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Application of Orthogonal and Non-Orthogonal Rotations of Principal Component Analysis in Indigenous Goats of Bihar, India

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ABSTRACT: The present study was undertaken to segregate important the morphometric traits with principal component analysis with orthogonal and non-orthogonal rotations to aid goat selection programs. Data on 11 body morphometric measurements were collected from 400 adult goats from three Gaya, Patna and Madhepura districts of Bihar. Goats were randomly selected in a range from first to fifth parity on the basis of availability at farmers. The mean of morphometric traits of Goats such as Body Weight (BW), Face Length (FL), Face Width (FW), Face Height (FH), Ear Length (EL), Body Length (BL), Withers Height (WH), Chest Width (CW), Chest Depth (CD), Chest Girth (CG) and Cannon Bone Circumference (CC) were estimated 24.7± 0.56 Kg, 17.4 ± 0.58 cm, 12.56±0.25 cm, 18.53±0.36 cm, 13.32±0.34 cm, 53.29±0.65 cm, 53.89±0.78 cm, 30.59±0.65 cm, 26.59±0.56 cm, 66.21±1.77 cm and 8.4±0.23 cm, respectively.

Correlation coefficient estimated ranged between 0.01 (CG and CC) to 0.76 (BL and FL) among various body measurements. The positive and significant ($p<0.05/0.01$) correlations among body measurements suggest high predictability among the different traits. This was further checked for validity of factors with Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and Bartlett's test of Sphericity. After Varimax and Promax rotations, two principal components were generated with cumulative variance of 64%. The first component which explained 53% of the variance included body measurements traits such as FL, WH, BL, FH, FW, CD, CW, BW and CC. The first component in general explained the conformation and body size of indigenous goat. The second (PC2) component of body measurements explained 11% of total variation of goat body measurements data and is represented by significant high loading of EL trait. The first principal components represent traits FL, WH, BL, FH, FW, CD, CW, BW and CC may utilised for selection of animals.

Keywords: Phenotypic correlations, Germplasm, Varimax and Promax.

INTRODUCTION

The goats in Bihar belonging to indigenous types and sometimes considered as variants of Black Bengal goats. The goats of Bihar are known for its adaptation to harsh environmental conditions, ability to convert low quality forages and resistance to various disease conditions. In Bihar, goat population is next highest in numbers to the cattle population in livestock species. Bihar possess 10.16 million goats out of 140.53 million goat of India and take 5th rank among states for goat population (BAHS, 2010). They have evolved over long period of time with natural selection. The germplasm of these stocks are now being diluted using various Black Bengal, Barbari, Beetal, Jamunapari, Sirohi and Jhakhrana breeds in the state for genetic upgradation. Maintenance of indigenous breeds or populations represents the best economic tool for preserving diversity and sociocultural traditions. The influence of improved breeds leads many of the local breeds to endangerment before they have been defined, studied or catalogued. Knowledge of extensive genetic variation within breeds is essential for the development of efficient breeding programs in goats. However, prior to this, morphological characterization of breeds and study of variation within and between breeds is imperative (Chacon *et al.*, 2011). Since morphological selection may be an effective system in preservation and breeding programs. The selection has a notable economic importance to livestock breeders for improving rate of weight gain. Hence, selective breeding is very essential to improve breed performances and genetic upgradation of local goat. Body dimensions/Biometric traits have been used to indicate breed, origin and relationships, body conformation, comparison of growth, prediction of body weights, selection and breeding. European Federation of Animal Science (EAAP) and FAO have used height at withers as a prime indicator for their type. Recently, alternative body measurements estimated from different combinations of different body traits produced a superior guide to measure the body weight and were also used as an indicator of type and function in domestic animals. Analysis of variance fitting least squares model and correlations are widely used for phenotypic or morphometric characterization and to obtain relationships among different body measurements of animals.

The factor analysis using principal component analysis represents a better multivariate statistical tool to be applied in correlated genetic characteristics (Yakubu *et al.,* 2011). Principal Component Analysis (PCA) is one of a refined technique which explain relationships between body measurements traits in a better way when the recorded traits are correlated. It provides information about the relative importance of each variable in characterizing the individuals. This analysis transforms an original group of variables into another group, principal components, which are linear combination of original variables. A small number of these new variables are usually sufficient to describe the individual without losing too much information. For genetic improvement, principal components simultaneously consider a group of attributes which may be used for selection purpose. Different body measurements, which represents the size of the goat is one of the important criteria in selection of elite animals. There is an urgent need to describe the body conformation by recording a minimum number of body measurements/biometric traits which reduce the cost, labour and time.Principal component analysis affects the management of conservation and selection of animals by multiple traits by breeders (Salako, 2006). The PCA of body measurement in goat had been reported by several workers (Okpekum *et al*. 2011; Eyduran *et al.* 2013; Khan *et al.,* 2014; Paul *et al.,* 2011; Yakubu *et al*. 2011). Different body measurements, which represents the size of the goat is one of the important criteria in selection of elite animals. The present investigation aims to segregate important the morphometric traits with principal component analysis to aid goat selection programs.

