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Factor analysis of body measurements of local cows of Manipur, India

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Abstract

Eighteen different biometric traits in 250 local cows of Manipur from their breeding zone, i.e. Imphal valley of Manipur, India, were recorded and analyzed by principal component analysis to explain body conformation. The averages of height at withers (HW), body length, heart girth, paunch girth, forehead width, ear length, tail length, switch length, neck circumference, neck length, arm length, elbow length, fore-shank length, thigh length, hind-shank length, pes length, head length and eye to eye space were 103.92±0.33, 111.34±0.92, 135.34±0.47, 140.31±0.53, 14.90±0.15, 15.24±0.13, 75.50±0.55, 31.04±0.24, 58.61±0.53, 29.95±0.21, 29.34±0.19, 29.88±0.17, 29.59±0.20, 30.32±0.20, 29.88±0.13, 31.65±0.25, 37.30±0.25 and 26.47±0.20 cm, respectively. The correlation coefficients ranged from -0.20 (hind shank length and eye to eye width) to 0.74 (heart girth and paunch girth). Factor analysis with promax rotation revealed seven factors which explained about 64.31% of the total variation. Factor 1 described the general body conformation and explained 17.74% of total variation. It was represented by significant positive high loading of height at wither, heart girth, paunch girth and ear length. The remaining factors described 11.71%, 8.88%, 7.47%, 6.60%, 6.04% and 5.86% of total variability. It was necessary to include some more variables for a reliable analysis of factors as there were less than three variables except the first factor in the present study. The communality ranged from 0.493 (elbow length) to 0.782 (neck circumference) and unique factors ranged from 0.507 to 0.218 for all these 18 different biometric traits. The lower communalities for some of the traits like ear length, tail length, arm length, elbow length and thigh length might indicate that these traits were less effective to account for total variation of body conformation as compared to the other traits in local cows of Manipur. The result suggests that principal component analysis (PCA) could be used in breeding programs with a drastic reduction in the number of biometric traits to be recorded to explain body conformation.

Keywords: Local cows of Manipur, Morphometric traits, phenotypic correlation, factor analysis, Principal Component Analysis

INTRODUCTION

The characterization of a breed of livestock is the first approach to a sustainable use of its animal genetic resource. Body dimensions have been used to indicate breed, origin and relationship or shape and size of an individual as they give an idea of body conformation. Biometric traits are also used for comparison of growth and prediction of body weight in different individuals. Body dimensions also describe an individual or population in a better way than the conventional methods of weighing and grading. EAAP and FAO have used height at withers as a prime indicator for their type [1]. Recently, alternative body measurements and indices estimated from different combinations of different body traits produced a superior guide to weight and were also used as an indicator of type and function in domestic animals [2, 3]. Body shapes measured objectively could improve selection for growth by enabling the breeder to recognize early-maturing and late-maturing animals of different size [4]. Significant differences in different body measurement/biometric traits due to age and sex were reported by many workers in cattle [5, 6, 7], buffalo [8], sheep [2] and horses [9,10].

Analysis of variance and correlations are widely used for phenotypic characterization and to obtain relationships among different body measurements of animals [11]. However, principal component analysis (PCA) is a refinement and can explain relationships between biometric 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. The purpose of factor analysis is to discover simple pattern of relationship among the variables. For genetic improvement, principal components simultaneously consider a group of attributes which may be used for selection purpose.

Manipur, one of the North-eastern states of India have 0.41 million cattle, out of which, 0.34 millions are indigenous cattle and the rest are cross bred [12]. The indigenous cattle are known for their genetic potential for draught power, disease resistance, adaptability to harsh agro-climatic conditions and ability to survive and perform under scarce feed and fodder. It is still considered as non-descript cattle in the country. These indigenous cattle of Manipur are source of livelihood to many people by providing milk and draft power. Recently, the population of the cattle has decrease to an alarming level due to lack of scientific efforts for its genetic improvement, mechanization of agriculture and shrinkage in grazing areas.

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Different body measurements, which represents the size of the cow 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, labor and time. Therefore, the present study was undertaken to study the different body measurements, relationships among different body measurements and to develop unobservable factors (latent) to define which of these measures best represent body conformation in local cattle of Manipur. The study will help in stabilizing these cattle as a breed and to indulge in the conservation strategies.

