Archivos de Zootecnia
Journal website: https://www.uco.es/ucopress/az/index.php/az/

Canonical discriminant analysis applied to biometric data of nigerian indigenous turkeys

Adeyemi, M.A.@ and Oseni, S.O.

Department of Animal Sciences. Faculty of Agriculture. Obafemi Awolowo University. Ile-Ife. Nigeria.

SUMMARY

Body weight and eight morphometric variables were used to differentiate three colour variants (white, black and lavender) of Nigerian indigenous turkey populations. Data included the following variables: body weight (BW, Kg), shank length (SL), beak length (BL), abdomen circumference (AC), thigh length (TL), snood length (SN), spur length (SP), tail feather (TF) and caruncle (CR). Phenotypic homogeneity and differences were evaluated using linear discriminant analysis. Results indicated that the black and lavender coloured variants were the closest in all the evaluated parameters. The pairwise squared Mahalanobis distance of 6.745 was obtained between black and lavender while the corresponding distances between white and each of black and lavender were 9.242 and 57.595 respectively (P<0.01). The results of predicted group membership showed that 100.00, 96.40 and 95.10 percent of black, white and lavender colour variant turkeys respectively, were correctly assigned into their phenotypic groups. Also, among the colour variants, white turkeys, showed significantly higher means (P<0.05) for BW, SL, SN and SP. Of all the morphometric variables, BW, SL and AC were the most discriminatory variables to separate the three colour variants. These results could indicate inherent within population variation in morphometric traits among indigenous turkey. Further detailed phenotypic and genetic characterization studies will contribute to the development of strategic breeding programmes for the genetic improvement of indigenous population of turkeys in Nigeria.

Additional keywords

Nigerian indigenous turkeys.
Morphometric variables.
Phenotypic characterization.
Canonical discriminant analysis.
Selection criteria.

Análisis discriminante canónico aplicado en datos biométricos de pavos autóctonos nigerianos

RESUMEN

Para diferenciar tres variantes de color (blanco, negro y lavanda) de las poblaciones indígenas de pavo de Nigeria se utilizaron el peso corporal y ocho variables morfométricas: peso corporal (BW, kg), longitud de la caña (SL), longitud del pico (BL), circunferencia abdominal (AC), longitud del muslo (TL) pluma de cola (TF) y carúncula (CR). La homogeneidad fenotípica y las diferencias se evaluaron mediante análisis discriminante lineal. Los resultados indicaron que las variantes de color negro y lavanda fueron las más cercanas en todos los parámetros evaluados. Entre negro y lavanda la distancia de Mahalanobis fue de 6,745, mientras que las correspondientes distancias entre blanco y negro o lavanda fueron 9,242 y 57,595, respectivamente (P<0,01). El 100,00, 96,40 y 95,10 por ciento de pavos de las variantes de color negro, blanco y lavanda, respectivamente, fueron asignados correctamente a sus grupos fenotípicos. Además, entre las variantes de color, los pavos blancos, mostraron valores medios significativamente más altos (P<0,05) para BW, SL, SN y SP. De todas las variables morfométricas, BW, SL y AC fueron las variables más discriminatorias para separar las tres variantes de color. Estos resultados podrían indicar variación dentro de la población en rasgos morfométricos en los pavos indígenas nigerianos. Otros estudios detallados de caracterización fenotípica y genética contribuirán al desarrollo de programas estratégicos de mejoramiento genético de la población indígena de pavos en Nigeria.

Palabras clave adicionales

Pavos nigerianos indígenas.
Variables morfométricas.
Caracterización fenotípica.
Análisis discriminante canónico.
Criterios de Selección.

Information

Cronología del artículo.
Recibido/Received: 16.06.2016
Aceptado/Accepted: 09.10.2017
On-line: 15.01.2018
Correspondencia a los autores/Contact e-mail:
ade_maxwell@yahoo.com

INTRODUCTION.

