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Multivariate Analysis of Body Measurements of Indigenous Goats of Bihar, India

Birendra Kumar[1], Ramesh Kumar Singh[1] and Rajesh Kumar[2]
[1]Department of Animal Genetics and Breeding, Bihar Veterinary College, Patna (Bihar), India.
[2]Assistant Professor (A.H.), Department of Agronomy, Bihar Agriculture College, Sabour (Bihar), India.

(Corresponding author: Ramesh Kumar Singh)
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ABSTRACT : The present study was aimed to investigate the body measurement traits in indigenous Goat of Bihar. Data on 11 body morphometric measurements were collected from 400 adult goats from three Gaya, Patna and Madhepura districts of Bihar. The data was analysed with least square mean considering district as non-genetic factor and Multivariate Analysis using Principal Component Analysis method. Based on descriptive statistics, Indigenous Goats of Bihar is comparable to the size of Black Bengal and Assam Hill goats of eastern India. The multivariate analysis of body measurements yielded two principal components sufficient to explain the conformation of indigenous goats. The extracted two principal components represent the general body size and shape of the goat population. These extracted components may dictate in elimination of unimportant traits to be recorded to explain conformation and selection of animals. The body measurements traits BW, FL, FW, FH, BL, WH, CW CD and CC represented in PC_1 may be applied in selection programme of goat for improvement in production.

Keywords: Multivariate, Body Measurements, Indigenous, Goats, Bihar India.

INTRODUCTION

Goat is an important livestock in Bihar because of their adaptation to harsh climatic conditions, disease tolerance capacity and they can provide a full range of products for humans especially of meat production. Goat is popularly known as poor man's cow. Goat farming is an integral part of livelihood security of people and agriculture of Bihar. In Bihar, goat population is next highest in numbers to the cattle population in livestock species. Goat rearing has distinct economic and managerial advantages over other livestock because of its less initial investment, low input requirement, higher prolificacy, early sexual maturity and ease in marketing. Goats can efficiently survive on available shrubs and trees in unfavourable environments. The goats can be maintained easily and can be easily liquidated at the time of distress. In recent years, goat enterprise has also shown promise of its successful intensification and commercialisation. Development of goat sector has the potential to impact the livelihood of twenty million goat rearers. Demand for animal protein in India is increasing day by day at very faster rate (Delagado *et al.,* 1999). Human population growth, increasing urbanization and rising incomes are predicted to increase the demand for livestock and livestock products exponentially. The goats of Bihar are mostly indigenous type and seems to variants of Black Bengal goats. 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). To meet the demand, goat should be evaluated and bred to enhance their production. It would be most ideal to have desirable characteristics like larger body size of goat and faster growth rate.

Growth and development are an important for production of meat animals. Body measurements are important parameters to describe size and growth. Therefore, linear body measurements can be used as selection criteria for improvement of meat production in goat. Body conformation by recording of minimum body measurements which reduce the cost, labour and time is the need of the day. Body measurements describes more completely an individual or population than the conventional method of weighing and grading. In order to reduce the number of morphometric measurements to be recorded for evaluation of goat population, little progress in this regard has been achieved. 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. The PCA of body measurement in goat had been reported by several workers (Okpekum *et al*. 2011; Eyduran *el al.*, 2013; Khan *et al.*, 2014; Paul *et al.,* 2011 and 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 was taken to identify the morphometric redundant 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. The data collected were analysed using fixed effect model, by considering district effect as fixed so as to adjust the data for significant effect of district if any as per following statistical model (Harvey, 1987).

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

where, Y_{ij} is the phenotypic observation for one of the morphometric Biometric traits, μ is the overall mean; D_i is fixed effect of District, while e_{ij} is the random error associated with each record which is NID $(0, \sigma_e^2)$. 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.

RESULTS AND DISCUSSION

The effect of district in least square analysis had non-significant effects on body measurement traits of goats. The goat population was found uniform in shape and size across the districts. The descriptive statistics for all the body measurements of goat was presented in Table 1. The different body measurements of goat were estimated lower than Sannen Goats (Pesmen and Yardimici, 2008) and Goats of Pakistan (Khan *et al.,* 2006).

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

The differences in descriptive measurements among different populations of goat may be attributed to variation in genetic constitution and environmental factors experienced across habitats like feeds, fodder, management systems and climate.

Phenotypic correlations. The phenotypic correlations (r) among body measurements were presented in Table 2. The highest positive correlation between body measurements was recorded between BL and FL (0.76), while the lowest positive correlation CG and CC (0.01). 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 differences in correlation estimates between body measurements may be assigned to reason the body development does not take place proportionality in all organs of the body.

Table 2: Correlations among of body measurements goats of Bihar.

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. The scree plot of component number with eigenvalues for body measurements of goats is given in Figure 1. The two principal components were extracted from different body measurements with eigenvalues greater than 1.00 and accounted for 63% of total variance (Table 3).The Eigenvalues and variance proportions for the principal components (PC) of 11 body measurements traits are presented in Table 3. The first (PC1)and second (PC2) components of body measurements explained the goat body measurements about53% and 11% of total variance, respectively. The morphometric traits BW, FL, FW, FH, BL, WH, CW CD and CC had high loading in first PCs. These traits reflect cranial shape and size features and height, length and diameter features of goat.

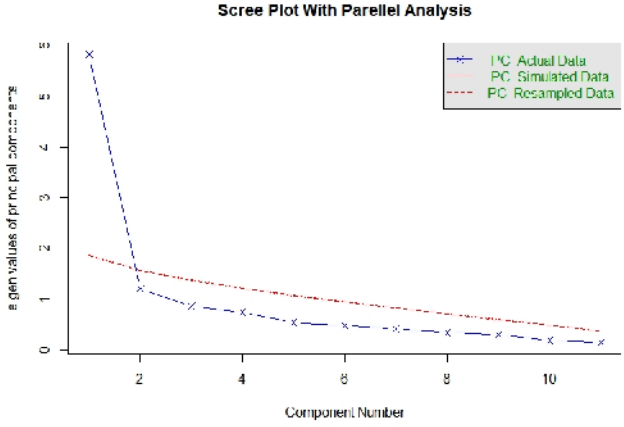

Fig. 1. Scree Plot of Body Measurement Traits of Goat.

Table 3: Total variance explained by different Principal Components for Body Measurement Traits in indigenous 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

In general, first component explained the conformation and body size of indigenous goat of Bihar. The second component explained 11% of total variation of data and was represented by the characteristic Ear Length (EL) having significant correlation with component.

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). The body measurements BW, FL, FW, FH, BL, WH, CW CD and CC having high loading in PC_1 group were determined as the important measurements for goat selection.

Table 4: Component Matrix or Standardized loading of Two Extracted Principal Component for Body Measurement Traits in indigenous Goat.

Traits	PC1	PC2
BW	0.65	0.2
FL	0.92	-0.01
FW	0.81	-0.03
FH	0.81	0.07
EL	0.41	0.66
BL	0.82	0.08
WH	0.84	-0.16
CW	0.72	-0.3
CD	0.79	-0.06
CG	0.40	-0.71
CC	0.64	0.31

The body measurement traits in indigenous Goat of Bihar is comparable to the size of Black Bengal and Assam Hill goats of eastern India. The multivariate analysis of body measurements may be used to explain the conformation of indigenous goats. The extracted two principal components represent the general body size and shape of the goat population. These extracted components may dictate in elimination of unimportant traits to be recorded to explain conformation and selection of animals. The body measurements traits BW, FL, FW, FH, BL, WH, CW CD and CC represented in PC_1 may be applied in selection programme of goat for improvement in production.

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