MATERIAL AND METHODS

Place of research. The data for morphometric characterizations on the aspects of body measurements were collected by direct observations and measurements. Data on body morphometric measurements were collected from 400 adult goats from three Gaya, Patna and Madhepura districts of Bihar in the period of 2012 to 2014. Goats were randomly selected in a range from first to fifth parity on the basis of availability at farmers. The morphometric traits of Goats (Face Length (FL)-Measured between the horn site / poll to the lower lip; Face Width (FW)-Measured as the widest point of the head; Face Height (FH)-Measured from the poll to the jaw; Ear Length (EL)-The distance from the base to the tip of the ear along the dorsal surface; Ear Width (EW)-Maximum distance at the middle of the ear; Body Length (BL)-Distance from the point of the shoulder to the pin bone; Withers Height (WH)-Vertical distance from ground to the point of withers measured vertically from the ridge between the shoulder bones to the fore hoof; Chest Width (CW)-Measured as a distance from left to right upper arm; Chest Depth (CD)-The distance from the backbone at the shoulder to the brisket between the front legs; Chest Girth (CG)-Perimeter of the chest just behind the front legs and withers; Cannon Bone Circumference (CC)-The smallest circumference of the cannon bone of foreleg) were recorded and taken into study. The data were standardized for any missing values and outliers. All the measurement of body dimensions of Goats was recorded once in upright animal standing on a level ground and by the same technical person to avoid between recorder effects. All these body dimensions taken from adult goat were measured by using Measuring Tape.

Statistical analysis. Means and standard error were calculated. Peason's correlations (r) among different morphometric traits were estimated. When the recorded data of the morphometric traits were highly correlated then data for the Principal Component Analysis (PCA) were generated using variance-covariance matrix.

Principal Components Analysis (PCA). Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and Bartlett's test of Sphericity were computed to establish the validity of the data set. KMO's measure determines whether the common factor model is appropriate. Principal Components Analysis (PCA) is a distinct methodology for exploring and simplifying complex multivariate normal data. It is performed to combine a large number of variables to smaller number of factors. The goal of PCA is to replace a large number of correlated variables with a smaller number of uncorrelated variables while capturing as much information in the original variables as possible. These derived variables, called principal components, are linear combinations of the observed variables. The PCA analysis was accomplished using the model in matrix form Y = XB; Where, Y is a matrix of observed variables; X is a matrix of scores on components; B is a matrix of eigenvectors (weights). PCA decomposes a correlation matrix with ones on the diagonals. The amount of variance is equal to the trace of the matrix, the sum of the diagonals or the number of observed variables in the analysis. PCA minimizes the sum of the squared perpendicular distance to the component axis (Truxillo, 2003). Orthogonal (Varimax) and non-orthogonal (Promax) rotations of Principal Components in Indigenous goats of Bihar was done through the transformation of the components to approximate a simple structure. The raw varimax and promax criterion of the orthogonal rotation method was employed for the rotation of the factor matrix. Cumulative proportion of variance criterion was finally employed to determine the number of components to extract.

RESULTS AND DISCUSSION

The descriptive statistics for all the body measurements of goat was presented in Table 1. The different body measurements of goat were observed lower than Sannen Goats (Pesmen and Yardimici 2008) and Goats of Pakistan (Khan *et al.* 2006). The variation among different populations of goat across habitats may be attributed to the differences in genetics, nutrition, management system and climate.

Table 1: Descriptive statistic of body measurements goats of Bihar.

Trait	Code	Mean
Body Weight (Kg)	BW	24.7± 0.56
Face Length (cm)	FL	17.4 ± 0.58
Face Width (cm)	FW	12.56±0.25
Face Height (cm)	FH	18.53±0.36
Ear Length (cm)	EL	13.32±0.34
Body Length (cm)	BL	53.29±0.65
Withers Height (cm)	WH	53.89±0.78
Chest Width (cm)	CW	30.59±0.65
Chest Depth (cm)	CD	26.59±0.56
Chest Girth (cm)	CG	66.21±1.77
Cannon Bone Circumference (cm)	CC	8.4±0.23