Indigenous poultry (turkeys, chickens, geese, ducks, quails and guinea fowls) constitute about 90% of total poultry in Nigeria (Gueye, 1998; Sonaiya, 1999). However, indigenous turkeys remain the least produced with less than 1% among domesticated poultry species in Nigeria (Yakubu *et al.*, 2013), despite its greater potential as a meat bird when compared to the chicken (Ajayi *et al.,* 2012). This is because, most (90%) indigenous poultry breeding programmes are targeted at improving the productivity of indigenous chickens (Kitalyi, 1998; FAO, 2000). The indigenous turkeys are hardy, better adapted, cheaper to raise, are natural foragers and scavengers, thrive best where they can move about freely, feeding on seeds, fresh grass, locusts, crickets, grasshoppers, worms, slugs and snails (Singh and Sharma, 2012). Also, these indigenous turkeys demonstrate series of phenotypic variations (Ogah, 2011), in addition to serving as reservoirs and gene pool for genetic studies and strategic breed improvement (Yakubu *et al.,* 2012; Zanetti, 2009). Therefore, improving the quality of Nigerian indigenous turkeys through sustainable breeding and management will further increase opportunities in agriculture, while promoting food security. In order to achieve this, a critical starting point is livestock breed characterization (Lanari *et al.,* 2003). Phenotypic characterization is the identification of detectable variations resulting from differences in morphology (de Vicente *et al.,* 2005). The first step in such characterization involves the measurement of morphological traits. Several studies (Nesamvuni *et al.,* 2000; Rastija *et al.,* 2004; Araujo *et al.,* 2006; Mwacharo *et al.,* 2006; Martins *et al.,* 2009; Yakubu, 2010) have reported the importance of morphometric traits as important tools for breed improvement. For Nigerian indigenous turkeys, detailed characterization studies are needed to uncover within population variation, as well as the genetic structure of the population.

Canonical discriminant analysis according to Tabachnick and Fidell (2001) is a multivariate statistical procedure that shows relationships between or among two or more maximally correlated variable sets through linear combinations that allow discovery of dominant gradients of variation among groups. The technical importance of canonical discriminant approach to indigenous turkey populations is not only critical to features extraction but also in explaining the complex mechanisms involved in morphological variations within populations, which affect biologically related traits owing to linkage and pleiotropy (Yakubu *et al.,* 2012; Ogah, 2011). Thus, multivariate discriminant analysis is applied to the evaluation of phenotypic variations among breeds (Rosario *et al.,* 2008; Al-Atiyat, 2009; Lanari *et al.,* 2003; Zaitoun *et al.,* 2005; Traore *et al.,* 2008; Yakubu and Akinyemi, 2010; FAO, 2009; Yakubu and Ibrahim, 2011).

Research from various authors (Aquino *et al.,* 2003; SAGARPA, 2003; Janjecic and Muzic 2007) showed a major concern for recent losses of genetic diversity within and among indigenous turkey breeds. Therefore, to avert further losses in indigenous turkey genetic resources, as well as designing improved breeding programmes, it is imperative that efficient phenotypic and genetic characterization studies are done. The objective of this study was to evaluate the phenotypic relatedness of indigenous turkey populations on the bases of morphometric traits using discriminant analysis. The study also provided answers to the following: (i) are there sub-groups of indigenous turkey populations that show distinctness and homogeneity based on plumage colours? (ii) which traits have the highest discriminant powers that contribute best to group classification?.

MATERIALS AND METHODS.

Study location.

This research was carried out at the Turkey Unit of the Teaching and Research Farm, Obafemi Awolowo University (OAU), Ile-Ife, Nigeria. The OAU is located within the rainforest zone, Latitude 7°28′N and Longitude 4°33′E at an elevation of about 200 m above sea level.

Management of experimental turkey population.