MATERIALS AND METHODS

Data

Data consisted of 18 different body measurements on 250 local cows of Manipur (4 years of age and above) were collected during 2010 from 20 villages of their native tract *i.e*. Imphal valley of Manipur, India. The Imphal valley is at an elevation of 790 meter from the sea level. The state lies at latitude of 23°83' - 25°68'N and longitude of 93°03' - 94°78'E. All cattle recorded were in Imphal East and Imphal West districts. All measurements were recorded twice by the same recorder to minimize the error and to avoid between-recorder effects. The circumference measurements were taken by a measuring tape while the other measures were taken by a mapping stick. The recorded body measurements were height at withers (HW), body length (BL), heart girth (HG), paunch girth (PG), forehead width (FW), ear length (EL),tail length (TL), switch length (SL), neck circumference (NC), neck length (NL), arm length (AL), elbow length (EbL), fore-shank length (FsL), thigh length (ThL), hind-shank length (HsL), pes length (PL), head length (HL) and eye to eye space (EEW).

Statistical analysis

To study the effects of village on all recorded body measurements, data were analyzed using the following model

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

Where Y_{ij} is the observation of the 18 biometric traits of the cattle studied, μ is the overall mean, V_j is the fixed effect of village and e_{ij} is the random error associated with each observation ~ NID (0, σ^2). Data were adjusted for village effects and Pearson's coefficients of correlations between different body measurements were estimated.

Principal component analyses

The objective of principal component analysis is to account for the maximum portion of the variance present in the original set of variables with a minimum number of composite variables. Each principal component is a linear combination of original variables, whose coefficients are equal to the eigen vectors of the correlation matrix. The eigen values are obtained by the spectral decomposition of the data matrix and arrange in decreasing order of the corresponding eigen values, which equal the variance of the components. Thus, the first component has the largest variance. The estimate of communality for each variable measure the proportion of variance of that variable explained by all other factors jointly. The unique factors are specific to a particular variable and include the error variance. The principal component analysis considers both the total variance and unique variance and does not make any differentiation between these two. It assumes that the unique variance represents a small portion of the total variance.

Rotation of factors

Promax rotation was used for rotation of principal factors through the transformation of the factors to approximate a simple structure. The Kaiser rule criterion [13] was used to determine the number of factors *i.e.* retaining only the factors that have eigen value greater than one. Kaiser's measure of sampling adequacy (MSA) was used to determine whether the common factor model was appropriate. All the analysis was carried out using the SPSS [14] statistical package for social science.

RESULTS

Morphometric traits

The basic descriptive statistical parameters for all the body measurements are presented in Table 1. The adult cows from 4.0 years of age and above were considered to avoid age and sex effects in the present study. There was no significant effect of village on all the traits studied.

The morphometric characteristics observed in the present study suggested that indigenous cow of Manipur are small size cattle, with short and horizontally placed ears, long tail almost similar to local cows of Assam and Siri cattle of Sikkim, India.

The coefficient of variation for different biometric traits ranged from 3.20 (body length) to 9.80 (forehead width).

Phenotypic correlations

The coefficients of correlation between various biometric traits in the study are given in Table 2. The correlation coefficients ranged from -0.20 (hind shank length and eye to eye width) to 0.74 (heart girth and paunch girth). A total of 153 correlations (in all combinations) were estimated out of these 52 were significant and 49 were positive and 3 negative. Height at wither showed positive correlation with body length (0.31), heart girth (0.37), paunch girth (0.35), tail length (0.22), neck length (0.20), elbow length (0.25), fore shank length (0.31) and pes length (0.37), while the body length showed negative phenotypic correlation with switch length (-0.11) and thigh length (-0.01).

