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Factor analysis of body measurements of bulls of local cattle of Tripura, India

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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. 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 (Tolenkhomba *et al*. 2021a, b). 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 indigenous cattle of Tripura are still considered as non-descript cattle in the country. 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 bulls of local cattle of Tripura. Thus, the study will help in stabilizing these cattle as a breed and to indulge in the conservation strategies.

Data consisted of 18 different body measurements on 50 local bulls of Tripura (3 years of age and above; Fig. 1) were collected during 2019–20 from 3 districts of their native tract, i.e. South Tripura, North Tripura and West Tripura of Tripura, India. 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 body length, height at wither, heart girth, paunch girth, arm length, elbow length, fore-shank length, thigh length, hind shank length, pes length, tail length, switch length, ear length, head length, eye to eye space, circumference of horn, space between horns and horn length.

Data collected were analyzed using fixed effect model, by considering the districts effect as fixed so as to adjust the data for significant effect of village if any for further analysis.

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. Promax rotation was used for rotation of principal factors through the transformation of the factors to approximate a simple structure. The Kaiser rule criterion (Johnson and Wichern 1982) 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 (2001) statistical package for social science.

The basic descriptive statistical parameters for all the 18 body measurements in bulls are presented in Table 1. There was no significant effect of village on all the traits studied. The morphometric characteristics observed in the present study suggested that indigenous bull of Tripura are small size cattle, with short and horizontally placed ears, long tail almost similar to local bulls of Manipur (Pundir *et al.* 2015) and Siri cattle of Sikkim (Phanchung and Roden 1996).

The average body length, height at withers and chest girth of adult males of local cattle of Tripura were smaller to that in adult males of Bachaur cattle (Singh *et al.* 2010) and Manipur cattle (Tolenkhomba *et al.* 2013). They reported the respective average of these body measurements as 117.40±0.40, 118.39±0.51 and 148.58±0.71 cm and 120.36±0.84, 112.55±0.78 and 142.94±1.16 cm, respectively. Gaur *et al*. (2004) recorded almost similar heart girth (140.6±0.50 cm), but shorter body length (102.5±0.5 cm) in adult males of Ponwar cattle. Singh *et al*. (2002) also reported higher height at wither (134.36=2.03 cm) in male Deoni cattle.

The Anti-image correlations computed showed that the partial correlations were low, indicating that true factors existed in the data. This was supported by Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy which was 0.498. Tolenkhomba *et al.* (2013) and Tolenkhomba *et al.*

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Fig. 1. A bull of local cattle of Tripura.

(2021b) reported higher estimates of sampling adequacy as 0.609 in Manipur bulls and 0.741 in local cows of Mizoram, respectively. 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 348.81, P<0.01) was significant and provided enough support for the validity of the factor analysis of data. Higher estimate of Bertlett's test of Sphericity (5,182.01) as compared to the present study were observed by Pundir *et al.* (2011).

The estimated factors loading extracted by factor analysis, eigen values and variation explained by each factor are presented in Table 2. There were six factors extracted with eigen values greater than 1 and accounted for 76.64% of total variance. Similarly, Tolenkhomba *et al.* (2013) extracted six factors with eigen values greater than 1 in bulls of local cattle of Manipur. However, Tolenkhomba *et al.* (2021a) and Tolenkhomba *et al.* (2021b) extracted five factors in explaining 75.02% (cow) and 78.37% (bull) of the total variation by studying 20 morpho-structural traits of Mizoram local cattle (Zobawng). In the present study, the first factor accounted for 21.85% of the variation out of the total of 18 original measurements. It was represented by significant positive high loading of body length, height at wither, head length, circumference of horn, distance between horns and horn length (Table 3). This factor seemed to be explaining the body of the bull, i.e. general size of the bull

Similarly, Tolenkhomba *et al.* (2013) extracted the first factor accounting for 21.93% of the variation out of the total of 15 original measurements in Manipuri bulls. It was represented by height at wither, body length, heart girth, paunch girth and ear length. Pundir *et al*. (2011) reported in Kankrej cows that the first factor explained 38.89% of total variation.

