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PRINCIPAL COMPONENT ANALYSIS OF THE CONFORMATION TRAITS OF YANKASA SHEEP

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Abstract: This study was preformed to evaluate the biometric traits of 227 Yankasa sheep in northern Nigeria under a multivariate approach. The body measurements taken were: withers height, rump height, body length, heart girth, tail length, face length, shoulder width, head width, rump width, ear length, foreleg length, hind leg length and rump length. The animals were divided into two age groups: <15.5 and 15.5 – 28.3 months old, respectively. General linear model was used to study age group effect while principal component factor analysis was performed to define body shape upon the correlation matrix of the thirteen body measurements. Age group significantly (P<0.05) affected the morphological characters except ear length. Pearson's coefficients of correlation were positive and significant in both age groups. In <15.5 months old sheep, four principal components (factors) were extracted (ratio of variance = 89.27). The first factor accounted for 73.03% of the total variance and was interpreted as a measure of general size. The second factor which explained 7.61% of the generalized variance tended to describe flesh dimensions (shoulder width and rump width), while the third factor had its loadings for tail length and ear length. The fourth factor was influenced by head width. In 15.5–28.3 months old sheep, three factors (ratio of variance=75.21) were identified. These seven extracted factors could be considered in breeding programmes to improve body conformation of sheep since variation in meat traits was not associated with body height.

Key words: Yankasa sheep, body dimensions, age group, principal components, breeding

Introduction

Body composition and growth performance are important to assess the potential of development in animals. External body measurements of animals have been extensively used to assess the growth of skeletal parts; and to describe the changes in animal conformation with age (*Ngere et al., 1984*). Morphometric characters are easy to monitor (*Herrera et al. 1996; Yakubu and Akinyemi, 2010*) and they facilitate the use of ethnological characterization and at the same time institute reliable racial discriminants.

Since conformation and some production traits are intercorrelated both genetically and phenotypically (*Brown et al., 1973; Shahin, 1996; Yakubu and Mohammed, 2012*), the analysis of zoometrical variables could be considered in selection programmes to acquire highly coordinated animal bodies. Factor analysis is a multivariate methodology that can be employed when characteristics are correlated, thereby describing objectively the underlying dimension of size and shape. It permits the elimination of redundancies from sets of interdependent variables, extract and identify covariant variable sets that are statistically unrelated (*Nugent and Notter, 1991; Shahin et al., 1995; Yakubu et al., 2011).*

Yankasa sheep are the third largest breed of sheep in Nigeria. However, there is general dearth of information on their body measurements using a multivariate approach. The present investigation therefore aimed at documenting changes in the morphological indices of Yankasa sheep across two age groups. It equally examined the interdependence among body measurements with a view to reducing the number of traits for genetic and breeding purposes using varimax rotated principal component factor analysis (*Posta et al*., 2007).

Materials and Methods

The study was carried out in Lafia, Nasarawa State, which falls within the guinea savannah zone of north central Nigeria. It is located between latitude 08° 35′N and longitude 08° 33′E

Experimental animals

Two hundred and twenty seven Yankasa rams reared through the extensive system of management were randomly measured. The animals were carefully observed to avoid measurements from crossbreds and unhealthy ones. The sheep were divided into two age groups namely < 15.5(n=92) and 15.5–28.3(n=135) months old. The age was determined using the number of permanent incisors as described by Wilson and Durkin (1984) who worked on indigenous sheep and goat breeds of semi- arid Africa. Animals were categorized as follows:

Number of permanent incisors	Age (months)
0 (milk teeth)	< 15.5
1-2 pairs (2-4)	15.5-28.3

Body parts measured

Thirteen metric traits were measured on each animal following standard procedure and anatomical reference points described by Yakubu *et al*. (2005). The body parts consisted of withers height (WH), distance between the most cranial palpable spinous process and the ground, rump height (RH), distance from the top of the pelvic girdle to the ground, body length (BL), measured from distance between the tip of scapula to tail drop, heart girth (HG), body circumference immediately behind the forelegs, face length (FAL), distance from between the horn site to the lower lip, foreleg length (FL), distance from the proximal extremity of the olecranon process to the mid-lateral point of the coronet. Hind leg length (HL), measured up to the mid-lateral point of the coronet, and rump width (RW), width between the hip bones (*Tuber coxae*), rump length (RL), measured from hips (*Tuber coxae*) to pins (*Tuber ischii*), shoulder width (SW), measured as a distance from left to right upper arm, and head width (HW), measured as the widest point of the head, tail length (TL), measured from tail drop to tip of the tail, and ear length (EL), the distance from the point of attachment to the tip of the ear. A graduated measuring stick was used for the height measurements, the length and circumference measurements were done using a flexible tape, while a special wooden calliper was used for the width measurements.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using the general linear model. Age group was the factor included in the model as a source of variation. Pearson's coefficients of correlation (r) among the various body measurements were estimated. From the correlation matrix, data were generated for the principal component factor analysis. This involved the use of the factor programme of SPSS (2001).

