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ORIGINAL RESEARCH ARTICLE

Principal component analysis approach in describing the biometric traits of Ostrich (*Struthio camelus*) eggs in Southern Guinea Savanna region of Nigeria

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ABSTRACT

The use of Principal Components Analysis (PCA) was recently common in the analysis of relationships between scores of traits in animals due to its merit over correlation and regression analyses that usually used for two traits at a time. Therefore, the study was carried out to examine the PCA approach in describing the biometric traits of Ostrich (Struthio camelus) eggs under Southern Guinea Savanna region of Nigeria. A total of eighty (80) eggs were sourced for this study and traits measured were egg weight (EW), egg length (EL), egg width (EWD), shell weight (SW), shell thickness (ST), shell index (SI), yolk weight (YW), yolk length (YL), yolk height (YH), albumen weight (AW), albumen length (AL), albumen height (AH), yolk index (YI), albumen index (AI) and haugh unit (HU). The descriptive statistics results revealed that the mean egg weight was 1742 g while other biometric measurements were 140.00 mm, 126.69 mm, 272.56 g, 25.10 mm, 0.4 %, 578.21 g, 214.62 mm, 23.03 mm, 884.36 g, 206.56 g, 39.10 mm, 33.35 %, 50.65 % and 89.65 for EL, EDW, SW, ST, SI, YW, YL, YH, AW, AL, AH, YI, AI and HU, respectively. The phenotypic correlations among traits were positive and highly significant ($P<0.001$, $P<0.05$) ranging from $r = -0.31$ to $r = 0.92$. The PCA with variance maximizing orthogonal rotation was used in extraction of the components. Three principal components were extracted for the eggs traits accounted for 66.17 % of the total variance while the first factor accounted for 51.94 % of the variation out of the total of 5 original statistic value traits extracted. It was concluded that four traits of higher communalities (EW=0.899, SW=0.904, AW=0.746 and YW=0.829) extracted components could be used as selection indices for improving the quality traits of Ostrich eggs with recommendations that information obtained could be useful in appropriate management, breeding programmes, selection and utilization for egg quality genetic resources.

Keywords: Ostrich eggs, Biometric traits, Correlation coefficient, Principal component analysis

INTRODUCTION

The largest and heaviest living species of any living birds is known to be an ostrich (*Struthio camelus)*, it's a large flightless bird native to Africa. It is the only living species of its family, Struthionidae. Ostrich belong to the order Struthioniformes with the kiwi, emu, rhea and other ratites of distinctive appearance, with a long neck and legs (Hermes, 2006). Farming of Ostrich (*Struthio camelus*) in Nigeria is not well developed since the birds were not popular in Nigerian contents (Amao, 2019). Nigeria as a nation is behind many of African countries such as South Africa, Zimbabwe, Botswana and Namibia in ostrich production and contributes a partially 0.2 % of the world domesticated flock (Ostrich Products Case Study Discussion Draft, 2005). Recently, ostrich farming has been rapidly expanding in many countries to produce usable products such as meat, hide, eggs and feathers (Aono and Hotchi, 2002). The potential of Ostrich industry in Nigeria might form the base to support its expansion in the country since its presents every suggestion that environmental conditions are conducive for ostrich survival. The dearth of information pertaining to growth, reproductive performance and eggs of ostriches (Mushi *et al*., 1999; Mushi *et al*., 2008) could be one of the factors hinder the growth of the industry in many African countries.

In Nigeria, more emphasis and studies were laid on domestic fowl to the neglect of other classes of poultry such as duck and goose eggs, smaller eggs such as quail eggs and the largest bird eggs, from ostriches and emus (Amao and Olugbemiga, 2016). Egg biometric variables such as egg weight, egg width, albumen and yolk weights are very important in poultry because these traits influence egg quality and grading (Farooq *et al*., 2001), reproductive fitness of the chicken and embryonic development (Onagbesan *et al*., 2007). Popoola *et al*. (2015) noted that the physical characteristic of the egg play an important role in the processes of embryo development and successful hatching. The most influential egg variables are weight, shell thickness and porosity, shape index (maximum breadth to length ratio, and the consistency of the contents). Ostrich egg weight ranges from 350 g to over 2,200 g. (Cooper *et al*., 2007) recommended that eggs weighing 1,300 to 1,700 g give the best hatchability.

