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Study of Body Conformation of Carpet Wool Type Chitarangi Sheep of India using Principal Component Analysis

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ABSTRACT

Background: The principal component analysis is applied to identify minimum number of combined variables that account for maximum portion of the variance existing in all variables studied. Chitarangi is a lesser known carpet type wool sheep distributed in Fazilka and Muktsar districts of Punjab, Sri Ganganagar district of Rajasthan and the adjoining areas. The information on body biometry is a prerequisite to characterize the lesser known sheep population available in the country. Hence, it is important to describe the body conformation by recording minimum number of biometric traits.

Methods: Body biometry traits of Chitarangi sheep, a lesser known carpet quality wool producing sheep population were studied using Principal Component Analysis. The traits studied were body length (BL), height at wither (HW), chest girth (CG), paunch girth (PG), ear length (EL), face length (FL), face width (FW), tail length (TL) and adult body weight (BW). The data were collected on 297 ewes in the breeding tract of Chitarangi sheep. The descriptive statistics were determined for all the traits. The phenotypic correlations between different body biometric traits were estimated using partial correlations. Principal components were estimated using correlation matrix. Principal component analysis (PCA), a multivariate approach, is used when the recorded traits are highly correlated. Rotation of principal components was through the transformation of the components to approximate a simple structure. Factor analysis using oblique (promax) rotation was used. All the analysis was carried out using the SPSS statistical package.

Result: The averages for body weight and biometry traits confirmed large size of Chitarangi animals. Most of the phenotypic correlations amongst the studied traits were positive and significant ($p<0.01$). The three components extracted from nine principal components accounted for 69.06% of the total variance. The first component, which described body size of ewes, accounted for 43.68% of the total variation with high loading for BW, CG, PG, HW, BL and FL. The components two and three explained 13.54 and 11.83% of total variance, respectively. The communalities ranged from 0.490 (FL) to 0.888 (PG). The lower communalities for face length indicated lower contribution of the trait to explain the total variation than others. The study indicates that principal components provided a means of reduction in number of biometric traits to explain body confirmation of adult female Chitarangi sheep.

Key words: Biometric traits, Chitarangi sheep, Multivariate analysis, PCA.

INTRODUCTION

The body weight and physical biometric traits of livestock are utilized to describe different breeds as this give Information on overall body confirmation of a particular breed. The morphological classification using principal component analysis support selection for multiple economic characters and in identification and conservation of diversity (Brown *et al*., 1973, Yunusa *et al.,* 2013). As per FAO (2012) the characterization based on phenotype is applied to identify diversity within and between distinct breeds. The Principal component analysis is applied to identify minimum number of combined variables that account for maximum portion of the variance existing in all variables studied. Chitarangi is a lesser known carpet type wool sheep distributed in Fazilka and Muktsar districts of Punjab, Sri Ganganagar districts of Rajasthan and the adjoining areas. Chitarangi animals are medium to large in size. The coat colour is white. A red brown ring around eyes, patches on muzzle, red brown colour of distal half of the ear pinna and serration of various shape and depth in distal part of the ear pinna (Fig 1) are distinct and distinguishing characteristic of this sheep (Mishra *et al*., 2020). Significant differences in different biometric traits in various species and breeds were studied by other workers (Pundir *et al*., 2011, Vohra *et al*., 2015, Mishra *et al.,* 2017). The information on body biometry is prerequisite to characterize the lesser known sheep population available in country. Hence, it is important to describe the body conformation by recording minimum number of biometric traits. In present investigation various body biometric characters, relationship among them and to develop unobservable components to define which measurements best represent body confirmation in Chitarangi sheep were studies using principal component analysis.

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Fig 1: Chitarangi female.

MATERIALS AND METHODS

The study was conducted in Fazilka and Muktsar of Punjab and Sri Ganganagar and Bikaner districts of Rajasthan, India. A total of 56 sheep flocks were surveyed during the study from August 2015 to September 2017. The body measurement included were body length (BL), height at wither (HW), chest girth (CG), paunch girth (PG), ear length (EL), face length (FL), face width (FW), tail length (TL) and adult body weight (BW). To overcome the effect of age, only adult sheep (2 teeth stage and above) were included in the study. The data were collected on 297 ewes in the breeding tract of Chitarangi sheep (Mishra *et al.,* 2020). The biometric traits were recorded using measuring tape and body weight was taken using spring weighing balance of 500 gm accuracy.