A total of 192 Nigerian indigenous turkeys comprising of three colour variants of 76 white, 50 black and 66 lavender respectively were used for this study. These experimental birds consisted of 103 males out of which 35 were white, 28 black and 40 lavender and 89 females out of which 41 were white, 22 black and 26 lavender. The foundation stock of these indigenous stocks was sourced as day old poults from Amo Farms, Oyo State, Nigeria. The turkeys were reared through intensive management system at the Turkey Unit, OAU, Ile-Ife, Nigeria. Clean and cool water was supplied daily. Starter ration (25 percent crude protein (CP)), grower ration (22 % CP) and finisher ration (19 % CP) were fed to the birds from 0 to 6 weeks, 7 to 14 weeks and 15 to 28 weeks, respectively, *ad libitum*. The turkeys were vaccinated against Newcastle, Gumboro and Fowl Pox diseases at the ages of 7, 14, 21 and 56 days respectively while drugs against coccidial infections were administered, following Veterinary guidelines. There was strict sampling restriction only to pure colours among the three variants (lavender, black and white) by carefully checking through the feather colours covering the flesh so as to observe equal classification descriptors for all the observed colour variations.

Traits measured.

Data were obtained on body weight and eight morpho-metric traits of turkeys at the age of 28 weeks. Measurements taken on the birds were all carried out by one person to avoid between-persons variation. All measurements followed the descriptor lists for turkeys as published in Animal Genetic Resources Data Bank (FAO, 1986). The measured traits (in cm) were: (i) shank length (SL) measured from the back joint and the tarso-metatarsus, (ii) beak length (BL) measured from the broader end of the beak (towards the head) to its pointed end, (iii) abdomen circumference (AC) which is the circumference of the breast around the deepest region, (iv) thigh length (TL) measured from the hock to the pelvic joints, (v) snood length (SN) measured from the base of the head to the end of the fleshy projection, (vi) spur length (SP) which is the length of the spiny projection on the shank, (vii) tail feather (TF) measured from the point of attachment of the base of the tail feather to its terminal, and (viii) caruncle (CR) measured from the base of fleshy nodule on the neck region to its terminal. Direct measurement of body weight (BW, Kg) was done using weighing scale. All linear measurements were taken in Centimetre using graduated flexible tape, as outlined by Ogah *et al.*, (2009, 2011).

Statistical Analysis.

Canonical discriminant analysis was performed using SPSS 20®. Also, Analysis of Variance (ANOVA) procedure was run to establish differences among colour variants, while the separation of means was done using Duncan Multiple Range Test. In the canonical discriminant analysis, the discriminant function combined several quantitative variables, each of which makes an independent contribution to the overall discriminant analysis. Taking into consideration the effect of all quantitative variables, the discriminant functions produced the statistical basis for predicting the subgroup of classification variables that each colour variant belongs, through a weighted combination of all quantitative variables.

RESULTS AND DISCUSSION.

Table I showed the means and standard deviation of the morphometric variables across the three colour variants of indigenous turkeys. Generally, the means obtained for the white colour variant were significantly ($P \leq 0.05$) higher than those of black and lavender variants with the exemption of abdomen circumference, length of tail feathers and number of caruncles ($P>0.05$). Results from the literature on morphometric traits of Zagorje turkey classified according to plumage colours showed that black and bronze colours had the highest mean for BW, BL, TL and SL (Janječić and Mužic, 2007). Results further showed that there were similarities in some of the measurements among the black and lavender colour variants especially for BW, BL, TL, SL, SN and SP ($P>0.05$). Also, the standard deviation (SD) especially for body weight observed among lavender coloured variant was larger compared to the white indicating, possibly higher variation in body weight within this subgroup. This may be a possible reflection of the differences in body sizes among the three colour variants studied. These observed variations in body measurements among the three colour variants may be attributed to inherent intra-population peculiarities or attributes as reported by various authors (Mckracken *et al.*, 2000; Latshaw and Bishop, 2001; Ajayi *et al.*, 2008) that morphometric measurements are useful in differentiating sizes as well as shapes of animals. Similarly observed was the significant variation among the turkey population by sex with the males having higher ($p<0.05$) means in all the morphometric traits than the females except for the BL. These results are consistent with the reports of Yakubu *et al.* (2012) on sexual dimorphism of Nigerian indigenous, exotic and cross-bred turkeys with the males having significantly higher ($p < 0.05$) BW, BL, SL, TL and keel length than females. Differences between sexes had been confirmed by the results of various studies (Baeza *et al.*, 2001; Blondel *et al.*, 2002; Yakubu *et al.*, 2012) conducted on sexual dimorphism to include the well established between-sex differences in hormonal action, which invariably leads to differential growth rates and sexual dimorphism between male and females.