Principal component analysis

The Anti-image correlations computed showed that the partial correlations were low, indicating that true factors existed in the data. The estimate of sampling adequacy Kaiser-Meyer-Olkin (KMO) revealed the proportion of the variance in different biometric traits caused by the underlying factors. The overall significance of the correlations tested with Bertlett's test of Sphericity for the biometric traits (chi-square was 372.99, P<0.01) was significant and provided enough support for the validity of the factor analysis of data. The estimated factors loading extracted by factor analysis, eigen values and variation explained by each factor are presented in Table 4. There were seven factors extracted with eigen values greater than 1 and accounted for 64.31% of total variance. In the present study, the first factor accounted for 17.74% of the variation out of the total of 18 original measurements. It was represented by significant positive high loading of height at wither, heart girth, paunch girth and ear length. This factor seemed to be explaining the body of the cow, i.e. general size of the cow. The second factor accounted for 11.71% of total variability. It had comparatively higher loading for body length and pes length. The third factor accounted for 8.88% of total variation. It contained high loading for thigh length and neck circumference. The fourth and fifth factors accounted for 7.47% and 6.60% of total variation containing high loading for fore-shank length and switch length, respectively. The sixth and seven factors explained 6.04% and 5.86% of total variation with higher component loading values for elbow length and neck length, respectively. While a commonly used rule is that there would be at least three variables per factor [15], in this case there was a need to include some more variables for a reliable analysis of factors as there were less than three variables except the first factor in the present study.

The communality ranged from 0.493 (elbow length) to 0.782 (neck circumference) and unique factors ranged from 0.507 to 0.218 for all these 18 different biometric traits (Table 3). In the present study, common variance explains approximately 64.31% of the total variance present among all 18 measures. The lower communalities for some of the traits like ear length, tail length, arm length, elbow length and thigh length might indicate that these traits were less effective to account for total variation of body conformation as compared to the other traits in local cows of Manipur.

The inter-factor correlations between different factors are presented in table 5. The value of correlation ranged from -0.003 to 0.263. The first factor showed positive correlation with all other factors while the second factor was negative with fourth and fifth factors.

The coefficients of the principal analysis of the seven extracted factors are presented in Table 6. The first factor gave different weights and positive sign to all the traits. This factor represents the general shape and size of the cow. The second factor assigned negative weights to heart girth, paunch girth, forehead width, ear length, switch length, neck length, arm length and eye to eye space and positive sign to all other traits. The third factor assigned positive weights to body length, switch length, neck circumference, arm length, thigh length, head length and eye to eye width and negative sign to all other measurements. The fourth factor assigned negative weights to body length, heart girth, paunch girth, forehead width, tail length, switch length, neck circumference and hind shank length and positive sign to all other traits. These factors explained 17.74%, 11.71%, 8.88%, 7.47%, 6.60%, 6.04% and 5.86% of the total sample variance, respectively.

Table 1. Means with standard error of different traits in local cows of Manipur

Traits	Measurement	Mean ±SE (cm)	Coefficient of variation (%)
Body length	Distance from point of the shoulder to the point of the pin bone	103.92±0.33	3.20
Height at wither	Distance from the highest point of wither to the ground	111.34± 0.92	8.20
Heart girth	Circumference of the heart	135.34± 0.47	3.50
Paunch girth	circumference at the pouch region just anterior to the hip join	140.31± 0.53	3.70
Forehead width		14.90± 0.15	9.80
Ear length	Distance from the point of attachment of ear to the tip of the ear	15.24± 0.13	7.40
Tail length	length between the root of the tail up to the tip excluding switch at the tip	87.50± 0.55	6.20
Switch Length	length between the tip of the tail up to the end of the switch	31.04± 0.24	7.80
Neck Circumference	Circumference at the middle of the neck	58.61± 0.53	9.00
Neck length	Distance from neck attachment to breast	29.95± 0.21	7.10
Arm length	length between the point of shoulder up to the point of elbow	29.34± 0.19	6.60
Elbow length	length between the knee joint up to the point of elbow	29.88± 0.17	5.70
Foreshank length	length between the pastern joint up to the knee joint	29.59± 0.20	6.90
Thigh length	length between the hip joint up to the stifle joint	30.32± 0.20	6.70
Hind shank length	length between the pastern joint up to the hock joint	29.88± 0.13	4.50
Pes Length	length between the tarsal joint / hock joint upto the end of distal phalange	31.65± 0.25	8.00
Head length	length from the pole up to the tip of the nostril (Excluding the muzzle) along the nasal bone	37.30± 0.25	6.60
Eye to eye space	Distance between the inner canthuses	26.47±0.20	7.60

Table 2. Correlation among different morphometric traits in local cows of Manipur