To overcome the effect of districts, the data were analysed using following statistical model (Harvey 1987).

$$Y_{ij} = \mu + D_i + e_{ij}$$

Where,

Y_{ij} is j^{th} observation on i^{th} trait, μ is overall mean, D_i is the fixed effect of district and e_{ij} is the random residual error associated with each observation which is normally and independently distributed with mean zero and unit variance. The 3 observations of Bikaner district were added in group of Sri Ganaganagr as they were from adjoining villages. The descriptive statistics were determined for all the traits. Data were adjusted for district effects and the phenotypic correlations between different body biometric traits were estimated using partial correlations. Principal components were estimated using correlation matrix. Principal Component Analysis (PCA), a multivariate approach, is used when the recorded traits are highly correlated. Rotation of principal components was through the transformation of the components to approximate a simple structure. Factor analysis using oblique (promax) rotation was used. Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and Bartlett's test of sphericity were computed to establish the validity of data set, at 1% level of significance. The analysis was carried out using the SPSS 20.0 statistical package.

RESULTS AND DISCUSSION

Biometric traits

The averages of different biometric traits along with standard error (SE), standard deviation (SD) and coefficient of variation (CV) are presented in Table 1. The effect of districts were significant for body weight, body length, paunch girth and face width. The adult body weight and body measurements of Chitarangi are comparable with Kajali sheep, a newly registered breed of Punjab (Mishra *et al.* 2016) except tail length. Tail length of Kajali (54.6±0.3) is longer than Chitarangi sheep. The body weight and biometric traits of Chitarangi ewes are higher than that reported by Kushwaha *et al.* (1999) for Chokla, a carpet type wool sheep breed of Rajasthan. The coefficient of variation (CV) for body biometric characters ranges between 4.57 (height at wither) to 18.51 (body weight). Amongst all the biometric traits studied ear length, tail length and body weight are comparatively more variable and others showed less variability. The CV's of present study are in accordance with Mishra *et al.* (2016) and were relatively lower than Mavule *et al.* (2013) for Zulu sheep (8-31.18%). The standard deviations of present investigation were falls within normal range, indicating that biometric traits were less affected by environment. This may be due to natural selection for better adaptability for individual body shape, size and confirmation (Tolenkhomba *et al.,* 2013).

Phenotypic correlations

Phenotypic correlations among different traits are given in Table 2. The phenotypic correlation coefficient ranged between- 0.09 (tail length and face length) to 0.82 (chest girth and paunch girth). Majority of the estimates of correlation coefficients were positive and significant, except those of TL with FW and BL. The BW, HW, CG and PG positively and significantly ($p<0.01$) correlated with all the body biometric traits. The correlation of BW with CG was high (0.81) but with TL it had lower (0.04) in magnitude. The highly significant and positive correlation of BW with CG support the theory, that chest/heart girth may be used as single predictor of body weight (Kunene *et al.* 2009, Yakubu and Ayoade, 2009). The findings are in full agreement with Mavule *et al.* (2013) and Mishra *et al.* (2017). The high, positive and significant ($p<0.01$) correlations among biometric measurements indicates high predictability between traits. The lower correlation of TL with CG and EL indicating that these traits are determined by non-additive

Table 1: Descriptive statistics of adult chitarangi sheep (N=298).

Traits	Mean	SD	CV (%)
Body length	71.54±0.24	4.10	5.73
Height at withers	72.47±0.19	3.31	4.57
Chest girth	85.51±0.32	5.51	6.44
Paunch girth	87.80±040	6.94	7.90
Face length	19.88±0.06	1.03	5.18
Face width	9.29±0.04	0.74	7.96
Ear length	17.88±0.10	1.79	10.01
Tail length	21.85±0.18	3.03	13.86
Body weight	46.13±0.50	8.54	18.51

Body weight is expressed in kg and all other traits in cm.

genetic effects and are presumably less influenced by environment (Mavule *et al.* 2013).

