MULTIVARIATE ANALYSIS OF CHOLISTANI CATTLE IN PUNJAB PAKISTAN

W. A. Shah, N. Ahmad*, K. Javed, M. Saadullah, M. E. Babar, T.N. Pasha[2], S. Ahmad[2], A. Ali, Nasrullah[3], M. Z. Farooq and A. H. Saleem

Department of Livestock Production, [2]Department of animal Nutrition, University of Veterinary and Animal Sciences, Lahore, Pakistan.
[3]Department of Livestock Management, Faculty of Veterinary Sciences, Lasbella University of Agriculture, Water and Marine, Uthal Balochistan, Pakistan
*Corresponding author email: nisarahmad@uvas.edu.pk;

ABSTRACT

Data on 18 Biometric traits of 325 lactating Cholistani cows of 4-6 years age were recorded and analyzed by principal component analysis (PCA) to explain the body conformation. These animals were kept at government livestock experimental station Jugaitpeer, Punjab province, Pakistan. The average of these traits indicated that Cholistani cows breed are of medium type. Factor analysis with promax rotation revealed 4 factors which explained about 83.618 % of the total variation. Factor 1 explained 56.817% variation in the general body conformation. It was represented by significant positive high loading of body length (BL) and heart girth (HG). The results suggested that PCA could be used in breeding programs with a drastic reduction in the number of biometric traits to be recorded for the explanation of body conformation.

Key words: Cholistani cattle, Principal component analysis, Traits, Body length, Breeding program.

INTRODUCTION

The indigenous cattle of Pakistan belong to zebu (humped type) cattle (*Bos indicus*). At present, the population of cattle in our country is 41.2 million nos. (Anonymous, 2015) which inhabit different ecological zones of country. They are mainly kept for milk and meat, but some may be used for draught purpose. There are 15 recognized breeds of cattle in the country, with most population (49%) found in Punjab (Saeed *et al.*, 2014). Some of the breed level population estimates may not qualify to be more than guesses because ground realities and farmers' opinion do not match with the breeding population trends. Cholistani cows are one of the recognized cattle breeds of this country and probably have the largest size among different breeds of Pakistani origin. This breed is available in Cholistan area of Punjab, Pakistan and is a source of livelihood to many people by providing milk and draft power. This breed has dairy potential along with water tolerance and better ability to thrive on feed scarcity than many other breeds (Khan *et al.*, 2008). They can produce ~2200 kg of milk in a lactation of 300 days. Presently, the size of the cow, represented by different body measurements, is one of the important criteria in selection of elite animals. Body dimensions are used to indicate breed, origin, 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. Therefore, the present study was conducted to study different body measurements along with relationships and to develop unobservable factors (latent) to define which of these measures represent the better body conformation in Cholistani cows.

MATERIALS AND METHODS

Data collection: Body measurement data were recorded on the basis of some phenotypic traits in 325 lactating Cholistani cows . The animals were kept at government livestock experimental station in Jugaitpeer, Punjab province, Pakistan. The measurements were taken according to FAO (2011) standards for phenotypic characterization.

Measuring traits: Eighteen (18) biometric traits i.e., Head width (HW), Face length(FL), Eye to eye space (EE), Neck length (NL), Neck circumference (NC), Heart girth (HG), Switch length (SL), Foreleg length (FLL), Withers height (WH), canon circumference (CC), Rump length (RL), Rumpwidth (RW), Rump height (RH),Hinleg length (HLL), Tail length (TL), Switch width (SW), Pes length (PL) and Body length (BL) were measured on each animal.

Height measurements were taken by a graduated measuring stick. Flexible tape was used for circumference measurement and width was measured using calibrated wooden caliper. Measurements were taken by the same person to avoid any variation in recording. All the measurements taken were in centimeters (cm).

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. 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, 1992) 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.

Rotation of factors: Rotation of principal factors was made through the transformation of the factors to have an estimate of approximate simple structure. Factor analysis using oblique (promax) rotation with power 3, was used with the following model:

$$Y_{ij} = \sum_{K=1}^{q} a_{ik} c_{kj} + e_{ij}$$

Where Y_{ij} is the value of the i^{th} observation on the jth measure (j = 1, 2, …., 18), q is the number of common factor, a_{ik} is the value of the i^{th} observation on the k^{th} common factor (factor loadings), c_{kj} is the regression coefficient of the common factor for predicting the j^{th} measure and e_{ij} is the value of the i^{th} observation on the j^{th} unique (specific) factor.