Table II showed the eigenvalues, variance proportion (CP), canonical correlation and standardized discriminant coefficient of functions 1 and 2 that describe the data for the three sub-groups. The significance of the two discriminant functions obtained was each tested by Wilk's Lambda (λ), which were 0.155 and 0.639 respectively as well as Chi square test (χ^2), which were 58.736 and 14.101 ($P \leq 0.001$). These results provided validity for the discriminant analysis. Functions 1 and 2 explained 84.7% and 15.3% of total variation respectively. This implies that, function 1 has the best linear combination of traits sufficient in discriminating among the three colour variants. This was similarly reported by Ogah (2013); Yakubu *et al.*, (2012) using canonical discriminant analysis applied to Nigerian indigenous chicken and Multifactorial discriminant analysis of morphological and heat-tolerant traits in

Table I. Body weight and morphometric variables for three colour variants and sexes of Nigerian indigenous turkey population (Peso corporal y variables morfométricas para tres variantes de color y sexos de la población nigeriana indígena de pavo).

Traits	Colour variants			Sex	
	White	Black	Lavender	Male	Female
BW	7.70 ±1.52^a	7.58 ±1.66^b	7.55 ±2.70^b	7.74±1.13^a	6.20±1.46^b
BL	5.24 ±0.60^a	5.17 ±0.69^a	5.08 ±0.58^a	5.30±0.62^a	5.12±0.57^a
TL	16.65 ±2.51^a	15.98 ±2.28^b	15.70 ±2.18^c	16.91±2.49^a	14.37±2.14^b
SL	12.37 ±1.71^a	11.90 ±1.59^b	11.99 ±1.70^b	12.55±1.78^a	10.79±1.56^b
AC	56.65 ±6.49^b	54.88 ±7.42^c	58.50 ±8.14^a	60.02±9.35^a	55.49±7.22^b
SN	4.13 ±1.97^a	3.65 ±1.95^b	3.61 ±1.56^b	4.20±1.90^a	3.01±1.64^b
SP	0.63 ±0.78^a	0.33 ±0.57^b	0.33 ±0.50^b	0.72±0.69^a	0.28±0.55^b
TF	29.70 ±5.05^b	30.18 ±3.20^a	29.02 ±5.26^c	31.00±4.61^a	28.84±4.20^b
CR	4.00 ±1.11^a	4.07 ±1.20^a	3.72 ±1.45^b	4.14±1.30^a	3.46±1.09^b

BW: Body Weight, BL: Beak Length, TL: Thigh Length, SL-Shank Length, AC- Abdomen Circumference, SN: Snood Length, SP:Spur Length, TF-Tail Feather, CR-Caruncle.

^{abc}Means within the same row having different superscripts differ significantly ($P< 0.05$) among the three colour variants.

^{ab} Means within the same row having different superscripts differ significantly ($P<0.05$) between the two sexes.

Table II. Summary of Canonical Discriminant Functions (Resumen de las funciones discriminantes canónicas).

Function	Eigenvalues	CP	Canonical Correlation	λ	χ^2	Significant level
1	3.125	84.7	0.870	0.155	58.736	0.001
2	0.565	100.0	0.601	0.639	14.101	0.003

Table III. Standardized canonical coefficient and total variations explained by canonical variables (Coeficiente canónico estandarizado y variaciones totales explicadas por variables canónicas).