Principal component analysis

The factor analysis was applied on body weight and biometric traits in Chitarangi sheep. The measure of sampling adequacy (MSA); Kaiser Meyer- Olkin (KMO) test is observed as 0.787. Kaiser (1974) suggested 0.5 as acceptable value for MSA. Mishra *et al.* (2017) reported almost similar MSA as 0.736 in Kajali sheep; however Yunusa *et al.* (2013) reported it as 0.932 for Uda sheep. The estimate of sampling adequacy KMO revealed the proportion of the variance in different biometric traits caused by the underlying components (Kaiser 1958). The significance of correlation matrix tested with Bertlett's test of sphericity for the biometric traits (chi-square value = 1236.44) was significant ($p<0.01$) and indicates the validity of component analysis of data.

The estimated factors loading extracted by Principal Component Analysis, Eigen values and variation explained by each component are presented in Table 3 and the Scree plot showing component number with Eigen values are presented in Fig 2. Mavule *et al.* (2013) reported that PCA determines the variability of individual traits and how they contribute towards total morpho-structural variance of animal. In present study three factors (components) were extracted from nine traits using Kaiser Rule theory (Johnson and Wichern, 1982) to find out the number of significant factors. Table 3 reveals that three components with Eigenvalue greater than one and accounted for 69.06% of total variance. The residual unexplained variation may be assigned to segregation of casual alleles at contributory loci, environmental factors and errors during measurements (Brooks *et al.* (2010). In accordance with present study Mishra *et al.* (2017) also extracted three components which accounted for 68.66% of total variance however, Salako (2006) and Yunusa *et al.* (2013) extracted two components in Uda sheep and Balami sheep which accounted for 75% and 66.91% of total variation, respectively. Mavule *et al.* (2013) extracted four components accounted for 62.13% of total variance in Zulu sheep.

In present study the first principal component (PC1) accounted for 43.68% of the total variation and was represented by significantly positive and high loading for BW, CG, PG, HW, BL and FL. The PC1 emerge to be explaining maximum of body conformation and size. In a similar kind of study Yunusa *et al.* (2013) observed that PC1 explained 54.81% and 48.07% of total variance in Balami and Uda sheep, respectively. Mishra *et al.* (2017) also reported that PC1accounted for 36.04% of the total variance. The PC2 explained 13.54% of total variance with high loading for tail length and third component (PC3) explained 11.83% of total variance with high loading for ear length (Table 4). The component plot of the three components in rotated space is shown in Fig 3.

The PC1 gave different weights with positive sign to all the biometric traits (Table 4). The lower coefficients in PC1 for TL, FW and EL were an indication that these traits have very little contribution in total variation. Mavule *et al.* (2013) also reported similar findings for ear length.

The communalities ranges between 0.490 (FL) to 0.888 (PG) and unique factors ranges from 0.112 to 0.510 (Table 4); shows that almost all variances are shared between the variables allowing the application of PCA. The lower communalities for face length indicate that this trait is less effective to account for total variance than others. The communalities shows the common variance that is shared

Table 2: Phenotypic correlation among different body biometry traits in chitarangi sheep.

Traits	BL	HW	CG	PG	FL	FW	EL	TL	BW
BL	-	0.45**	0.44**	0.27	0.30**	0.33**	0.23**	-0.01	0.59**
H			0.51**	0.47**	0.34**	0.27**	0.45**	0.17*	*0.55**
CG				0.82**	0.32**	0.30**	0.24**	0.06	0.81**
PG					0.29**	0.17**	0.24**	0.19**	0.77**
FL						0.38**	0.25**	0.03	0.41**
FW							0.16**	-0.09	0.38**
EL								0.17**	0.32**
TL									0.04
BW									-

**Significant at $p<0.01$; BL: Body length; HW: Height at wither; CG: Chest girth; PG: Paunch girth; EL: Ear length; FL: Face length; FW: Face width; TL: Tail length; BW: Body weight.

Table 3: Total variance explained by different components in adult Chitarangi ewes.

Component	Extraction sums of squared loadings			Rotation sums of squared loadings
	Total	% of variance	Cumulative %	
1	3.93	43.68	43.68	3.44
2	1.22	13.54	57.22	2.89
3	1.78	11.83	69.06	1.78

Table 4: Rotated component matrix showing different component loadings, communalities and unique factor for biometric traits in adult Chitarangi ewes.

