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Principal Component Analysis of Morphometric Traits Explain the Morphological Structure of Thalli Sheep

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MAA conducted research. KJ supervised the research. AW analyzed the data and helped in write up. AF wrote the article.

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Thalli sheep, Principal component analysis, Body measurements, Correlation, Morphometrics traits

ABSTRACT

The present research was conducted to define the morphological structure of Thalli sheep. Data on 792 Thalli sheep were collected and biometric traits recorded were withers height (WH), body length (BL), head length (HL), head width (HW), ear length (EL), ear width (EW), neck length (NL), neck width (NW), heart girth (HG), rump length (RL), rump width (RW), tail length (TL), barrel depth (BD), sacral pelvic width (SPW), birth weight (BiW), Live body weight (BW), teat length (TEL), teat diameter (TED), testes length (TsL), testes width (TsW) and scrotal circumference (ScD). Male and female animals were placed in two separate groups. The correlation coefficients among most of the morphometric traits were high and significant (P≤ 0.01) particularly among withers height, body length, heart girth and live body weight in both male and female animals. Principal component analyses of morphometric traits were done and two principal components were extracted in females with 66.02% variance and three components were extracted for males with 76.72% variance. PC1 of females had 56.27% variance and 57.51% for male animals. PCA of biometric traits showed that withers height, body length and heart girth had high values for both groups. Principal components were more suitable for analysis of morphometric traits than that of simple correlation method. PCA was used to ascertain the important morphometric traits having greater variation and these traits can be helpful for improvement and in formulation of breeding plans and selection criteria for elite animals.

INTRODUCTION

Small ruminants are vital animals in economy of Pakistan as they are providing the animal protein and by-products like leather from skins. Sheep are the major source of income in semi-arid and arid rural regions and mainly in small holdings (Kakar *et al*., 2011). A total of 31 breeds of sheep are present in Pakistan that provide three major products meat, wool and milk (Khan *et al*., 2007; Tariq *et al*., 2012). Thalli is a thin-tailed sheep breed found in central regions of province Punjab, Pakistan. Thalli originated in Thal desert and is now found in areas of Muzaffargarh, Mianwali, Layyah, Bhakar and parts of Jhang, Multan and Sargodha districts. Thalli is medium size breed having white body color, brown/black head with black spots on legs (Khan *et al*., 2003).

Body conformation and size are very important traits of meat animals (Yakubu and Mohammed, 2012). Therefore, phenotypic information is necessary for the explaining relationship among linear type traits (Ali *et al*., 1995). Body measurements also provide information about growing abilities of animals and their morphological structures (Gurcan, 2000). Principal components analysis (PCA) technique, introduced by Pearson (1901) and Hotelling (1933), is a multivariate ordination practice used to demonstrate arrangements in multivariate data. Linear combination with maximum variance is the first principal component (Johnson and Wichern, 2007). Morphometric variables are combined by this analytical tool to produce components or catalogue that are uncorrelated and data can be viewed from different dimensions (Manly, 1994).

PCA has been used to evaluate different phenotypic characters in sheep breeds by many researchers (Salako, 2006 for Uda Sheep; Lopez-Carlos *et al*., 2010 for Hairy sheep; Osaiyuwu *et al*., 2010 for Balami sheep; Birteeb *et al*., 2012 for Sahel and Djallonke sheep in Northern

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Ghana; Yakubu, 2013 for Yankasa sheep and Mavule *et al*., 2013 for Zulu sheep but this information is not available for Thalli sheep in Pakistan.

The present study was conducted to develop the association among different morphometric traits, to explain the body conformation of Thalli sheep and to study the phenotypic measures of biometric traits for selection and breeding purposes of elite animals.

MATERIALS AND METHODS

Experimental site

The research was conducted at two livestock farms; Small Ruminant Research and Development Centre, Rakh Khairewala, District Layyah and Livestock Experiment Station, Rakh Ghulaman, District Bhakkar, Punjab, Pakistan. During summer season, temperature may reach up to 45-50°C at day time and may fall to 0°C during winter. Animals are sent to grazing from 07:00 am to 05:00 pm during summer season and from 09:00 am to 04:30 pm during winter season and lambs are kept indoor. Concentrate ration was provided to animals during breeding season and scarcity period.

Data collection

The present study was conducted on 792 animals of Thalli sheep. Male and female animals were grouped separately. The data on body measurements were recorded on the basis of some phenotypic traits in Thalli sheep. Weighing balance (digital) was used for determination of body weight and a flexible measuring tape (tailor tape) was used to record the different body measurements (Iqbal *et al*., 2014). Twenty one (21) morphometric traits were measured on each animal. Body measurements recorded were withers height (WH), body length (BL), head length (HL), head width (HW), ear length (EL), ear width (EW), neck length (NL), neck width (NW), heart girth (HG), rump length (RL), rump width (RW), tail length (TL), barrel depth (BD), sacral pelvic width (SPW), birth weight (BiW), live body weight (BW), teat length (TEL), teat diameter (TED), testes length (TsL), testes width (TsW) and scrotal circumference (SC).