The second factor accounted for 18.570% of total

Table 1. Mean with standard error of various biometric traits of local bulls of Tripura

Trait	Measurement	Mean±SE (cm)	Coefficient of variation (%)
Body length	Length between the point of shoulder up to the point of pin bone was measured for both sides and the average was recorded	106.08±9.47	19.91
Height at withers	Distance from the highest point of wither to the ground after allowing the animal to stand	108.22±7.93	8.05
Heart girth	It was measured as circumference of the heart	137.35±11.28	10.09
Paunch girth	Circumference at the pouch region just anterior to the hip joint	135.14±1.99	8.98
Arm length	Length between the point of shoulder up to the point of elbow	26.16±0.86	19.99
Elbow length	Length between the knee joint up to the point of elbow	38.97±1.05	16.38
Fore-shank length	Length between the pastern joint up to the knee joint	28.92±0.48	10.13
Thigh length	Length between the hip joint up to the stifle joint	42.59±1.10	15.65
Hind shank length	Length between the pastern joint up to the hock joint	38.03±0.68	10.94
Pes length	Length between the tarsal joint / hock joint up to the end of distal phalange	44.14±3.43	5.93
Tail length	Length between the root of the tail up to the tip excluding switch at the tip	51.95±1.60	18.75
Switch length	Length between the tip of the tail up to the end of the switch	18.59±0.73	23.93
Ear length	Distance from the point of attachment of ear to the tip of the ear	18.12±0.40	13.33
Head length	Length from the poll up to the tip of the nostril (Excluding the muzzle) along the nasal bone	41.68±2.79	11.59
Eye to eye space	Distance between the inner canthuses	13.00±0.37	17.20
Circumference of horn	Circumference of the horn were recorded at three places viz., at base, middle and tip for two horn separately and the average will be taken	12.81±1.54	26.19
Space between the horns	Space between two horns were measured at three places viz., space between two horns at base, middle and tip	13.51±1.39	17.50
Horn length	Measured from the base up to the tip of the horn along the middle course. Measurement for both the horns were taken for length and the average values was recorded.	16.17±1.81	29.99

Table 2. Total variance explained by different factors in bulls of local cattle of Tripura

Component	Initial Eigen values			Extraction sums of squared loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of variance	Cumulative %	Total
1	3.93	21.85	21.85	3.93	21.85	21.850	3.263
2	3.34	18.57	40.42	3.34	18.57	40.419	3.090
3	2.32	12.89	53.31	2.32	12.89	53.306	3.079
4	1.69	9.40	62.70	1.69	9.40	62.705	2.478
5	1.38	7.68	70.38	1.38	7.68	70.383	2.224
6	1.13	6.26	76.64	1.13	6.26	76.638	2.087
7	0.87	4.82	81.46				
8	0.68	3.75	85.21				
9	0.58	3.23	88.44				
10	0.52	2.87	91.31				
11	0.41	2.28	93.59				
12	0.33	1.85	95.44				
13	0.26	1.46	96.90				
14	0.20	1.11	98.01				
15	0.13	0.75	98.76				
16	0.12	0.68	99.44				
17	0.05	0.31	99.75				
18	0.04	0.25	100.00				

Table 3. Component matrix of different factors for biometric traits in bulls of local cattle of Tripura

Trait	Component					
	1	2	3	4	5	6
Body length	0.742	0.310	0.146	0.114	–0.379	0.055
Height at withers	0.619	0.515	0.230	–0.025	–0.191	–0.095
Heart girth	0.566	0.427	–0.467	0.350	0.153	–0.095
Paunch girth	0.428	0.549	–0.514	0.318	0.137	–0.016
Arm length	–0.488	0.666	0.229	0.033	0.222	–0.034
Elbow length	–0.546	0.341	0.300	0.279	0.290	–0.206
Fore–shank length	0.135	–0.513	0.359	0.683	0.113	–0.003
Thigh length	0.345	–0.519	0.417	0.516	–0.150	–0.093
Hind shank length	–0.329	0.140	0.670	0.263	0.112	0.178
Pes length	0.345	0.536	0.269	–0.302	–0.104	–0.288
Tail length	–0.169	0.326	–0.427	0.614	–0.345	0.089
Switch length	–0.094	0.397	0.381	0.081	–0.253	0.627
Ear length	–0.141	0.271	–0.272	0.095	0.703	0.368
Head length	0.632	–0.083	0.171	0.112	0.078	–0.284
Eye to eye space	0.415	–0.523	–0.405	–0.018	–0.030	0.332
Circumference of horn	0.602	–0.024	0.168	–0.172	–0.120	0.449
Space between the horns	0.652	0.127	0.375	–0.212	0.412	0.099
Horn length	0.795	–0.094	0.185	0.049	0.316	–0.005