Phenotypic correlations. The phenotypic correlations (r) among body measurements were presented in Table 2. Correlation coefficient estimated ranged between 0.01 (CG and CC) to 0.76 (BL and FL) among various body measurements. A total of 66 correlations (in all combinations) were estimated. Among these 61 correlations were significant and positive (Table 2). These correlations among all 61 correlations were low to moderate in magnitude. Only one negative and non-significant low correlation was found between EL and CG (-0.05). The phenotypic correlations (r) among body measurements of goat were in concordance with the results of Pesmen and Yardimici (2008); Khan *et al.* (2006). The positive and significant (p<0.05/0.01) correlations among body measurements suggest high predictability among the different traits. Further, varying estimates of correlations in body measurements could be attributed to the fact that postnatal growth does not take place proportionality in all tissue categories or body regions within those tissue categories.

Table 2:Phenotypic correlations among body measurements of goats.

Trait	BW	FL	FW	FH	EL	BL	WH	CW	CD	CG	CC
BW	1										
FL	0.63^{**}	1									
FW	0.43^{**}	0.66^{**}	1								
FH	0.43^{**}	0.73^{**}	0.63^{**}	1							
EL	0.29^{**}	0.36^{*}	0.27	0.36^{**}	1						
BL	0.55^{**}	0.76^{**}	0.57^{**}	0.59^{**}	0.39^{**}	1					
WH	0.42^{**}	0.74^{**}	0.61^{**}	0.69^{**}	0.24	0.64^{**}	1				
CW	0.41^{**}	0.69^{**}	0.54^{**}	0.47^{**}	0.05	0.56^{**}	0.61^{**}	1			
CD	0.37^{**}	0.63^{**}	0.72^{**}	0.58^{**}	0.33^{**}	0.61^{**}	0.72^{**}	0.47^{**}	1		
CG	0.17	0.37^{**}	0.29^{*}	0.29^{*}	-0.05	0.26	0.36^{*}	0.33^{*}	0.33^{*}	1	
CC	0.43^{**}	0.56^{**}	0.52^{**}	0.52^{**}	0.25^{**}	0.41^{**}	0.45^{**}	0.43^{**}	0.42^{**}	0.01	1

**<0.01; *<0.05

Principal component analysis. The PCA was applied on 11 body measurements traits of goats of Bihar. The KMO measure of sampling adequacy (MSA) was obtained as 0.95. The estimate of sampling adequacy KMO revealed the proportion of the variance in different biometric traits caused by the underlying components (Kaiser, 1958). The overall significance of the correlation matrix was tested with Bertlett's test of sphericity for the biometric traits (chi-square was 299.5 p<0.01) was significant, it means correlation matrix is not an identity matrix and provided enough support for the validity of the factor analysis of data.

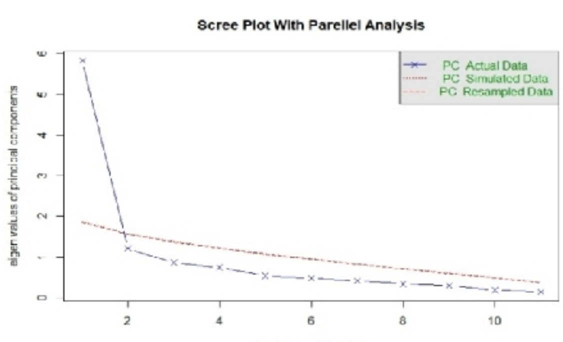

Fig. 1.

The scree plot of component number with eigenvalues for body measurements of goats is given in Fig. 1. Principal components (PCs) extracted from different body measurements with Eigen values greater than 1.00 and accounted for 64% of total variance (Table 3). PCA was performed using values of 11 body measurements traits of goat. The first (PC1) and second (PC2) components of body measurements explained the goat body measurements about 53% and 11% of total variance, respectively. Two principal components of different body measurements were obtained in goats of Bihar which is lesser to the three principal components obtained in various population or breeds of goats (Edyuran *et al.*, 2013; Yakubu *et al.*, 2011).

Table 3: Principal Components, Eigenvalues and Proportion of variances explained in morphometric traits of goat.