Macciotta *et al.* (2010) described Principal Component Analysis (PCA) as a composite information contained in a group of an observed variable by seeking a new group of orthogonal variables named PC which is calculated from intrinsic of the correlation matrix with main objective to reduce the original variables into limited number of hidden latent variables that are extracted to explain correlation among the observed variables, in addition to explain why the variables are correlated with each other (Pundir *et al*., 2011). The principal component are extracted in a descending order of corresponding eigenvalue that measures the contribution value of original variables expressed by each PC (Macciotta *et al*., 2010) and explain the maximum portion of the variance present in the original group of variables with a minimum number of synthesize variables (Xue *et al*., 2013). The use of correlation and regression approaches only take cares of two traits in an animal at a time which recently limits their uses in selection and breeding plans and therefore, this study adopts the method of PCA in describing the egg quality traits of Ostrich in Southern Guinea Savanna region of Nigeria.

MATERIALS AND METHODS

Experimental site

The study was carried out at the Poultry Unit of Teaching and Research Farm, Emmanuel Alayande College of Education, Oyo, Oyo state, Nigeria and Oyo lies on the longitude 3^{o} 56$^{'}$ east of the greenwich meridian and latitudes 7^{o} 51’ North eastwards from Ibadan, the capital of Oyo State. The altitude is between 300 and 600 meter above sea level. The mean annual temperature and rainfall are 27^{o}C and 1,165mm respectively. The vegetation of the area is Southern Guinea Savanna zone of Nigeria (Amao, 2019).

Source of eggs

Freshly laid eggs of Ostrich were obtained from Old Oyo National park, Oyo. Oyo State, Nigeria. A total of eighty freshly laid eggs were used for the evaluation of external and internal egg quality traits of Ostrich *(Struthio camelus)* eggs.

Data Collection

The eggs from the ostrich were collected and weighed to ascertain the weight of the individual eggs. Ten eggs were randomly selected for breakout to take these measurements on weekly basis for eight weeks. Egg weight, yolk weight and shell weight using digital weighing scale of 5000g. The yolk and shell weights were subtracted from the corresponding egg weight to determine the albumen weight. Shell from the egg’s equatorial region was used to measure shell thickness to 0.01 mm with the aid of micrometer screw gauge. Albumen height was measured using a spherometer to determine the Haugh unit of the individual eggs. Haugh Units: Individual Haugh Unit (HU) score was calculated using the egg weight and albumen height (Haugh, 1937). The Haugh Unit value was calculated for individual eggs using the following formula:

$$HU = 100 \log10 (H + 7.5 – 1.7W^{0.37})$$

where:, H = Observed height of the albumen (mm), W = Weight of egg (g)
Other estimated values were shell index, yolk index and albumen index with formula of El-Safty and Mahrose (2009).

Data Analysis

The means, standard errors and coefficient of variation of egg weight and other biometric measurements of the ostrich eggs were obtained using SPSS 22 (2013). The correlation matrix was the primary data required for principal component analysis (PCA). Bartlett's test of sphericity was used to test if the correlation matrix was an identity matrix or a correlation matrix full of zeros. The suitability of the data set to carry out PCA was further tested using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. This tested whether the partial correlations among variables were small. A KMO measure of 0.60 and above was considered adequate (Eyduran *et al*., 2010). The principal components analysis was carried out using the SPSS 22 (2013) statistical package.

RESULTS

The descriptive statistics for means, standard error, minimum, maximum and coefficient of variations (CV) for external and internal egg measurements of ostrich eggs were presented in Tables 1 and 2. The results revealed that the mean egg weight, egg length, egg width, shell weight, shell thickness and shell index were 1742.34 g, 140.08 mm, 126.70 mm, 272.25 g, 25.11 mm and 14 % respectively (Table 1) while values of 578.75 g, 214.58 mm, 23.03 mm, 884.75 g, 206.50 g, 39.10 mm, 33.35 %, 50.65 % and 89.65 were observed for yolk weight, yolk length, yolk height, albumen weight, albumen length, albumen height, yolk index, albumen index and haugh unit, respectively (Table 2).

Table 3 indicated the correlations coefficients of egg weight and other biometric measurements of ostrich eggs. The obtained correlation ranged from r = -0.36 to r = 0.92. The correlations between the egg weight and egg width (0.16), shell thickness (0.92), yolk weight (0.51), albumen weight (0.75), albumen index (0.18) were positive and highly significant. The Kaiser- Meyer Olkin (KMO) measure of sampling adequacy was 0.67.