Variables	CAN 1	CAN 2
BW	-0.316	0.614
BL	-0.116	0.114
TL	-0.057	-0.129
SL	0.782	0.202
AC	-0.103	0.565
SN	-0.101	0.072
SP	-0.113	0.037
TF	-0.029	0.014
CR	-0.227	-0.277
Total Variance	0.847	0.153

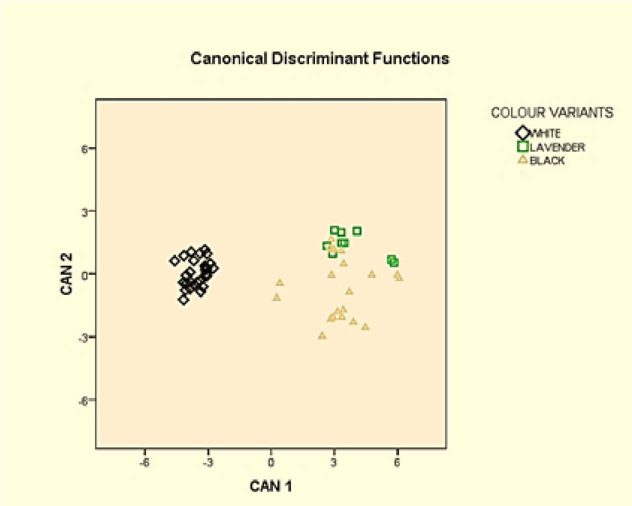

Figure 1. Canonical representation of the three colour variants of Nigerian indigenous turkeys (Representación canónica de tres variantes de color de pavos indígenas Nigerianos).

indigenous, exotic and cross-bred turkeys in Nigeria respectively.

Table III showed the standardized canonical coefficients and total variation as explained by canonical variables. For all the variables, each corresponding value indicates the original contribution of each trait to the overall variation among the population, which is a reflection of its discriminatory power. Generally, any variable with a loading of 0.30 (or higher) is considered to contribute significantly as a discriminating variable. Therefore, in CAN 1 with the best linear contribution of traits, BW and SL are the two most discriminating variables for the three colour variants whereas in CAN 2, AC in addition to BW are the only two variables with loadings of 0.30 and higher. Results reported by Yakubu *et al.*, (2012) using Nigeria indigenous, exotic and cross-bred turkeys indicated BL and Thigh Length as the only two morphometric traits with the best linear combination in both CAN 1 and CAN 2. Also, these results conform to those of Ogah (2013); Rosario *et al.*, (2008); Abdelqader *et al.*, (2010) in discriminant analysis applied to broiler chicken performance and three Jordanian chickens respectively. **Table IV** shown below further re-affirmed this finding. A two-dimensional plot of CAN 1 and CAN 2 variables demonstrating the existing connections among the three colour variants is shown in figure 1 with significant overlap between the black and lavender while the white colour variant had no overlap of any kind.

Results in **Table V** showed the pair-wise squared Mahalanobis distance and probability values for the three colour variants of turkeys. The black and lavender colour variants were the closest (6.745) with the largest distance obtained between the white and lavender (57.595). This result was further re-affirmed with the **Figure 1** as shown above. These results may indicate inherent and latent, within population variation in body weight as well as morphometric variables for indigenous turkeys. Similar results have been reported by Al-Naseer *et al.* (2007); Moiseyeva *et al.*, (2003) in multivariate characterization of chickens on the basis of feather colours and found that the greatest similarity was between *Gallus gallus* and egg type breeds of Mediterranean origin. The large variations among the white and lavender colour variants may possibly reflect such within population variability in morphometric traits, and supports the results of previous studies by Misso-

Table IV. Total canonical discriminant functions for the three colour variants of Nigerian indigenous turkeys (Funciones discriminantes canónicas totales para las tres variantes de color de pavos indígenas nigerianos).

	Function 1	Function 2
BW	-0.983	0.363
SL	0.986	0.240
AC	0.822	0.468

Table V. Pairwise Squared Mahalanobis distance and probability value for the three colour variant of Nigerian turkeys (Distancias de Mahalanobis y valor de probabilidad para las tres variantes de color de pavos nigerianos).