	HW	BL	HG	PG	BF	LE	TL	SL	CN	NL	AL	EL	FSL	ThL	HSL	LP	HL	EEW
HW	-	0.31	0.37	0.35	0.17	0.16	0.22	-0.11	0.08	0.20	0.11	0.25	0.31	-0.01	0.12	0.37	0.14	0.04
BL		-	0.21	0.21	-0.06	-0.01	0.26	0.10	0.37	-0.12	0.06	0.18	0.11	0.18	0.11	0.24	0.06	-0.16
HG			-	0.74	0.21	0.41	0.21	0.04	0.20	0.24	0.23	0.04	-0.13	-0.03	0.06	0.06	0.22	0.27
PG				-	0.13	0.42	0.21	-0.08	0.25	0.21	0.21	0.03	-0.02	-0.11	-0.01	0.16	0.18	0.22
FW					-	0.27	0.09	0.02	-0.19	0.09	0.19	-0.09	-0.12	-0.04	-0.07	-0.12	-0.04	0.29
EL						-	0.14	0.01	0.17	0.28	0.22	0.05	0.09	-0.13	-0.13	0.09	0.17	0.26
TL							-	0.16	0.07	0.10	0.04	0.02	0.02	-0.04	0.13	0.06	0.11	0.01
SL								-	-0.02	-0.06	0.10	-0.13	0.03	0.13	0.06	0.02	0.02	0.13
NC									-	0.04	0.18	-0.07	0.11	0.24	0.06	0.07	0.06	0.23
NL										-	0.08	0.05	0.06	-0.01	0.07	0.10	0.05	0.25
AL											-	-0.07	-0.04	0.19	-0.13	0.14	0.08	0.32
EbL												-	0.17	-0.08	0.06	0.08	0.05	-0.10
FsL													-	0.03	-0.05	0.26	0.14	-0.04
ThL														-	-0.05	-0.04	0.12	-0.01
HsL															-	-0.02	0.07	-0.20
PL																-	0.31	-0.17
HL																	-	-0.09
EEW																		-

Table 3. Communalities of different morphometric traits in local cows of Manipur

Traits	Communalities	Unique factor
Body length	0.669	0.331
Height at wither	0.767	0.233
Heart girth	0.773	0.227
Paunch girth	0.767	0.233
Forehead width	0.653	0.347
Ear length	0.515	0.485
Tail length	0.512	0.488
Switch Length	0.643	0.357
Neck Circumference	0.782	0.218
Neck length	0.663	0.337
Arm length	0.52	0.48
Elbow length	0.493	0.507
Foreshank length	0.666	0.334
Thigh length	0.497	0.503
Hind shank length	0.643	0.357
Pes Length	0.634	0.366
Head length	0.677	0.323
Eye to eye space	0.702	0.298

Table 4. Total variance explained by different factors in local cows of Manipur

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings (a)
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.193	17.737	17.737	3.193	17.737	17.737	2.697
2	2.108	11.711	29.448	2.108	11.711	29.448	2.012
3	1.599	8.885	38.333	1.599	8.885	38.333	1.680
4	1.345	7.470	45.803	1.345	7.470	45.803	1.707
5	1.189	6.604	52.407	1.189	6.604	52.407	1.582
6	1.088	6.042	58.449	1.088	6.042	58.449	1.552
7	1.055	5.858	64.308	1.055	5.858	64.308	1.552
8	0.939	5.218	69.526				
9	0.841	4.670	74.196				
10	0.789	4.386	78.582				
11	0.752	4.178	82.760				
12	0.695	3.859	86.619				
13	0.635	3.526	90.145				
14	0.555	3.081	93.226				
15	0.400	2.220	95.447				
16	0.337	1.872	97.319				
17	0.271	1.503	98.822				
18	0.212	1.178	100.000				

Table 5. Component Correlation Matrix between different factors

Component	1	2	3	4	5	6	7
1	-	0.236	0.046	0.090	-0.053	0.094	0.240
2		-	0.126	-0.080	0.213	-0.054	0.129
3			-	0.006	0.162	-0.026	0.127
4				-	-0.052	0.263	0.186
5					-	0.020	-0.003
6						-	0.016
7							-

DISCUSSION

The estimates of height at wither, ear length, face length, chest girth and tail length are in close agreement with the report of Sarkar et al. [16] in high yielding desi cattle of West Bengal and Singh et al. [17] in Bachaur breed of cattle. In earlier study [18], almost similar means for heart girth and pouch girth but slightly lower mean values for body length and height at wither was reported. Phanchung and Roden [19] reported lower average body length, but higher wither height and heart girth in Siri cows (Table 1). Gaur et al. [20] reported lower average body length in Ponwar cows as compare to the present estimate. The lower estimates of height at wither as compared to local cows of Manipur was reported in Vechur breed of cattle [21]. The higher estimates for height at withers, body length, heart girth, paunch girth, ear length, neck length, tail length with switch and without switch were reported in Kankrej cows[22], in Hallikar cows [6] and in Red Sindhi cows [23].