Statistical analysis

Normality of data was checked against all animals and data on morphometric traits were analyzed statistically for mean, range, coefficient of variation and standard deviation. Pearson's coefficient of correlation among different biometric traits was estimated and data were generated for principal component analysis (PCA) from the correlation matrix. SPSS software 20.0 was used for statistical analysis of morphometric traits.

RESULTS AND DISCUSSION

Descriptive statistics (mean, range, standard deviation and coefficient of variation) of body measurements of female and male animals of Thalli sheep are given in Table I. Coefficient of variations (CVs) of female animals of Thalli sheep for most variables ranged between 10-20% and coefficients of variations of birth weight and body weight were 22.38% and 25.75%, respectively. Coefficient of variations of linear body measurements of male animals ranged in between 08-25% and tail length had high coefficient of variations as 26.89%.

Afolayan *et al*. (2006) reported CVs of body length, heart girth and withers height as 7.2%, 8.3% and 8.6%, respectively. These results are similar to those of Birteeb *et al*. (2012), Mavule *et al*. (2013) and Vincent *et al*. (2014). The results are in line with milk-tooth age group of Uda sheep as reported by Yakubu *et al*. (2011). Animals born as twins had lower birth weight than single and male animals had more birth weight than females but single female had more birth weight than twin males.

Correlation coefficients of morphometric traits of female and male animals are shown in Tables II and III. In female animals, there were highly positive and significant (P≤0.01) correlations among WH, BL, HL, HW, EL, NL, NW, HG, RL, RW, BD, SPW and BW. Correlation coefficients were low but positive between EW and RW, between TL and BiW. Morphometric traits of overall male animals of Thalli sheep had highly positive and significant (P≤0.01) correlation coefficients among WH, BL, HL, HW, EL, NL, NW, HG, RL, RW, BD, SPW and BW. There were low correlations between TL and other body measurements, between BiW and other body measurements.

These results are similar to those of Mavule *et al*. (2013), Yunusa *et al*. (2013), Afolayan *et al*. (2006) and Vincent *et al*. (2014) which showed that there were positive and significant correlations among withers height, body length, heart girth and live body weight. Okpeku *et al*. (2011) also reported the similar results in Red Sokoto and West African Dwarf goats that there were positive and significant correlation among live body weight, height at withers, neck length, heart girth and body length.

PCA of morphometric traits of female animals showed that there were two principal components with eigenvalues 9.005 and 1.558 and 56.279% and 9.74% variances for PC1 and PC2, respectively, and their cumulative variance was 66.02%. Body length, withers height and heart girth had maximum values in PC1 as it showed maximum variance. Component matrix is given in Table IV. Communalities of all variables were high for all variables except tail length and birth weight (0.148 and 0.185) as shown in Table IV.

Table I. Body measurements of female and male animals of Thalli sheep.

Body measurements	Females				Males			
	N	Range	Mean±SD	C.V (%)	N	Range	Mean±SD	C.V (%)
Withers height (cm)	642	40.60-87.40	68.56±7.28	10.62	150	43.20-94.00	66.34±9.62	14.50
Body length (cm)	642	38.10-88.90	68.75±8.21	11.93	150	38.10-91.44	64.77±10.5	16.27
Heart girth (cm)	642	43.69-96.77	74.50±9.56	12.83	150	43.69-99.06	70.49±11.3	16.06
Head length (cm)	642	15.24-34.80	26.93±3.75	13.96	150	15.24-38.35	24.74±4.45	18.00
Head width (cm)	641	05.33-13.71	10.15±1.40	13.83	150	05.33-13.72	09.70±2.08	21.45
Ear length (cm)	642	19.05-35.81	27.70±2.87	10.35	150	19.05-33.02	27.12±2.62	09.66
Ear width (cm)	642	07.62-15.49	12.10±1.30	10.75	150	07.62-14.22	11.67±1.33	11.42
Neck length (cm)	642	15.24-37.34	26.57±3.87	14.59	150	15.24-35.81	24.23±4.40	18.14
Neck width (cm)	642	09.39-21.59	16.46±2.17	13.23	150	09.40-22.86	16.17±2.96	18.30
Rump length (cm)	642	06.10-23.11	14.34±2.67	18.63	150	07.62-22.10	13.11±2.49	18.98
Rump width (cm)	641	07.37-27.94	19.29±3.99	20.71	150	09.65-27.94	16.53±3.77	22.83
Tail length (cm)	609	02.54-20.57	11.85±3.16	26.67	148	02.54-20.57	10.73±2.88	26.89
Barrel depth (cm)	642	22.86-59.69	44.83±6.07	13.54	150	21.59-60.96	43.37±7.19	16.58
Sacral pelvic width (cm)	640	47.00-108.0	79.23±11.1	13.97	78	57.20-108.0	80.63±9.51	11.80
Birth weight (Kg)	583	01.50-05.50	03.01±0.68	22.38	143	02.00-05.00	03.19±0.60	19.08
Body weight (Kg)	641	09.00-50.00	30.00±7.73	25.75	150	09.00-95.00	25.37±13.5	53.34
Teat length (cm)	642	0.250-22.86	02.25±1.64	72.99				
Teat diameter (cm)	640	0.250-15.24	02.85±1.78	62.64				
Testes length (cm)					146	02.03-57.15	10.92±6.31	57.82
Testes width (cm)					146	0.640-13.97	05.66±2.77	48.93
Scrotal circumference (cm)					146	05.08-41.15	20.048.82	44.04

