.08±2.12
BW4	193.53^{a}±3.97	199.27^{a}±4.27	165.40^{b}±3.32	186.07±2.34
BW5	241.53^{a}±4.55	253.39^{a}±5.27	211.73^{b}±4.13	235.55±2.82
BW6	313.00^{a}±6.61	327.20^{a}±6.74	275.67^{b}±5.75	305.29±3.82
BW7	398.50^{a}±8.25	427.60^{b}±9.15	352.93^{c}±6.70	393.01±4.88
BW8	499.00^{a}±9.77	535.43^{b}±9.95	448.60^{c}±9.46	494.34±5.85
BW9	604.00^{a}±11.21	631.87^{a}±11.18	531.47^{b}±9.65	589.11±6.48
BW10	728.67^{a}±12.34	840.23^{b}±14.27	685.80^{c}±11.49	773.30±8.57
BW11	793.87a±15.63	840.23b±14.27	685.80^{c}±11.49	773.30±8.57
BW12	873.80^{a}±15.07	924.33^{b}±13.95	759.20^{c}±12.12	852.44±8.58
BW13	901.47^{a}±14.48	959.80^{b}±14.04	771.73^{c}±10.87	877.67±8.47
BW14	1021.29^{a}±16.91	1090.43^{b}±15.12	887.37^{c}±14.86	999.70±9.86
BW15	1108.68^{a}±16.32	1179.23^{b}±16.16	975.80^{c}±13.75	1087.90±9.75
BW16	1171.87^{a}±18.75	1250.37^{b}±17.52	1020.65^{c}±16.33	1147.63±11.07
BW17	1241.20^{a}±19.59	1325.52^{b}±17.96	1080.93^{c}±15.83	1215.88±11.35
BW18	1350.60^{a}±19.84	1423.28^{b}±17.87	1167.60^{c}±16.50	1313.83±11.61
BW19	1506.22^{a}±23.20	1531.07^{a}±19.01	1272.53^{b}±19.66	1436.60±13.13
BW20	1566.22^{a}±23.20	1601.47^{a}±18.99	1322.53^{b}±19.66	1496.74±13.28
BW40	2059.73^{a}±10.90	2128.13^{b}±16.82	2121.04^{b}±15.24	2102.97±8.50
ASM	156.87^{a}±1.14	164.76^{b}±1.73	165.37^{b}±1.51	162.33±0.87
BWSM	1670.40^{a}±19.56	1751.40^{b}±20.22	1460.87^{c}±18.93	1627.56±12.67
FEW	43.18±0.56	43.23±0.47	42.22±0.41	42.87±0.28
EP40	94.99^{a}±1.54	89.48^{b}±1.55	85.55^{b}±1.85	53.28±0.20
EW40	53.09±0.34	53.72±0.35	53.03±0.35	53.28±0.20
EP52	136.13^{a}±2.73	119.25^{b}±1.96	116.61^{b}±1.85	124.00±1.34
EW52	50.96^{a}±0.34	51.16^{a}±0.33	49.42^{b}±0.41	50.51±0.21

BW 0 to BW20= Body weight (gm) at 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,14,15,16,17,18,19 and 20 week of age, ASM= Age at sexual maturity (days), BWSM= Body weight at sexual maturity (gm), FEW=First egg weight (gm), EP40= Egg production upto 40th week of age (no's), EW40=Egg weight (gm) at 40th week of age, EP52= Egg production upto 52nd week of age (no's) and EW52=Egg weight (gm) at 52nd week of age.

significance of correlation matrix was tested by Bartlett's test of sphericity and chi-square value was highly significant (P<0.01) and estimated as 20910.58. The sum of square loadings was extracted by PCA, Eigenvalues (Fig 1) and variation explained by each component is given in Table 2. Out of total 25 components three components were extracted using Kaiser rule criterion (Johnson and Wichern, 1982) for determination of number of significant components. A total variance of 75.524% was explained by three principal components (PC1, PC2 and PC3) which were having Eigen value more than 1. The variability of individual traits was as per explained by PCA (Mavule *et al.*, 2013). The component plot of the three components in rotated space is shown in Fig 2.