According to Johnson and *Wichern (2002),* principal components are linear combination of the original variables and are estimated in such a way that the first principal component explains the largest percentage of the total phenotypic variance. The varimax criterion of the orthogonal rotation method was employed for the rotation of factor matrix. The choice of varimax rotation is informed by its ability to maximize sum of the variances of the squared loadings within each column of the loading matrix. This tends to produce some higher loadings and some loadings near zero which is one of the aspects of simple structure that enhance the interpretability of the factors. Considering a P-variate system, the principal component is given in expression as

$$PC_i = a_{i1} X_1 + a_{i2} X_2 + \text{---------------------------------} a_{ij} X_j$$

with

$i = 1,2,$----------------------------------, n principal components and

j = 1,2,-----------------, p original variables
where,
a_{ij} = the jth component of the coefficient vector of the linear transformation
X_j = the original variable

Results and Discussion

Morphological traits

The mean, standard deviation and coefficient of variation for each of the recorded linear body measurements of the two age groups are presented in Table 1. Generally, the linear body dimensions for 15.5 – 28.3 months old sheep were significantly higher ($p<0.05$) than of those <15.5 months old except ear length. The animals were found to be taller at the withers than at the rump, sloping gently backwards. The marked differences observed in the variables of the two age groups are not surprising since component parts of the animals are expected to increase differentially as the animal grows with age (*Salhab et al., 2001; Yakubu, 2003*). Higher variability was observed in the body parameters of less than 15 months old sheep compared to those of 15.5 – 28.3 months old. Tail length, ear length, rump width, heart girth, shoulder width and body length were more variable in the former (CV= 21.84, 20.41, 16.79, 14.57, 14.37 and 14.03 respectively) while in the latter, variability was highest in tail length followed by ear length, head width, shoulder width, heart girth and rump width (CV = 19.36, 17.19, 15.90, 11.20 and 10.60 respectively). The coefficient of variation values obtained for heart girth, shoulder width and rump width might reflect the sensitive response of these measurements to changes in the fitness (condition) of an animal.

Table 1: Means, standard deviations (SD) and coefficients of variation (CV) of the body measurements of Yankasa sheep

	<15.5 months Old (n=92)			15.5 -28.3 Months Old (n = 135)		
Traits (cm)	Mean	SD	CV	Mean	SD	CV
Withers height	60.48	7.92	13.10	67.86	5.42	7.99
Rump height	59.67	7.51	12.59	66.66	5.15	7.73
Body length	57.10	8.01	14.03	66.10	6.50	9.83
Heart girth	65.00	9.47	14.57	76.58	8.58	11.20
Tail length	25.59	5.59	21.84	28.72	5.56	19.36
Face length	20.22	2.44	12.07	23.01	2.20	9.56
Shoulder width	14.13	2.03	14.37	16.71	1.90	11.37
Head width	8.17	0.96	11.75	9.37	1.49	15.90
Rump width	12.51	2.10	16.79	15.75	1.67	10.60
Ear length	10.68	2.18	20.41	10.76	1.85	17.19
Foreleg length	41.61	4.04	9.71	44.40	3.51	7.91
Hind leg length	38.27	3.10	8.10	41.40	3.06	7.39
Rump length	18.95	2.47	13.03	21.55	2.06	9.56

Correlation analysis

The correlations were all positive and significant (P<0.05) as shown in Table 2. However, the magnitude of the correlations among the morphological characters was higher in <15.5 months old sheep (upper matrix) compared to their 15.5-28.3 months old counterparts (lower matrix). This is not astounding as it lends credence to the rapidity in the growth of body parts at this stage of life. Withers height was more closely related to rump height (r = 0.97 in both age groups). Shoulder width was more highly associated with rump width compared to other morpho-structural measurements (r = 0.97 and 0.75 respectively). The varying estimates of correlation in both age groups could be attributed to the fact that postnatal growth does not take place proportionally in all tissues categories and body regions; instead, it gives preference in the different growth phases to particular tissue types or body regions within those tissue categories (*Kallweit, 1993*).