Table 1: Means, standard error (S.E), minimum, maximum and coefficient of variation (CV) for external egg measurements of Ostrich eggs

Variable	Mean±S.E	Minimum	Maximum	
Egg weight (g)	1742.34 ± 7.67	1600.00	1800.40	3.76
Egg length (mm)	140.08 ± 10.01	140.00	140.30	0.06
Egg width (mm)	126.70 ± 20.08	125.10	126.20	0.70
Shell weight (g)	273.25± 35.70	200.20	310.30	12.11
Shell thickness (mm)	25.11± 0.23	25.00	25.10	0.20
Shell Index (%)	14.00 ± 0.16	10.90	20.04	35.21

Table 2: Means, standard error (S.E), minimum, maximum and coefficient of variation (CV) for egg weight and biometric measurements of Ostrich eggs.

Variable	Mean±S.E	Minimum	Maximum	CV %
Yolk weight (g)	578.75±35.11	530	630	4.81
Yolk length (mm)	214.58±21.10	213	216	3.45
Yolk height (mm)	23.03±0.09	21	24	0.40
Albumen weight (g)	884.75± 35.36	800	910	3.68
Albumen length (mm)	206.50±9.48	200	212	0.21
Albumen height (mm)	39.10±0.06	39	39.2	2.07
Yolk index (%)	33.35±0.61	32	35	2.98
Albumen Index (%)	50.65±0.08	50	52	1.44
Haugh unit	89.65±9.13	129	136	0.93

Table 3: Correlations coefficients of egg weight and biometric traits of Ostrich eggs

Variable	EW	EL	EWD	SW	ST	YW	YH	YL	AW	AH	AL	SI	YI	AI	HU
EW	1.00														
EL	-0.01	1.00													
EWD	0.16***	-0.19	1.00												
SW	0.92***	-0.19	0.24	1.00											
ST	0.06***	0.16	-0.10	0.03	1.00										
YW	0.51***	-0.02	0.04	0.37*	-0.01	1.00									
YH	-0.14	0.11	0.41	-0.11	0.02	-0.39	1.00								
YL	-0.28	-0.08	-0.04	-0.26	-0.41	-0.15	0.09	1.00							
AW	0.75***	0.11	0.14	0.78*	0.11	0.07	0.01	-0.26	1.00						
AH	0.04	-0.12	-0.12	-0.02	0.26	0-03	0.04	-0.16	-0.07	1.00					
AL	-0.20	-0.08	-0.08	-0.18	0.05	-0.01	-0.15	0.02	-0.19	-0.05	1.00				
SI	-0.11	-0.24	0.16	-0.03	0.00	0.00	0.04	0.05	-0.06	-0.16	0.08	1.00			
YI	-0.02	-0.25	0.09	-0.10	-0.09	0.24	-0.36	0.03	-0.12	-0.02	-0.11	0.43	1.00		
AI	0.18	-0.03	0.03	0.22	-0.14	0.13	-0.29	0.00	0.22	-0.27	0.09	0.04	0.07	1.00	
HU	-0.32	0.28	0.14	-0.31	-0.27	-0.02	0.04	0.07	-0.29	-0.16	0.19	-0.02	-0.04	-0.03	1.00

***Significant at $P<0.001$ for all correlation coefficients except where otherwise stated; *Significant at $P<0.05$

Table 4 showed the eigen values and percentages of total variance along with the rotated component matrix and communalities of quality traits of ostrich eggs. This result gave good description of principal component for easy interpretation. The rotated eigen values for PC1 (-0.082 to 0.934) and PC2 (-0.001 to 0.808) increased while the value for PC3 (-0.048 to 0.832) decreased.

The communalities values represented the proportion of variance in the original variables that was accounted for by each common factor. Communalities values for egg weight (0.899), shell weight (0.904), yolk weight (0.829) and albumen weight (0.746) were better in PC1 interpretation and thus reflected in the communalities values obtained.

The total variance explained, component initial eigen values loading by principal component analysis, eigen values and variation explained are as indicated in Table 5. There were five factors extracted with eigen values >1 and accounted for 66.17 % of the total variance. The first factor accounted for 51.94 % of the variation out of the total 15 original statistical value traits extracted.