Ecotypes	White	Black	Lavender
White	0	9.242	57.595
Black	***	0	6.745
Lavender	***	***	0

***P<0.001.

Table VI. **Percent (%) of individual Nigerian turkeys predicted group membership** (Porcentaje de pavos Nigerianos correctamente agrupados)

Colour variants	Black	White	Lavender
Black	100.00	0.00	0.00
White	0.00	96.40	3.60
Lavender	0.00	4.90	95.10
Error level	0.00	0.036	0.050
Priors	0.333	0.333	0.333

hou *et al.*, (1998) in Senegal as well as Duguma (2006) in Horro, Tepi and Jarso indigenous chickens who found considerable variation in phenotypic characters within and between the Ethiopian chicken ecotypes with the greatest similarities between the Tepi and Jarso. Similar to this are the results of nearest-neighbour discriminant analysis shown in Table 6 below, which indicated that 100.00, 96.40 and 95.10 percent of black, white and lavender colour variants respectively were correctly assigned into their phenotypic groups. This result agrees with Yakubu *et al.*, (2012) findings on three sub-populations of turkeys, with an average predicted group membership of 98.37 percent.

CONCLUSION.

The use of discriminant analysis in differentiating three colour variants of Nigerian turkey populations has helped in understanding the phenotypic relatedness between the three phenotypic sub-groups. Of all the nine measured morphometric variables, only BW, SL and AC were the most important discriminant variables among the three colour variants. The white colour variant had the largest distance from the other two variants (lavender and black), and also recorded the highest means for BW, SL and AC. This study contributes to the phenotypic characterization of indigenous turkeys in Nigeria. Detailed phenotypic and genetic characterization studies are needed to uncover the genetic mechanisms for adaptation, morphology and performance-related traits of these indigenous turkey populations.

ACKNOWLEDGEMENTS:.

Turkey Unit, Teaching and Research Farm, OAU, Ile-Ife.

EU-funded ilINOVA project (www.ilinova.org) for partial funding of the study.

.REFERENCES.

(SAGARPA) Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (2003). Informe Sobre la Situación de los Recursos Genéticos Pecuarios (RGP) en México. www.sagarpa.gob.mx/Dgg/FTP/infofao.pdf. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación; México, DF. (12/05/2006).

Abdelqader, A., Wollny, C.A.B. and Gauly, M. 2010. On farm investigation of indigenous chicken biodiversity and performance potentials in rural areas of Jordan. *Anim Genetic Resource Inf,* 43: 49-59.

Ajayi, F.O. Adenowo, J.A. and Agaviezor, B.O. 2012. Phenotypic characterization of indigenous chicken in selected indigenous government area of Bayelsa state. Nigeria. Proceedings of the 3rd Nigerian International Poultry Summit Feb. 22-26. Abeokuta. pp 75-78.

Ajayi, F.O., Ejiofor, O. and Ironke, M.O. 2008. Estimation of body weight from linear body measurements in two commercial meat-type chickens. *Global Agric Sci*, 7: 57-59.

Al-Atiyat, R.2009. Diversity of chicken populations in Jordan determine using discriminate analysis of performance traits. *Int J Agric Biol*, 11: 374 -380.

Al-Naseer, A., Al-Khalaifa, H., Al-Saffar, A., Khalil, F., Al-Bahouh, M., Ragheb, G., AlHaddad, A. and Mashaly, M. 2007. Overview of chicken taxonomy and domestication. *World Poultry Sc J, 63: 285-300.*

Aquino Rodríguez, E., Arroyo Lara, A., Torres Hernández, G., Riestra Díaz, D., Gallardo López, F. y López Yáñez, B. 2003. El Guajolote Criollo (Meleagris gallopavo L.) y la Ganadería Familiar en la Zona Centro del Estado de Veracruz. *Tec. Pec. Méx.* 41: 165 -173.

Araujo, J.P., Machado, H., Cantalapiedra, J., Iglesias, A., PetimBatista, F., Colaco, J. and Sanchez, L. 2006. Biometric analysis of Portuguese Minhota cattle. Proceedings 8th World Congress on Genetics Applied to Livestock Production, 13 -18 Aug. Belo Horizonte, MG. Brazil.

Baeza, E., Williams, J., Guemene, D. and Duclos, M.J. 2001. Sexual dimorphism for growth in Muscovy ducks and changes in insulin-like growth factor I (IGF- I), growth hormone (GH) and tri-iodothyronine (T3) plasma levels. *Reprod Nutr Develop*, 41: 173 -179.