Table 2. Correlation matrix for the linear body measurement of Yankasa sheep according to age group*

	WH	RH	BL	HG	TL	FAL	SW	HW	RW	EL	FL	HL	RL
WH		0.97	0.89	0.89	0.68	0.80	0.76	0.59	0.63	0.57	0.90	0.88	0.87
RH	0.97		0.89	0.89	0.70	0.82	0.75	0.59	0.63	0.57	0.91	0.89	0.88
BL	0.66	0.67		0.91	0.59	0.82	0.78	0.59	0.68	0.49	0.84	0.80	0.86
HG	052	0.56	0.52		0.63	0.87	0.77	0.64	0.70	0.52	0.82	0.79	0.90
TL	0.69	0.69	0.59	0.33		0.64	0.57	0.42	0.40	0.60	0.65	0.66	0.62
FAL	0.54	0.58	0.51	0.55	0.51		0.69	0.65	0.63	0.58	0.77	0.75	0.84
SW	0.54	0.57	0.64	0.74	0.48	0.55		0.55	0.79	0.39	0.71	0.69	0.71
HW	0.61	0.60	0.48	0.36	0.50	0.45	0.50		0.46	0.46	0.64	0.55	0.63
RW	0.48	0.49	0.59	0.70	0.33	0.52	0.75	0.41		0.20	0.61	0.58	0.63
EL	0.51	0.52	0.48	0.20	0.61	0.56	0.39	0.42	0.37		0.51	0.52	0.55
FL	0.61	0.63	0.41	0.31	0.52	0.33	0.40	0.46	0.27	0.29		0.92	0.88
HL	0.72	0.73	0.53	0.46	0.57	0.47	0.50	0.47	0.40	0.41	0.86		0.84
RL	0.70	0.71	0.58	0.51	0.55	0.55	0.60	0.50	0.49	0.44	0.50	0.57	

*Significant at P< 0.05 for all correlation coefficients.
Above diagonal: <15.5 months old sheep.
Below diagonal: 15.5 – 28 months old sheep.
WH: Withers height; RH: Rump height; BL: Body length; HG: Heart girth; TL: Tail length; FAL: Face length; SW: Shoulder width; HW: Head width; RW: Rump width; EL: Ear length; FL: Foreleg length; HL: Hind leg length; RL: Rump length.

Principal component matrix

Using principal component analysis, morphometric traits were aggregated into groups. Factor pattern coefficients of the varimax rotated factors are shown in Table 3. In < 15.5 months old sheep, four factors which contributed to 89.27% of the variability of the original thirteen traits were extracted. The first factor (principal component) accounted for 73.03% of the total variance. It was characterized by high positive loadings (factor–variate correlations) on withers height, rump height, body length, heart girth, face length, foreleg length, hind leg length and rump length; and appeared to be an index of general size factor. Similarly, *Salako (2006)* reported that 67.7% of the generalized variance in the body measurements of 0 – 14 months old Uda sheep was elucidated by the first factor. In another investigation, *Sadek et al. (2006)* found that a major size component was best represented by the first factor in stallions.

The subsequent factors in the present study were mutually orthogonal to the first and presented patterns of variation independent of general size, thereby breaking collinearity common in the analysis of closely related conformation traits. The second factor determined by shoulder width and rump width (flesh dimensions) explained only 7.61% of the generalized variance. The third factor was related to tail length and ear length and accounted for 4.73% of the total variation; whereas the fourth factor was influenced primarily by head width explaining only 3.90% of the variation. Using factor analysis, *Riva et al. (2004),* suggested that an improvement of rump dimensions may be considered as a selection criterion. In sheep that were 15.5 – 28.3 months old, three factors were retained. The first factor which explained 57.03% of the generalized variance was associated with withers height, rump height, foreleg length, hind leg length and rump length. About 11% of the total variance was explained by the second factor which had its loadings for body length, heart girth, shoulder width and rump width. In the third factor accounting for 7.48% of the variance, the largest coefficient was for ear length, followed by tail length and face length. This is consistent with the report of *Tabachnick and Fidell (2001)* that a large number of observed variables can be reduced to a smaller number of factors.