Mean, range, standard deviation and coefficient of variation of body measurements of female and male animals of Thalli sheep.

Table II. Correlation coefficients among morphometric traits of overall female animals of Thalli sheep.

	WH	BL	HL	HW	EL	EW	NL	NW	HG	RL	RW	TL	BD	SPW	BiW	BW
WH	1	.843**	.730**	.652**	.621**	.597**	.694**	.574**	.846**	.710**	.305**	.254**	.791**	.780**	.251**	.789**
BL		1	.743**	.585**	.580**	.506**	.665**	.611**	.788**	.685**	.390**	.205**	.757**	.739**	.219**	.793**
HL			1	.516**	.474**	.406**	.612**	.571**	.693**	.556**	.549**	.187**	.638**	.623**	.121**	.750**
HW				1	.421**	.491**	.559**	.405**	.657**	.565**	-.012	.254**	.666**	.658**	.237**	.599**
EL					1	.683**	.523**	.297**	.610**	.539**	.103**	.107**	.638**	.616**	.134**	.556**
EW						1	.502**	.298**	.549**	.442**	.004	.116**	.567**	.533**	.165**	.471**
NL							1	.414**	.711**	.584**	.084*	.141**	.701**	.675**	.253**	.685**
NW								1	.504**	.351**	.474**	.198**	.493**	.464**	.113**	.491**
HG									1	.748**	.250**	.230**	.874**	.881**	.310**	.812**
RL										1	.210**	.306**	.719**	.767**	.247**	.694**
RW											1	.212**	.221**	.222**	-.056	.341**
TL												1	.243**	.280**	.014	.202**
BD													1	.888**	.280**	.769**
SPW														1	.307**	.774**
BiW															1	.300**
BW																1

**Correlation is significant P≤ 0.01 (2-tailed). * Correlation is significant P≤ 0.05 (2-tailed).

WH, withers height; BL, body length; HL, head length; HW, head width; EL, ear length; EW, ear width; NL, neck length; NW, neck width; HG, heart girth; RL, rump length; RW, rump width; TL, tail length; BD, barrel depth; SPW, sacral pelvic width; BiW, birth weight; BW, live body weight.

Table III. Correlation coefficients among morphometric traits of overall male animals of Thalli sheep.

	WH	BL	HL	HW	EL	EW	NL	NW	HG	RL	RW	TL	BD	SPW	BiW	BW
WH	1	.924**	.830**	.748**	.583**	.541**	.788**	.825**	.937**	.847**	.252**	.122	.911**	.817**	.095	.792**
BL		1	.807**	.725**	.589**	.557**	.762**	.775**	.916**	.842**	.265**	.158	.888**	.811**	.080	.753**
HL			1	.573**	.520**	.394**	.625**	.695**	.837**	.728**	.420**	.074	.806**	.757**	-.101	.786**
HW				1	.397**	.626**	.723**	.678**	.734**	.707**	-.164*	-.013	.691**	.567**	.203*	.561**
EL					1	.506**	.496**	.494**	.589**	.437**	.264**	.112	.578**	.512**	-.010	.432**
EW						1	.485**	.467**	.508**	.504**	-.191*	-.062	.485**	.328**	.200*	.300**
NL							1	.699**	.782**	.729**	.051	.066	.757**	.630**	.218**	.615**
NW								1	.817**	.765**	.197*	.064	.790**	.689**	.061	.682**
HG									1	.850**	.289**	.083	.937**	.890**	.056	.828**
RL										1	.219**	.074	.799**	.806**	.174*	.748**
RW											1	.294**	.278**	.547**	-.352**	.403**
TL												1	.140	-.044	-.066	.018
BD													1	.828**	.052	.760**
SPW														1	-.165	.745**
BiW															1	-.098
BW																1

**Correlation is significant P≤ 0.01 (2-tailed). * Correlation is significant P≤ 0.05 (2-tailed).
WH, withers height; BL, body length; HL, head length; HW, head width; EL, ear length; EW, ear width; NL, neck length; NW, neck width; HG, heart girth; RL, rump length; RW, rump width; TL, tail length; BD, barrel depth; SPW, sacral pelvic width; BiW, birth weight; BW, live body weight.