The morphometric characteristics observed in the present study suggested that indigenous cow of Manipur are small size cattle, with short and horizontally placed ears, long tail almost similar to local cows of Assam and Siri cattle of India.

The coefficient of variation for different biometric traits showed that all body measurements showed less variability, indicating that the local cows of Imphal valley are almost similar in their body size. It might be due to natural selection favouring a particular shape and size from generation to generation for better adaptability. The tail length showed comparatively less variability than the switch length. The similar pattern of coefficient of variation for tail measurements was reported [22] in Kankrej cows.

Higher estimates of sampling adequacy were reported [22,7] in Kankrej cows and White Fulani cattle. The estimate of sampling adequacy Kaiser-Meyer-Olkin (KMO) revealed the proportion of the variance in different biometric traits caused by the underlying factors. Higher estimate of Bertlett's test of Sphericity (1,948.84, 1,977.59 and 5,182.01) as compared to the present study were observed by Yakubu et al. [7] and Pundir et al [22]. In comparison to seven factors extracted with eigen values greater than 1 and accounted for 64.31% of total variance, Yakubu et al. [7] extracted two factors in the age group of 1.5 to 2.4 years which accounted for 85.37% of total variation, and four factors in the age group of 2.5 to 3.6 years explained 86.47% of the total variation by studying the 14 morpho-structural traits of White Fulani cattle. Pundir et al. [22] extracted three factors from 18 different biometric traits in Kankrej cows which accounted for 66.02 % of total variation. Sadek et al. [10] extracted three factors for Arabian mares and stallions separately by studying 14 different traits and these explained 66% and 67% of total variation. In the present study, the first factor accounted for 17.74% of the variation represented by significant positive high loading of height at wither, heart girth, paunch girth and ear length. Pundir et al. [22] reported in Kankrej cows that the first factor explained 38.89% of total variation. In the earlier study, Yakubu et al. [7] reported in White Flauni cattle that the first factor explained 78.99% and 67.05% of total variation in two age groups and it represented the general size of the cattle. The first factor explaining maximum/highest variation was in accordance with those of the Pundir et al. [22], Yakubu et al. [7], Salako [2], Sadek et al. [10] and Karacaroen et al. [24].

In accordance to the present study, aproximate range of communality i.e. 0.372 to 0.613, 0.42 to 0.87 and 0.32 to 0.83 were reported by Pundir et al [22] and Sadek et al. [10] in Kankrej cows and Arabian mares and stallions, respectively. Higher estimates of communality (ranged from 0.79 to 0.93) were observed by Yakubu et al. [7]. The lower communalities for some of the traits like ear length, tail length, arm length, elbow length and thigh length might indicate that these traits were less effective to account for total variation of body conformation as compared to the other traits in local cows of Manipur.

The coefficients of the principal analysis of the seven extracted factors gave different weights and positive sign to all the traits. This factor represents the general shape and size of the cow. The second factor assigned negative weights to heart girth, paunch girth, forehead width, ear length, switch length, neck length, arm length and eye to eye space and positive sign to all other traits. The third factor assigned positive weights to body length, switch length, neck circumference, arm length, thigh length, head length and eye to eye width and negative sign to all other measurements.

CONCLUSIONS

The seven extracted factors determine the source of shared variability to explain body conformation in local cows of Manipur. However, only the first factor showed more than three variables. The communalities estimates indicated that ear length, tail length, arm length, elbow length and thigh length did not contribute effectively to explain body conformation in local cows of Manipur, while the remaining traits contributed effectively and these traits could be considered to explain the body conformation of the these cows. The results suggests that principal component analysis (PCA) could be used in breeding programs with a drastic reduction in the number of biometric traits to be recorded to explain the body conformation.

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