Trait	Principal component			Communalities	Unique factors
	1	2	3		
Body weight	0.905	-.027	-0.241	0.879	0.121
Chest girth	0.850	0.099	-0.393	0.887	0.113
Paunch girth	0.788	0.306	-0.416	0.888	0.112
Height at withers	0.735	0.139	0.252	0.623	0.377
Body length	0.652	-0.257	0.139	0.511	0.489
Face length	0.556	-0.302	0.301	0.490	0.510
Tail length	0.143	0.751	0.325	0.690	0.310
Face width	0.485	-0.575	0.204	0.607	0.393
Ear length	0.487	0.209	0.599	0.640	0.360

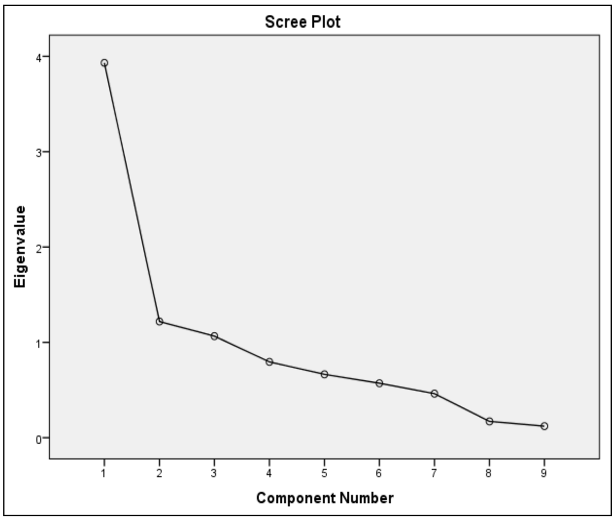

Fig 2: Scree plot showing component number with Eigen values.

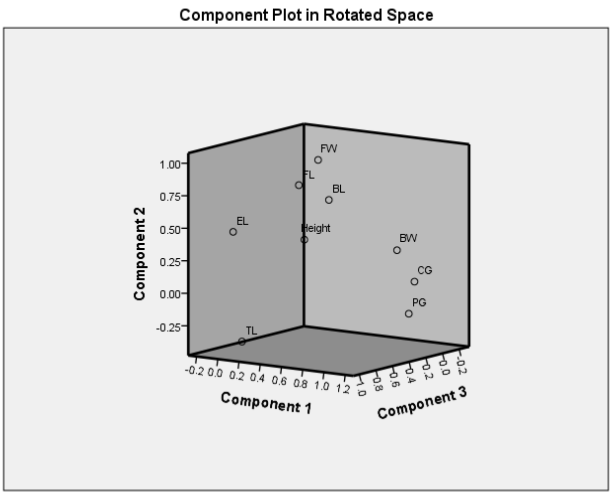

Fig 3: Component plot in rotated space. Bl: Body length; h, Height at wither; Cg: Chest girth; Pg: Paunch girth; El: Ear length; Fl: Face length; Fw: Face width; Tl: Tail length; Bw: Body weight.

Table 5: Pattern matrix for biometric traits in adult Chitarangi ewes.

Trait	Principal component		
	1	2	3
Paunch girth	1.004	-0.191	0.055
Chest girth	0.951	0.028	-0.080
Body weight	0.802	0.258	-0.060
Face width	-0.074	0.836	-0.230
Face length	-0.026	0.694	0.063
Body length	0.204	0.593	-0.005
Tail length	0.046	-0.376	0.838
Ear length	-0.174	0.417	0.663
Height at withers	0.288	0.360	0.397

between the variables (Yunusa *et al*., 2013). The inter-factor correlations between component 1 and 2, 1 and 3, 2 and 3 are 0.494, 0.321 and 0.262, respectively shows positive and high correlations amongst extracted components. The Pattern matrix (Table 5) indicates that the first principal component can be used in the evaluation and comparison of biometry in ewes using paunch girth, chest girth and body weight.

The extracted principal components in Chitarangi ewes determine the source of shared variance to explain body conformation. The communalities estimate indicates that body weight, chest girth and paunch girth contributed efficiently. The results of present study suggest that principal components especially PC1 provided a means of reduction in number of biometric traits to be recorded in Chitarangi sheep which could be used for describing body conformation and may be applied for phenotypic selection of females.

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