Table IV. Component matrix of female and male animals of Thalli sheep.

	Females				Males				
	Components		Communalities		Components			Communalities	
	1	2	Initial	Extraction	1	2	3	Initial	Extraction
Withers height	.925	.030	1.000	0.856	.962	.018	.023	1.000	0.927
Body length	.891	.168	1.000	0.823	.941	.050	.076	1.000	0.895
Heart girth	.934	-.068	1.000	0.877	.964	.075	-.041	1.000	0.936
Head length	.794	.361	1.000	0.761	.849	.292	-.122	1.000	0.821
Head width	.740	-.243	1.000	0.606	.800	-.376	-.016	1.000	0.781
Ear length	.705	-.255	1.000	0.562	.613	.098	.270	1.000	0.458
Ear width	.656	-.337	1.000	0.543	.647	-.387	.159	1.000	0.594
Neck length	.794	-.180	1.000	0.663	.829	-.204	.048	1.000	0.732
Neck width	.614	.449	1.000	0.579	.845	-.018	-.035	1.000	0.716
Rump length	.810	-.044	1.000	0.658	.890	-.039	-.042	1.000	0.796
Rump width	.294	.865	1.000	0.834	.109	.873	.027	1.000	0.774
Tail length	.300	.242	1.000	0.148	.009	.313	.879	1.000	0.870
Barrel depth	.915	-.114	1.000	0.850	.933	.107	.043	1.000	0.884
Sacral pelvic width	.907	-.096	1.000	0.832					
Birth Weight	.307	-.301	1.000	0.185	.088	-.681	.235	1.000	0.526
Body Weight	.885	.044	1.000	0.785	.804	.234	-.311	1.000	0.798
Variance (%)	56.279	9.740			57.516	12.184	7.022		
Eigenvalue	9.005	1.558			8.627	1.828	1.053		

Lower values of commonalities for birth weight and tail length indicated that these variables are not much important and these could be removed.

For male animals, three principal components have eigenvalues greater than 1 and PC1 showed high variance before and after rotation (57.516% and 57.382%). PC2 and PC3 had variances as 12.184% and 7.022% respectively and their cumulative variance was 76.721% and PC1 had high values for withers height, body length and heart girth and maximum variance. Component matrix was available in Table IV. Communalities of all variables were high from 0.526 (sacral pelvic width) to 0.936 (heart girth) and values of all variables were above 0.50 but ear length had lower value as 0.458 as showed in Table IV.

The results of present study are similar to those of Khan *et al*. (2014) who reported that there were high communalities for all variables for both male and female animals and PC1 had high values of withers height, body length and chest girth and cumulative variance of three components for male animals were 76.2% and 50.6% cumulative variance of two components for female animals of Harnai sheep. Okpeku *et al*. (2011) extracted two components for male and female animals and the results were almost similar as of current findings because there were found high values of communalities, high eigenvalues and high values of withers height, body length, neck length and heart girth for PC1.

Current findings support the results of Yunusa *et al*. (2013) as they extracted two principal components and their cumulative variance was 66.911% and 57.426% for Balami and Uda sheep, respectively with high eigenvalues and PC1 had high values for body length, heart girth, withers height, rump width and ear length. Tail length and rump length had different values as in the present study which may be due to environmental differences of the study area. Yakubu *et al*. (2011) documented the same results as they reported that there were two principal components with high values for withers height, body length, heart girth, rump length and rump width for PC1 with high communalities and eigenvalues and variance was 80.783%. While percentage of variance of principal components are not in accordance with the findings of Kurnianto (2013), Vincent *et al*. (2014) and Mavule *et al*. (2013) which may be due to age differences.

CONCLUSION

From findings of present study, it was concluded that body measurements (Withers height, body length and heart girth) had high correlations with each other and with body weight in almost all age groups. Principal component analysis of morphometric traits showed that most of variation explained by PC1. Commonalities were higher which showed that all the variables were important but PC1 had high values for withers height, body length and heart girth and maximum variance. This indicated that morphometric traits are very important for selection of genetically elite animals. Morphometric traits can be used to estimate the body weight in the field conditions, where weighing balance is not usually available.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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