RESULTS

Means of morphometric traits: The descriptive statistics of body measurements including HW, FL, EE, (NL, NC, HG, SL, FLL, WH, CC, RL, RW, RH, HLL, TL, SW, PL and BL are given in table -1.

Phenotypic correlations: The correlation coefficients between biometric traits of this study are given in table -2. The correlation coefficient ranged from -0.620 (SW and SL) to 0.942 (BL and WL). A total of 153 correlations (in all combinations) were estimated, 92 were found positive and 39 negative. BL had higher correlations with HG (0.914), pes length (0.060) had the lowest phenotypic correlation. The correlation between NL and NC was (0.481). The SW had negative correlations with SL (-0.620), RH (-0. 553) and TL (-0.466).The positive and significant (P<0.05/0.01) correlations among different biometric traits suggest high predictability among the different traits.

Multifactor Analysis: Anti-image correlations computed showed that 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 0.692. The estimate of sampling adequacy Kaiser-Meyer-Olkin (KMO) revealed the proportion of the variance in different biometric traits caused by the underlying factor. The overall significance of the correlations tested with Bartlett's test of Sphericity for the biometric traits (Chi-square was 182.865, P<0.01) was significant and provided enough support for the validity of the factor analysis of data (Table - 4). Higher estimated factors loading extracted by factor analysis, Eigen values and variation explained by each factor are presented in Table -3. The estimated factors loading extracted by factor analysis, Eigen values and variation explained by each factor are presented in Table -3. There were The first factor accounted for 56.817% of the variation out of the total of 18 original measurements. It was represented by significant positive high loading of HW, BL and HG. This factor seemed to be explaining the body/general size of the cow. The second factor accounted for 14.314 % of total variability. The third factor accounted for 6.339 % of total variation contained high loading for neck length and hind leg length.

Table 1. Descriptive statistics of body measurements.

Sr. No.	Trait	Mean ± SD (cm)
1	Head width (HW)	13.50 ± 0.87
2	Face length (FL)	37.56 ± 2.87
3	Eye to eye space (EE)	16.10 ± 1.44
4	Neck Length (NL)	33.10 ± 2.72
5	Neck circumference (NC)	55.60 ± 5.53
6	Heart girth (HG)	119.80 ± 11.90
7	Switch length (SL)	79.20 ± 7.25
8	Foreleg length (FLL)	74.160 ± 4.31
9	Wither height (WH)	109.04 ± 10.47
10	Canon circumference(CC)	10.90 ± 1.30
11	Rump length (RL)	28.64 ± 3.20
12	Rump width (RW)	25.28 ± 3.75
13	Rump height (RH)	110.80 ± 8.70
14	Hind leg length (HLL)	78.24 ± 4.74
15	Tail length (TL)	63.44 ± 8.61
16	Shoulder width (SW)	5.76 ± 1.96
17	Pes length (PL)	35.08 ± 2.75
18	Bodylength (BL)	85.16 ± 8.24

Factor analysis: Anti-image correlations were computed which showed that 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 0.609. The estimated factors loading extracted by factor analysis, eigen values and variation explained by each factor are presented in

Table -1. It was found that 4 factors extracted with eigen values were found greater than 1 and accounted for 83.618 % of total variance. In a similar study, Yakubu et al. (2009) extracted 2 factors in the age group of 2.5 to 3.6 years explained 86.47% of the total variation by studying 14 morpho-structural traits of White Fulani cattle. In the present study, the first factor accounted for 56.817% of the variation, out of the total of 18 original measurements. It was represented by significant positive high loading of height at wither, body length, heart girth, paunch girth and ear length. This factor seemed to be explaining the body of the cow, i.e. size of the cow. The second factor accounted for 14.314 % of total variability. It had comparatively higher loading for horn characteristics. The third factor accounted for 10.49% of total variation, contained 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 6 factors, 7.67% with no particular variable having high loading. The communality ranged from 0.597 (body length) to 0.857 (hind girth) and unique factors ranged from 0.403 to 0.143 for all these 18 different biometric traits (Table -2).. In the present study, common variance explains approximately 83.618% of the total variance present among 4 measures. The first factor showed positive correlation with all other factors except the sixth factor. The second factor was negative with third factor. The coefficients of the principal analysis of the 4 extracted factors showed different weights to the variables (Table -3). This first factor represents the general shape and size of the cow. The second factor showed higher importance for horn characteristics.