Principal Components	Eigenvalues	Proportion Variance	Cumulative Variance
PC1	5.83	0.53	0.53
PC2	1.2	0.11	0.64
PC3	0.85	0.08	0.72
PC4	0.74	0.07	0.78
PC5	0.54	0.05	0.83
PC6	0.47	0.04	0.88
PC7	0.41	0.04	0.91
PC8	0.33	0.03	0.94
PC9	0.3	0.03	0.97
PC10	0.18	0.02	0.99
PC11	0.15	0.01	1

After Varimax and Promax rotations, two principal components were generated with cumulative variance of 64%. Okpeku *et al*. (2011) extracted two components explaining 94.15 % and 97.65 % of the total variation in females and males, respectively in local goats of Nigeria. The first component which explained 53% of the variance included body measurements traits such as FL, WH, BL, FH, FW, CD, CW, BW and CC in Varimax rotation and high loading of FL, WH, BL, FW, FH, CD, CW, BW and CC traits in Promax rotation. Slightly higher estimate of first component explaining 60% and 80% of total variation was obtained in African goat and red Sokoto group, respectively (Yakubu *et al.,* 2011). The first component in general explained the conformation and body size of indigenous goat. The second (PC2) component of body measurements explained 11% of total variation of goat body measurements data and is represented by significant high loading of EL trait. The present study extracted two principal components which was different from observed PCs in West African goat (Yakubu *et al.,* 2011). The estimates of communality were high and ranged from 0.46 (BW) to 0.84 (FL) in Varimax and from0.46 (BW) to 0.84 (FL) Promax rotations. This indicated that traits variations of body measurement of goat were well explained by two extracted principal components (PCs). The estimated communality in the present study was different from observed in West African goat ranged from 0.56 to 0.97 (Yakubu *et al.,* 2011).

Table 4: Component Matrix or Standardized loading of different Varimax Rotated Component for morphometric traits of goat.

Traits	PC1	PC2	Communalities
BW	0.65	0.2	0.46
FL	0.92	-0.01	0.84
FW	0.81	-0.03	0.65
FH	0.81	0.07	0.66
EL	0.41	0.66	0.61
BL	0.82	0.08	0.67
WH	0.84	-0.16	0.73
CW	0.72	-0.3	0.61
CD	0.8	-0.06	0.64
CG	0.4	-0.71	0.66
CC	0.64	0.31	0.5

Table 5: Total Variance and Proportions of Variances explained by Varimax Rotated Components for morphometric traits of goat.

Variance Name	PC1	PC2
SS loadings	5.83	1.2
Proportion Variance	0.53	0.11
Cumulative Variance	0.53	0.64
Proportion Explained	0.83	0.17
Cumulative Proportion	0.83	1

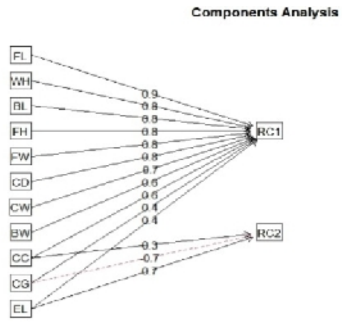

Fig. 2. Diagram of the Two Varimax Rotated Component Loading (Solution) for morphometric traits of goat**.**

Table 6: Component Matrix or Standardized loading of different Promax Rotated Component for morphometric traits of goat.

Traits	RC1	RC2	Communalities
BW	0.63	-0.19	0.46
FL	0.92	0.02	0.84
FW	0.81	0.04	0.65
FH	0.8	-0.06	0.66
EL	0.35	-0.66	0.61
BL	0.81	-0.07	0.67
WH	0.86	0.17	0.73
CW	0.75	0.31	0.61
CD	0.8	0.07	0.64
CG	0.47	0.72	0.66
CC	0.61	-0.3	0.5

Table 7: Total Variance and Proportions of Variances explained by Promax Rotated Components for morphometric traits of Goat.

Variance Name	PC1	PC2
SS loadings	5.83	1.2
Proportion Var	0.53	0.11
Cumulative Var	0.53	0.64
Proportion Explained	0.83	0.17
Cumulative Proportion	0.83	1

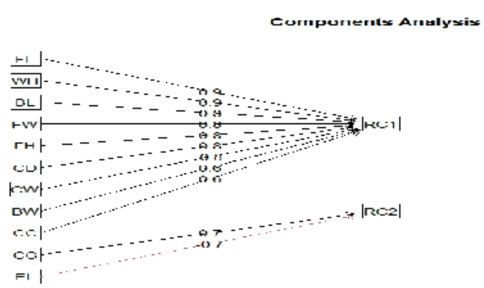

Fig. 3. Diagram of the Two Promax Rotated Component Loading (Solution) for morphometric traits of Goat.

CONCLUSIONS

The local goat of Bihar similar in size and shape of Assam Hill Goat based on different body measurements. The two principal components were generated after Varimax and Promax rotations of PCA analysis, are sufficient to explain 64% of total variance. These extracted PCs can be exploited in the evaluation and comparison of goat. The first principal component representing traits FL, WH, BL, FH, FW, CD, CW, BW and CC may utilised for selection of animals.

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