In current study, the first principal component (PC1) explained for 38.89% of the total variance. First principal component (PC1) described the body weight 10th week to 20th week (BW 10-BW 20) and BWSM in crossbred layer chicken. It was represented by a very high component loading for BW18**,** BW19 and BW20. Findings of Yakubu *et al.* (2009) revealed total variation of 85% was explained by body weight. Egena *et al.* (2014) found similar results with PC1 explaining 38.3% total variation. Saikhom *et al.* (2018) shows similar result with body weight explaining 60.2% total variation. Yakubu and Ari (2018) concluded the result that explained body weight has maximum share of total variance (92%). Vilakazi *et al.* (2020) revealed principal component 1 has large share on body weight.

The second principal component (PC2) explained for 27.072% of total variation with high loads on 1 week body weight to 9-week body weight (BW1-BW9). Similar results were reported by Yakubu *et al.* (2009), Yakubu and Ari (2018) and Vilakazi *et al.* (2020) in which PC2 has large share on body weight. The third principal component (PC3) explained

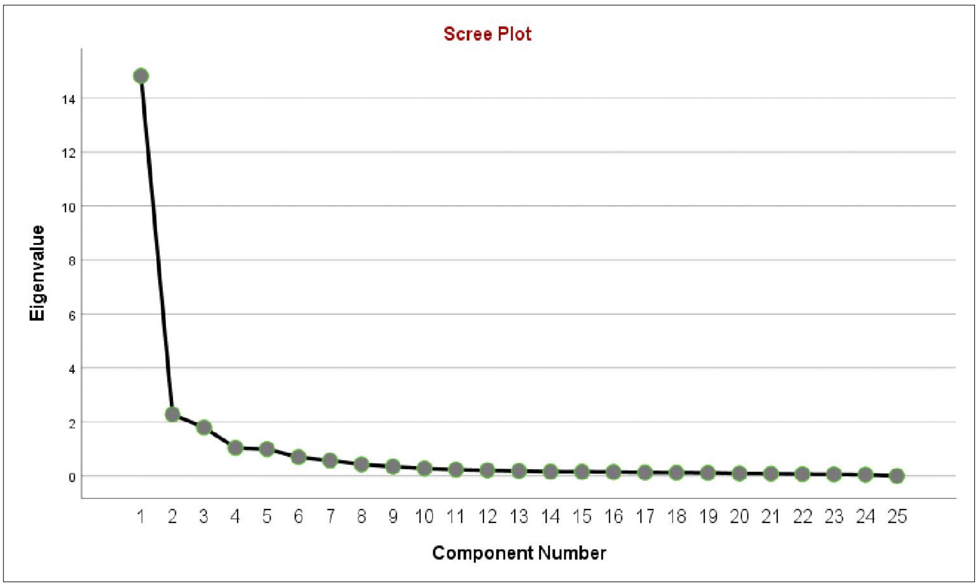

Fig 1: Scree plot showing component numbers with eigenvalues.

Table 2: Total variance explained by different components in different RIR crossbred chicken.

Total Variance Explained									
Components	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.812	59.249	59.249	14.812	59.249	59.249	9.723	38.892	38.892
2	2.278	9.113	68.362	2.278	9.113	68.362	6.768	27.072	65.964
3	1.790	7.162	75.524	1.790	7.162	75.524	2.390	9.560	75.524
4	1.038	4.150	79.674						
5	0.991	3.964	83.638						
6	0.694	2.778	86.416						
7	0.569	2.276	88.692						
8	0.429	1.715	90.407						
9	0.343	1.370	91.778						
10	0.276	1.104	92.882						
11	0.233	0.932	93.813						
12	0.210	0.840	94.653						
13	0.183	0.731	95.384						
14	0.155	0.620	96.004						
15	0.150	0.601	96.605						
16	0.142	0.568	97.173						
17	0.125	0.500	97.673						
18	0.117	0.469	98.142						
19	0.112	0.449	98.591						
20	0.092	0.369	98.960						
21	0.083	0.331	99.291						
22	0.067	0.267	99.558						
23	0.060	0.241	99.799						
24	0.050	0.200	99.999						
25	0.000	0.001	100.00						

Extraction method: Principal component analysis.