variability in bulls. It had comparatively higher loading for paunch girth and arm length in bulls. Whereas, in bulls of local cattle of Manipur, the second factor accounted for 12.36% of total variability with comparatively higher loading for horn characteristics (Tolenkhomba *et al.* 2013). The third factor accounted for 12.89% of total variation with high loading for hind shank length. The fourth factor accounted for 9.40% of total variation with high loading of fore-shank length and tail length. The fifth factor accounted for 7.68% and of total variation containing high loading for ear length and six factors, 6.26% with high loading for switch length.

In bulls of local cattle of Manipur, third factor accounted for 10.49% of total variation, containing high loading for neck length and hind leg length. The fourth factor accounted for 9.07% of total variation with high loading of fore leg length and tail length. The fifth factor accounted for 8.24% and of total variation containing high loading for switch length and six factors, 7.67% with no particular variable having high loading (Tolenkhomba *et al.* 2013).

The communality ranged from 0.535 (head length) to 0.890 (fore-shank length) and unique factors ranged from

Table 4. Communalities of different morphometric traits in bulls of local cattle of Tripura

Morphometric trait	Initial	Extraction	Unique factor
Body length	1.000	0.828	0.172
Height at withers	1.000	0.748	0.252
Heart girth	1.000	0.875	0.125
Paunch girth	1.000	0.869	0.131
Arm length	1.000	0.786	0.214
Elbow length	1.000	0.710	0.290
Fore-shank length	1.000	0.890	0.110
Thigh length	1.000	0.859	0.141
Hind shank length	1.000	0.690	0.310
Pes length	1.000	0.664	0.336
Tail length	1.000	0.821	0.179
Switch length	1.000	0.775	0.225
Ear length	1.000	0.805	0.195
Head length	1.000	0.535	0.465
Eye to eye space	1.000	0.721	0.279
Circumference of horn	1.000	0.636	0.364
Space between the horns	1.000	0.807	0.193
Horn length	1.000	0.777	0.223

0.465 to 0.110 for all the 18 different biometric traits (Table 4). Tolenkhomba *et al.* (2013) reported communality ranged from 0.597 (body length) to 0.857 (hind girth) in local bulls of Manipur. Aproximate range of communality i.e. 0.42 to 0.87 was reported by Sadek *et al*. (2006) in Arabian mares. Higher estimates of communality (ranged from 0.79 to 0.93) were observed by Yakubu *et al*. (2009).

The inter-factor correlations between different factors ranged from -0.123 to 0.347 in bulls. The first factor showed positive correlation with factors 3, 5 and 6 and negative with 2 and 4. In bulls of local cattle of Manipur, narrower range of inter-factor correlations, i.e. -0.07 to 0.17 was reported by Tolenkhomba *et al.* (2013). The first factor showed positive correlation with all other factors except the sixth factor.

The six extracted factors determine the source of shared variability to explain body conformation in local bulls of Tripura. The first factor contributes effectively to explain general body conformation in local bulls of Tripura. 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.

SUMMARY

Eighteen different biometric traits (body length, height at wither, heart girth, paunch girth, arm length, elbow length, fore-shank length, thigh length, hind shank length, pes length, tail length, switch length, ear length, head length, eye to eye space, circumference of horn, space between horn and horn length) in 50 bulls of Tripura local cattle were recorded from 3 districts (viz. North Tripura, South Tripura and West Tripura) of Tripura, India and analyzed by Principal component analysis to explain body conformation. The average of these various traits indicates that local cattle Tripura is of smaller type of cattle breed. Factor analysis with promax rotation revealed six factors which explained about 76.64% of the total variation. Factor 1 described the general body conformation and explained 21.85% of total variation. It was represented by significant positive high loading of body length, height at wither, head length, circumference of horn, distance between horns and horn length. The communality ranged from 0.535 (head length) to 0.890 (fore-shank length) and unique factors ranged from 0.465 to 0.110 for all the 18 different biometric traits. 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.

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