The aggregation of conformation traits into principal components might be related to the different association of each measurement with skeletal growth, environmental influence or the maturity period, which depended on the age of the animals. There is also the possibility that the traits strongly associated with each factor are under the same gene action (pleiotropism). The exploitation of the multivariate techniques especially the principal components have been found useful for a quantitative measure of animal conformation which is desirable as it will enable reliable genetic parameters for these traits to be estimated and permits its inclusion in breeding programmes (Ibe, 1989; Mavule et al., 2012; Silva et al., 2013). Therefore, the seven extracted principal components in the present study could be used for selection of animals in order to obtain the desired body conformation. Similarly, Kashiwamura *et al.* (2001) reported that selection of animals for potential performance ability should be guided by attention to the general balance of body comformation; which could be facilitated using principal components rather than the focus on any particular dimensional proportion of the body. Performance test traits had also been analyzed in 3 and 4–year old mares using principal components (Posta *et al.*, 2007).

Table 3. Eigenvalues and share of total variance, factor and factor loadings after rotation of the body dimensions of Yankasa sheep of two age groups

	<15.5months old sheep				15.5 – 28.3 months old sheep		
Traits	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3
Wither height	0.81	0.36	0.34	0.21	0.69	0.35	0.49
Rump height	0.82	0.35	0.35	0.19	0.69	0.38	0.48
Body length	0.74	0.46	0.23	0.27	0.36	0.55	0.46
Heart girth	0.70	0.47	0.28	0.33	0.26	0.87	0.04
Tail length	0.41	0.31	0.77	0.02	0.49	0.15	0.69
Face length	0.59	0.40	0.38	0.41	0.17	0.51	0.59
Shoulder width	0.43	0.77	0.26	0.20	0.27	0.82	0.26
Head width	0.32	0.24	0.20	0.85	0.44	0.30	0.45
Rump width	0.35	0.87	0.02	0.17	0.11	0.86	0.22
Ear length	0.27	-0.02	0.83	0.34	0.13	0.12	0.89
Fore leg length	0.84	0.29	0.27	0.25	0.92	0.11	0.10
Hind leg length	0.84	0.27	0.30	0.14	0.86	0.27	0.20
Rump length	0.78	0.33	0.28	0.32	0.50	0.46	0.41
Eigenvalues	9.49	0.99	0.62	0.51	7.41	1.39	0.97
Percentage of total variance	73.03	7.61	4.73	3.90	57.03	10.70	7.48

Conclusion

The principal component analysis technique explored the interdependence in the original thirteen body shape characters by analyzing them simultaneously rather than individually. The allocation of the body measurements to factors (principal components) was age dependent. In <15.5 months old sheep, four factors which accounted for 89.27% of the generalized variance were extracted. However, three factors which explained 75.21% of the total variation were identified in 15.5 – 28.3 months old sheep. Since variation in flesh dimensions (shoulder width and rump width) was not associated with body height, selection could be geared towards the improvement of body shape in order to obtain a tall animal with characteristic meat animal traits.

Analiza glavnih komponenti osobina konformacija ovaca rase Yankasa

A. Yakubu

Rezime

Ova studija je obavljen u cilju procene biometrijskih osobina 227 ovce rase Yankasau severnoj Nigeriji korišćenjem multivarijacionog pristupa. Telesme mere koje su razmatrane u ispitivanju su sledeće: visinagrebena, visina krsta, telesna dužina, obim srca, dužinarepa, dužinalica, širina ramena, širina glave, širina sapi, dužina uha,dužinaprednjih nogu, dužinazadnjih nogu i dužina krsta. Životinje su bile podeljene u dve starosne grupe: <15,5 i 15,5 - 28,3 meseci, respektivno. Opšti linearni model je korišćen za proučavanje uticaja starosne grupe, a faktorska analiza glavnih komponenti je obavljena da se definiše oblik tela prema korelacionoj matrici trinaest telesnih mera. Starosna grupa je značajno($P<0.05$) uticala na morfološkeosobine osim dužine ušiju. Pirsonovi koeficijenti korelacije su pozitivni i značajni u obe starosne grupe. U u grupi ovacauzrasta <15,5 meseci, četiri glavne komponente (faktori) su izdvojene (odnos varijanse = 89.27).Prvi faktor čini 73,03% od ukupne varijanse i bio protumačen kao mera opšte veličine.Drugi faktor koji je objasnio 7,61% od generalizovane varijanse pokazuje tendenciju da opiše dimenzije tela (širinaramena i krsta), dok jetreći faktor imao uticaj na dužine repi ušiju.Četvrti faktor je uticao na širinuglave. U grupi ovaca starosti 15.5-28.3 meseci, tri faktora (odnos varijanse = 75.21) su identifikovani. Ovih sedam se mogu uzimati u obzir u programima oplemenjivanja da poboljšaju usaglašenost tela ovaca, jer razlika u osobinama mesa nije povezana sa telesnom visinom.

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