Blondel, J., Perret, P., Anstett, M.C. and Thebaud, C. 2002. Evolution of sexual size dimorphism in birds: test of hypotheses using blue tits in contrasted Mediterranean habitats. *J Evol Biol*, 15: 440 -450.

de Vicente, M.C., Guzman, F.A., Engels, J. and Ramanatha Rao, V. 2005. Genetic characterization and its use in decision making for the conservation of crop germplasm. www.fao.org/biotech/docs/vicente.pdf. (20/05/2016).

Duguma, R., 2006. Phenotypic characterization of some indigenous chicken ecotypes of Ethiopia. *Liv Res Rural Develop* 18 (9), www.cipav.org.co/lrrd/lrrd18/9/dugu18131.htm.

FAO. 1986. Animal genetic resources data banks. 3. Descriptor lists for poultry 111pp.

FAO. 2000. Small-scale poultry production. FAO Corporate Document Repository. http//: www.fao.org/docrep/008/y5169e/y5169e01.htm.

FAO. 2009. Global Plan of Action for Animal Genetic Resources and the Interlaken Declaration. Rome http: //www.fao.org/docrep/010/a1404e/a1404e00.htm.

Gueye E.F. 1998. Poultry plays an important role in African village life. *World Poultry* 14: 14-17.

Janjecic, Z. and Muzic, S. 2007. Phenotypic traits in Zagorje turkey. *Acta Agr Kaposvariensis,* vol. 1: 1-5.

Kitalyi, A.J. 1998. Villahe chicken production systems in rural Africa: Households Food Security and Gender issues. FAO Animal Production and Health. Paper 142. Rome.

Lanari, M.R., Taddeo, H., Domingo, E., Centeno, M.P. and Gallo, L. 2003. Phenotypic differentiation of exterior traits in local Criollo goat population in Patagonia (Argentina). *Arch Tierz Dummerstorf,* 46, 347-356.

Latshaw J.D. and Bishop, B.L. 2001. Estimating body weight and body composition of chickens by using noninvasive measurements. *Poultry Sci,* 80: 868-873.

Martins, C.E.N., Quadros, S.A.F., Trindade, J.P.P., Quadros, F.L.F., Costa, J.H.C. and Raduenz, G. 2009. Shape and function in Braford cows:

The body shape as an indicative of performance and temperament. *Arch Zootec,* 58: 425 -433.

McKracken, K.V., Paton, D.C. and Afton, A.D. 2000. Sexual size dimorphism of the Musk duck. Wilson Bull. 112: 457-466.

Missohou, A., Sow, R. S. and Ngwe-Assoumou, C. 1998. Morphological and biometrical characteristics of the Senegal indigenous chicken. *AnGR Information*. 24: 63-69.

Moiseyeva, I.G., Romanov, M.N., Nikiforov, A.A., Sevastyanova, A.A. and Semyenova, S.K. 2003. Evolutionary relationships of red jungle fowl and chicken breeds. *Gen Select Evol,* 35: 403-423.

Mwacharo, J.M., Okeyo, A.M., Kamande, G.K. Rege, J.E.O. 2006. The small East African shorthorn zebu cows in Kenya. 1: Linear body measurements. *Trop Anim Health Prod,* 38: 65-76.

Nesamvuni ,A.E., Mulaudzi, J., Ramanyimi, N.D. and Taylor, G.J. 2000. Estimation of body weight in Nguni-type cattle under communal management conditions. *S. J. Anim. Sci., 30 (Supplement 1): 97-98* New York.

Ogah, D.M, Musa, I.S. and Momoh, O.M. 2009. Canonical correlation analysis for estimation of relationship between body measurements at birth and ten weeks period in muscovy duck. Proc. of 4th World Waterfowl Conference. Thrissur. India.

Ogah, D.M. 2011. Assessing size and conformation of the body of Nigerian indigenous turkey*. Slovak J Anim Sci,* 44: 21-27.

Ogah, D.M. 2013. Canonical discriminant analysis of morphometric traits in indigenous chicken genotypes. *Trakia J Sci*, 2: 170-174.