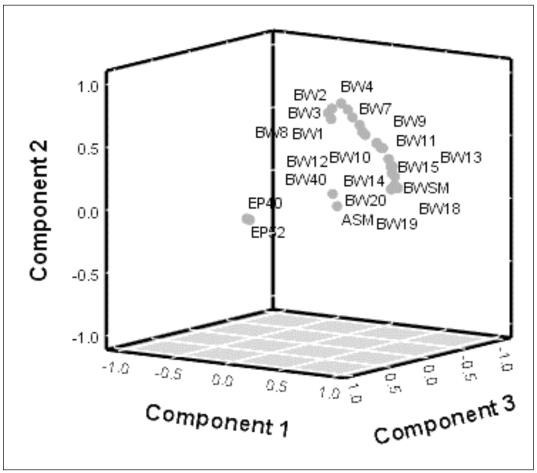

Fig 2: Component plot in rotated space showing three different components.

Table 3: Varimax rotated component matrix showing different component loadings and communalities for performance traits in crossbreds layer chicken.

Traits	Components			Communalities
	1	2	3	
BW1	0.164	0.685	-0.064	0.501
BW2	0.236	0.790	0.031	0.681
BW3	0.196	0.747	0.021	0.597
BW4	0.326	0.842	0.033	0.816
BW5	0.400	0.801	0.053	0.805
BW6	0.486	0.757	0.110	0.822
BW7	0.544	0.700	0.097	0.795
BW8	0.576	0.652	0.110	0.769
BW9	0.595	0.626	0.096	0.755
BW10	0.686	0.568	0.075	0.798
BW11	0.726	0.538	0.081	0.823
BW12	0.744	0.532	0.073	0.841
BW13	0.808	0.456	0.091	0.869
BW14	0.837	0.398	0.100	0.870
BW15	0.841	0.397	0.083	0.872
BW16	0.855	0.352	0.115	0.868
BW17	0.873	0.325	0.101	0.878
BW18	0.890	0.261	0.129	0.877
BW19	0.872	0.230	0.146	0.834
BW20	0.874	0.231	0.144	0.838
BW40	0.138	0.080	-0.122	0.040
ASM	-0.199	-0.130	-0.663	0.496
BWSM	0.788	0.199	-0.062	0.664
EP40	0.108	0.023	0.942	0.899
EP52	0.075	0.027	0.932	0.874

BW0 to BW 20= Body weight (gm) at 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,14,15,16,17,18,19 and 20 week of age, ASM= Age at sexual maturity (days), BWSM= Body weight at sexual maturity (gm), FEW= First egg weight (gm), EP40=Egg production upto 40th week of age (no's), EW40= Egg weight (gm) at 40th week of age, EP52= Egg production upto 52nd week of age (no's) and EW52= Egg weight (gm) at 52nd week of age

9.560% of total variance and had high loads on age at sexual maturity, 40-week egg production and 52-week egg production. Yamaki *et al.* (2009) and Savegnago *et al.* (2011) also shown similar results in which age at sexual maturity had its load on principal component.

Table 3 represents the coefficient of principal component analysis of rotated component matrix. The different weights were assigned by PC1 and PC2 to all the biometric traits which were having positive sign except age at sexual maturity (ASM). The PC3 gave different weights with negative sign to BW1 week, BW40 week, ASM and BWSM. All the other traits had positive sign. The communalities ranged between 0.040 (BW40) to 0.89 (EP40). The traits like BW40, BW1, BW2, BW3 and ASM had lower communality indicating that these traits are less effective in explaining the economic traits in layer chicken. From this study it was concluded that implementation of PCA can be done in breeding programme for selection of crossbred layer birds and performance trait can be predicted and evaluated using principal components.

CONCLUSION

PC1 had the largest share of overall variance and had high loading on BW18, BW19, and BW20 in distinct genetic groups of crossbred layers chicken. Similarly, PC2 was seemed to have high loads on BW1 to BW9 week. The subsequent component PC3 was found to have high loads on ASM, EP 40 week and EP 52 week. The three main components discovered in the study could be used as a factor score to predict various economic traits. These principal components moreover provide a way in dimension reduction of economic traits which can be used in breeding programme of layer chicken.