Table 4: Eigen values and shares of total variance along with factor loading after varimax rotation communalities of egg weight and biometric measurements of ostrich eggs

Variable	PC1	PC2	PC3	Communalities
Egg weight	0.918	-0.123	0.082	0.899
Egg length	-0.082	-0.120	0.158	0.688
Egg width	0.308	0.649	-0.107	0.687
Shell weight	0.934	-0.001	0.029	0.904
Shell thickness	0.046	0.008	0.832	0.698
Yolk weight	0.440	-0.490	0.029	0.829
Yolk height	-0.185	0.808	0.028	0.499
Yolk length	-0.360	0.001	-0.661	0.605
Albumen weight	0.831	0.111	0.057	0.746
Albumen height	-0.158	-0.157	0.545	0.508
Albumen length	-0.148	-0.159	0.096	0.486
Shell index	-0.063	0.135	0.001	0.661
Yolk index	-0.083	-0.345	-0.048	0.451
Albumen index	0.376	-0.274	-0.395	0.433
Haugh unit	-0.237	0.158	-0.266	0.522
Initial Eigenvalue	3.291	1.932	1.848	
% of the variance	51.94	12.90	12.32	
% cumulative variance	32.91	34.82	47.14	

DISCUSSION

Egg quality and its components are important indices to consumers and the economic success of producers depend on the total number of eggs sold. Egg quality is based on characteristics of the egg that affect its acceptability and the egg components are of nutritional importance. The egg quality traits of ostrich presently indicated that egg weight ranges from 1600 to 1800 g, the egg length, egg width, shell weight, shell thickness and shell index were in line with the documentation of earlier worker of El-Safty and Mohrose (2009) for African black neck ostrich eggs traits in Libya except for the egg weight and shell weight which were slightly lower than values obtained currently. The majority of values obtained for traits presently were in conformities with the findings of Mahrose (2002) and Mushi *et al*. (2008) in Bostwana and Egypt respectively which claimed that ostrich eggs were not oval in shaped and it is also not easy to give a visually distinguish the round end from the broad end. However, the egg quality traits for both external and internal variables currently were in accordance with the observations of Superchi *et al*. (2002) in Italy, the authors recorded the same range of values agreed with this current study.

Meanwhile, the correlation coefficient documented in this study was positive and highly significant for egg weight against shell weight, albumen weight and yolk weight was an indication for importance of each of the traits for the principal component. Majority of the values were positively correlated with egg weight indicating that these traits had a similar contribution. Thus, these observations were similar to the values obtained in the earlier study of Xue *et al.* (2013) in China for egg quality traits of native duck breeds. These authors documented similar correlations magnitudes for on egg weight, egg shape index, the intensity of the shell, shell thickness, the ratio of egg yolk and haugh unit. However, the obtained value of

Table 5: Total variance components of initial eigenvalues and extraction squared sum loadings

	Initial Eigenvalues loading			Extraction squared sum loading		
Component	**Total**	**Var. %**	**Cummulative %**	**Total**	**Var. %**	**Cummulative %**
1	3.29	51.94	51.94	3.29	51.94	51.94
2	1.93	12.88	34.82	1.93	12.90	34.82
3	1.85	12.32	47.14	1.85	12.32	47.14
4	1.60	10.65	57.79	1.60	10.65	57.79
5	1.26	8.38	66.17	1.26	8.38	66.17
Other 10	0.04	33.83	100	0.04	33.83	100

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.67 indicates that the correlation between the egg traits measured were not unique and not related to the remaining traits outside each correlation since Kaiser (1967) claimed that a measure of sampling adequacy above 0.60 to be mediocre and acceptable while the significant value of the Bartlett's test of sphericity obtained give a meritorious evidence for the authenticity of using factor analysis for the data set. The total variance explained, component initial eigen values loading by principal component analysis, eigen values and variation explained only five factors extracted were agreed with the reports of Jesuyon (2014) that the technique of principal component was used to reduce the number of variables into a smaller number of principal components for further analysis. Thus, explanations for smaller factor also were similar to the values obtained in the earlier study of Xue *et al.* (2013) in China for egg quality traits of native duck breeds.

CONCLUSION

Based on the outputs of the results, it can be concluded that the descriptive biometric traits obtained for Ostrich eggs in this region were in range with other countries of the world despite different ecological zones. The PCs obtained in the present study could be used to define egg weight and biometric traits of the Ostrich eggs since EW, SW, AW and YW were sufficient to assign them into their appropriate groups. The current study indicated that five traits were produced five composite traits by PCA, the cumulative contribution rate of 5 eigen values accounted for about 66.17 % of total variation out of 15 traits considered which amounted to 33.83%. Thus, it represented the better information of the original indicators for EW, SW, AW and YW.

RECOMMENDATIONS

Information obtained from this study for PCA could be useful as practical tools in prediction of egg weight in Ostrich eggs due indicators of SW, AW and YW which were better correlated with the PC1 values. These correlated traits can assist in selection and breeding programme for Ostrich farmers.

CONFLICT OF INTEREST

The author declare that there is no conflict of interest as regards the data presented in this manuscript

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