Table 2. Correlation Matrix of all morphometric traits.

Variable	HW	FL	EE	NL	NC	HG	SL	FLL	WH	CC	RL	RW	RH	HLL	TL	SW	PL	BL
HW	1	0.104	0.499	-0.122	0.236	0.058	-0.022	0.212	-0.052	0.457	-0.100	-0.159	-0.058	0.099	0.115	0.313	-0.086	0.035
FL		1	0.130	0.548	0.839	0.801	0.670	0.800	0.746	0.030	0.771	0.826	0.076	0.604	0.594	-0.322	0.105	0.758
EE			1	-0.002	0.100	0.020	-0.018	0.307	-0.080	0.650	-0.016	-0.043	-0.035	-0.009	-0.110	0.390	0.019	-0.085
NL				1	0.481	0.473	0.350	0.496	0.398	-0.162	0.520	0.441	0.408	0.321	0.217	-0.207	0.055	0.360
NC					1	0.936	0.789	0.784	0.866	0.105	0.738	0.787	0.833	0.754	0.789	-0.399	-0.037	0.871
HG						1	0.766	0.797	0.861	0.058	-0.730	0.809	0.819	0.766	0.741	-0.405	0.081	0.914
SL							1	0.617	0.928	-0.139	0.890	0.808	0.934	0.788	0.861	-0.620	0.056	0.892
FLL								1	0.689	0.241	0.706	0.714	0.675	0.538	0.592	-0.143	0.143	0.786
WH									1	-0.039	0.878	0.881	0.946	0.827	0.866	-0.528	-0.035	0.942
CC										1	-0.111	0.033	-0.130	-0.015	-0.095	0.428	0.014	-0.060
RL											1	-0.883	0.835	0.640	0.664	-0.565	-0.086	0.835
RW												1	0.823	0.616	0.706	-0.497	-0.043	0.836
RH													1	0.870	0.861	-0.533	0.179	0.906
HLL														1	0.707	-0.436	0.228	0.733
TL															1	-0.466	0.100	0.849
SW																1	-0.058	-0.045
PL																	1	0.060
BL																		1

Head width (HW), Face length(FL), Eye to eye space (EE), Neck length (NL), Neck circumference (NC), Heart girth (HG), Switch length (SL), Foreleg length (FLL), Withers height (WH), canon circumference (CC), Rump length (RL), Rumpwidth (RW), Rump height (RH),Hinleg length (HLL), Tail length (TL), Switch width (SW), Pes length (PL) and Body length (BL)

Table 3. Eigen values and variation of all 18 Biometric traits.

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18
Eigen value	10.227	2.577	1.141	1.107	0.701	0.566	0.445	0.389	0.271	0.218	0.163	0.092	0.038	0.024	0.022	0.011	0.006	0.003
Variability	56.817	14.314	6.339	6.148	3.892	3.144	2.469	2.159	1.507	1.209	0.908	0.512	0.212	0.135	0.121	0.062	0.031	0.019
Cumulative	56.817	71.131	77.470	83.618	87.510	90.655	93.124	95.283	96.790	97.999	98.907	99.419	99.631	99.766	99.888	99.950	99.981	100.00

Table 4. Bertlett's test of Sphericity.

Chi-square (observed value)	291.627
Chi-square (critical value)	182.865
DF	153
P value	<0.0001
Alpha	0.05

Test interpretation

H_0: There is no correlation significantly different from 0 between variables

H_a: At least one of the correlation between the variables is significantly different from 0

As the computed p value is lower than significance level alpha=0.05, one should reject the null hypothesis H_0 and accept alternate one H_a.