Conflict of Interest: None.

REFERENCES

Egena, S.A., Ijaiya, A.T., Ogah, D.M. and Aya, V.E. (2014). Principal compnent analysis of body measurementsin apopulation of Indegenous Nigerian chickens raised under extensive management system. Sloval Journal of Animal Science. 2: 77-82.

Everitt, B.S., Landau, S. and Leese, M. (2001). Cluster Analysis. 4th edn. Arnold Publisher, London.

Fernandez, G. (2002). Data Mining using SAS Application. USA: Chapman and Hall, CRC press.

Johnson, R.A. and Wichern, D.W. (1982). Applied Multivariate Statistical Analysis. USA: Prentice-hall Inc.

Kiani-Manesh, H.R., Nejati-Javaremi, A. and Saneei, D. (2002). Estimation of (co) variance components of economic all important traits in iranian native fowls, 7thWorld Congress on Genetics Applied to Livestock Production, August 19-23, 2002, Montpellier, France Session 04.

Liu, Z., Yang, N., Yan, Y., Li, G., Liu, A. and Wu, G. (2019).Genome-wide assosiation analysis of egg production performance in chickens acros the whole laying period. BMC Genetics. 1-9.

Mavule, B.S., Muchenje, V., Bezuidenhout and Kunene, N.W. (2013). Morphological structure of Zulu sheep based on principal component analysis of body measurements. Small Ruminant Research. 111: 23-30.

Nigussie, D., Vander, W. E. H. and Johan, A. M. V. A. (2011). Geneticand phenotypic parameter estimates for bodyweights and egg production in Horro chicken of Ethiopia. Tropical Animal Health and Production. 43: 21-28. DOI 10.1007/s11250-010-9649-4.

Paiva, A. L.C., Rafael, B. T., Marcos, Y., Gilberto, R.O.M.,Carla, D.S.L. and Robledo, A.T. (2010). Principal component analysis in laying hen production traits. Revista Brasileira de Zootecnia. 39: 285-288.

Saikhom, R., Sahoo, A.K., Taraphder, S., Pan, S., Sarkar, U. and Ghosh, P.R. (2018). Prinicipal component analysis of morphological traits of Haringhata black chicken in an organized farm. Exploratory Animal and Medical Research. 8: 64-68.

Savegnago, R.P., Caetano, S.L., Ramos, S.B., Nascimento, G.B., Schmidt, G.S. and Ledur, M.C.(2011). Estimates of genetic parameters and cluster and principal components analyses of breeding values related to egg production traits in a White Leghorn population. Poultry Science.90: 2174-2188.

SPSS. (2016). IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.

Tabachnick, B.G. and Fidell, L.S. (2013). Using Multivariate Statistics (6th ed.). Boston: Pearson Education.

Vilakazi, B. N., Ncobela, C.N., Kunene, N.W. and Panella, F. (2020). Determining the morphological structure of indigenous chickens using multivairate principal component analysis of body measurements. Applied Animal Husbandry and Rural Development. 13: 69-75.

Wold, S., Esbensen, K.and Geladi, P. (1987). Principal component analysis. Chemometrics and Intelligent Laboratory Systems. 2: 37-52.

Yakubu, A. and Ari, M.M. (2018). Principal Component and discriminant analyses of body weight and conformation traits of Sasso, Kuroiler and indigenous Fulani chickens in Nigeria. The Journal of Animal and Plant Sciences. 28: 46-55.

Yakubu, A., Kuje, D.and Okpeku, M. (2009). Principal components as measures of size and shape in Nigerian Indigenous chickens. Thai Journal of Agricultural Science. 42: 167176.

Yamaki, M., Menezes, G.R., Paiva, A.L., Barbosa, L., Silva, R.F. and Teixeira, R.B.(2009). Study of meat-type chickens production traits by principal components analysis . Arquivo Brasileiro de Medicina Veterinária e Zootecnia. 61: 227-231.

Yunusa, A.J., Salako, A.E. and Oladejo, O.A. (2013). Principal Component analysis of the morphostrucure of Uda and Balami sheep of Nigeria. International Research Journal of Agricultural Sciences. 1: 45-51.