Ogah, D.M., Momoh, O.M. and Dim, N.I. 2011. Application of canonical discriminant analysis for assessment of genetic variation in Muscovy duck ecotypes in Nigeria. *Egypt Poultry Sci*, 31: 429-436.

Rastija, T., Baban, M., Antunovic, Z. and Mandic, I. 2004. A comparison and development of morphometric characteristics of stallions and mares on the Lipizzaner stud of Dakovo. *Acta Agric Slovenica,* Supplement 1: 195 -200.

Rosario, M.F., Silva, M.A.N., Coelho, A.A.D., Savino, V.J.M. and Dias. C.T.S. 2008. Canonical discriminant analysis applied to broiler chicken performance. *Animal,* 2: 419-429.

Singh, R, and Sharma, D. 2012. Turkey and Guinea fowl: Role in Indian poultry production. http: //www.poulvet.com/poultry/articles/turkey_guinea.php.

Sonaiya, E.B. 1999. Backyard poultry production for socio-economic advancement of the Nigerian family: Requirements for research and development, In: Orskov, E.R., Adegbola, T.A., Bogoro, S. and Butswat, I.S.R. (eds). Proceedings of International Seminar on Promoting Sustainable Small Scale Livestock Production Towards Reducing Malnutrition and Poverty in Rural and Sub-urban families in Nigeria, March 7-11. Bauchi. Nigeria. pp. 24-41.

SPSS 20®. 2015. Statistical Package for Social Sciences. SPSS Inc., 444 Michigan Avenue. Chicago.

Tabachnick, B.G. and Fidell, L.S. 2001. Using multivariate statistics. Alyn and Bacon A Person Educ. Company. Boston.

Traore, A., Tamboura, H.H., Kabore, A., Royo, L.J., Fernandez, I., Alvarez, I., Sangare, M., Bouchel, D., Poivey, J.P., Francois, D., Sawadogo, L. and Goyache,F. 2008. Multivariate analyses on morphological traits of goats in Burkina Faso. *Arch Tierz Dummerstorf* 51: 588-600.

Yakubu, A., Abimiku, K., Musa Azara, I.S., Idahor, K.O. and Akinsola, O.M. 2013. Assessment of flock structure, preference in selection and traits of economic importance of domestic turkey (*Meleagris gallopavo*) genetic resources in Nasarawa state, Nigeria. *Liv. Res. Rural. Dev.* 25: 18.

Yakubu, A. 2010. Indigenous chicken flocks of Nasarawa state, Nigeria: their characteristics, husbandry and productivity. *Trop Subtrop. Agroecosyst,* 12: 69-76.

Yakubu, A. and Akinyemi, M.O. 2010. An evaluation of sexual size dimorphism in Uda sheep using multifactorial discriminant analysis. *Acta Agric Scand,* Section A-Animal Science, 60: 74-78.

Yakubu, A. and Ibrahim, I.A. 2011. Multivariate analysis of morpho-structural characteristics in Nigerian indigenous sheep, *Ital J Anim Sci,* 10: 83-86.

Yakubu, A., Akinfemi, A., Abimiku, H.K. and Hassan, D.I. 2010. Application of canonical discriminant analysis to performance traits in broiler strains. *Nigerian Poultry Sci J,* 7: 84 -88.

Yakubu, A., Peters, S.O., Ilori, B.M., Imumorin, I.G., Adeleke, M.A., Takeet, M.I., Ozoje, M.O., Ikeobi, C.O.N. and Adebambo, O.A. 2012. Multifactorial discriminant analysis of morphological and heat-tolerant traits in indigenous, exotic and cross-bred turkeys in Nigeria. *Anim Gen Resources,* 50: 21 -27.

Zaitoun, I.S., Tabbaa, M. and Bdour, S. 2005. Differentiation of native goats breeds of Jordan on the basis of morpho-structural characteristics. Small Rum Res, 56: 173-182.

Zanetti, E. 2009. Genetic, phenotypic and proteomic characterization of local chicken breeds. Department of Animal Sciences. Universita Degli Studi di Padova. Italy. 103 pp.