The risk to reject null hypothesis while it is true is lower than 0.01%

DISCUSSION

The results suggested that 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

Biometric Traits: The Descriptive statistics for all the biometric traits are presented in Table -1. The estimates for body length, wither height and heart girth were in close agreement with the reports of The coefficient of variation for different biometric traits ranged from 4.38 (height at withers) to 19.22 (heart girth). It is observed that traits, i.e. height at wither, heart girth had more variability which may be due to the fact that selection was applied for these traits or these parts respond more to the environment than others. The neck length with neck circumference (NC) had more variability. Approximate range of communality i.e. 0.42 to 0.87 was reported by Sadek et al. (2006). Higher estimates of communality (ranged from 0.79 to 0.93) were observed by Yakubu et al. (2009).

Phenotypic Correlations: The morphometric characteristics as observed in this study revealed that Cholistani cows have body medium size than Dhanni cows with pendulous ears, long tail similar to that of Sahiwal cows of Pakistan.

Multivariate Analysis: The measure of sampling adequacy, Kaiser-Meyer-Olkin (KMO) was 0.521. Yakubu et al. (2009) and Khuram, (2013) reported similar estimates of sampling adequacy as 0.9 and 0.63 in White Fulani and Dhanni cattle, respectively. The estimates of sampling adequacy Kaiser-Meyer-Olkin (KMO) revealed the proposition of the use in different biometric traits caused by the underlying factors. Lower estimates of Bartlett's test of Sphericity were observed as compared to the Yakubu *et al.* (2009). Yakubu *et al.* (2009) and Khuram, (2013) extracted two factors in the biometric traits, which accounts for 85.37% of total variation and 71 % of the total variation by studying the different biometric traits of White Fulani and Dhanni cattle. Salako (2006) extracted two factors from 10 different biometric traits in Uda Sheep, which accounted for 75% of total variation. Khuram (2013) reported two different variance 51 and 43 % of observed traits in Dhanni cattle. In the present study, the first factor accounted for 51.62 % of the variance out of the total of 18 original measurements was represented. This factor seemed to be explaining the body of the cattle i.e. general animal size. Yakubu *et al.* (2009) reported in White Fulani cattle that the first factor explained 78.99% and 67.05% of total variance in traits. Similar to the present study, Yakubu *et al.* (2009), Khuram (2013), Fumio *et al.* (1982), Pundir *et al.* (2007 b;c), Hammock and Shrade (1986) and Karacaören and Kadarmideen (2008) reported that the first factor explained maximum variance.. Yakubu *et al.* (2009) and Khuram (2013) reported that the second factor explained 6.38% of the total variance, while Salako (2006) reported that the second factor explained 11.03 % of the total variance in Uda sheep. The Third factor of the present study may describe the back view of the animal. While a commonly used rule is that there would be at least three variables per factor (Pundir and Singh 2008). The community ranged from 0.54 (face length) to 0.42 (shoulder length) and unique factor ranged from 0.344 to 0.234 for all these 18 different biometric traits. Higher estimates of communality (ranged from 0.87 to 0.67) were observed by Yakubu *et al.* (2009). Approximate range of communality i.e. 0.42 to 0.87 was reported by Sadek et al. (2006). Higher estimates of communality (ranged from 0.79 to 0.93) were observed by Yakubu et al. (2009) In the present study, common variance explained approximately 66.02% of the total variance present among all 18 measures. The inter factor correlation between factor 1 and 2, 1 and 3, 2 and 3 were 0.441, 0.51 and 0.331, respectively, indicating high positive correlations among the extracted factors. The lower communalities for some of the traits like neck length and neck circumference might indicate that these traits were less effective to account for total variance of body conformation as compared to the other traits in cows of Cholistani cattle breed.

The three extracted factors determined the source of shared variability to explain body confirmation in cows of Cholistani cattle breed. Pundir et al. (2011) reported that in Kankrej cows, the first factor explained 38.89% of total variation. The communalities estimates indicated that neck length and neck circumference did not contribute effectively and these traits could be considered to explain the body confirmation of Cholistani cattle.

It is suggested from this study that PCA could be used in breeding programs with a drastic reduction in the number of traits to be recorded to explain the body confirmation.

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