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Short Communication

Principal Component Analysis (PCA) in the Body Measurements of Nguni Cows

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TLT designed the study, collected the data and revised the manuscript. WPBP analysed data and drafted the manuscript. TLT and WPBP approved the final version of the manuscript.

Key words
Body measurements, Nguni cow, PCA, Body weight, Withers height

ABSTRACT

Nguni cattle is one of South African native cattle that kept for meat and milk productions. This study was aimed to perform Principal Component Analysis (PCA) in the body measurements of adult Nguni cattle kept with extensive management system. The study was conducted on the experimental farm of the University of Limpopo, South Africa. Nine (9) body measurements include face width, face length, ear length, body length, rump height, withers height, sternum height, rump width and chest girth were performed in this study and taken from forty-nine (49) Nguni cows. Pearson's correlation and PCA were utilized for analysis of data. The correlation results revealed that chest girth had a positively high statistically significant association ($P < 0.01$) with rump height ($r = 0.74$) and withers height ($r = 0.57$), and a positive statistically significant association ($P < 0.05$) with face length ($r = 0.40$), body length ($r = 0.47$) and sternum height ($r = 0.48$). Three principal components (PC's) were obtained in Nguni cows that explain about 68.12% of total variance in animals morphostructure. The first component (PC1) in Nguni cows was explained the animal's morphostructure about 24.31%. Thus, the PC1 in Nguni cows consisted of face width, body length, rump height and withers height. In addition, the Kaiser-Meiyer-Olkin (KMO) value in animals' study was 0.74 with significant value of Bartlett's test ($P<0.01$). In conclusion, the results of PCA in the present study was accurate and can be used for selection program of Nguni cows.

Nguni cattle is one of the largest multi-coloured (red, white, black, grey rown, and brindle) native cattle breeds in South Africa (Sanarana *et al*., 2016). According to Tyasi *et al*. (2020), the breed was developed from North Africa and is a mixture of *Bos indicus* and *Bos taurus*. Verma *et al*. (2015) explained principal component analysis (PCA) as a valuable multivariate statistical tool that is used when characteristics are associated. The PCA alters an original group of variables into another group, principal components, which are a linear mixture of the original variables. It decreases dimensionality of data and describes the greatest disparity in the data set over dependent variables (Karacaören and Kadarmideen, 2008). It also gives more dependable evaluation of morphometric association between livestock breeds (Sankhyan *et al*., 2018). This technique is employed in animal breeding to concurrently examine a group of traits which might be utilized for selection and conservation purpose (Panda *et al*., 2020). Tolenkhomba *et al*. (2013) used principal component analysis in bulls of local cattle of Manipur and Okoro *et al*. (2015) in crossbred pigs of Nigeria to study the biometric traits. In previous studies, principal component analysis have been used for analysis of body measurements and to evaluate growth performances of Malabari goats of India (Valsalan *et al*., 2020), Katjang does of Indonesia (Putra and Ilham, 2019) and to describe the body conformation of Pasundan cows (Putra *et al*., 2020), Hungarian Simmental cows (Török *et al*., 2021), local hill cattle of Himalayan state of Himachal Pradesh, India (Verma *et al*., 2015) and Yankasa sheep (Yakubu, 2013). However, based to the level of our knowledge, there is no documentation of principal component analysis in Nguni cattle breed. Hence, the objective of the study was to perform principal component analysis in the body measurements of adult Nguni cows kept with extensive management system in South Africa. Cattle farmers will get assistance from this study to determine the source of shared variability to explain morphostructure in cattle.

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Materials and methods

This research was carried out in accordance with the standard operation procedures of the Animal Research and Ethics Committee (AREC) at the University of Limpopo, South Africa.

A total of 49 adult Nguni cows were used in this study. The Nguni cows that used in this study were taken from the experimental farm of the University of Limpopo, South Africa. The temperatures in winter ranges from 5°C to 28°C and summer temperatures ranges from 10°C to 36°C. Thus, annual rainfall is less than 400 mm/year.

The Nguni cattle that used in the present study were kept with extensive management system. Bulls and cows were kept in separate kraals. The cattle were released to graze in the morning and then kraaled later in the afternoon. The grass given to the animal consisted of *Cenchrus ciliaris, Panicum maximum, Aristida tranvaalenesis, Eragristis curvula, Eragristis capensis, Eragristis frichophora, Themeda trianda* and *Cymbopogon caesius.* In addition, water was given *ad libitum* with regular medical care and vaccination.

Nine body measurements of face width (FW: measured as the widest point of head), face length (FL: measured from the horn site/ poll to the lower lip), ear length (EL: the distance from the base to the tip of the ear along the dorsal surface), body length (BL: distance from the point of the shoulder to the pin bone), rump height (RH: measured from rump/ *tuber coxae* to the surface of the platform on which the animal stands), withers height (WH: measured from the surface of the platform to the dorsal point / *os vertebrae thoracalis III*), sternum height (SH: measured as the vertical position from the lower tip of the sternum to the platform on which the animal stands), rump width (RW: measured as the distance between both of the hip bones / *tuber ischii*) and chest girth (CG: measured as circumference of the chest just behind the foreleg/ *os costa V*) were measured referring to Figure 1.

Means, standard deviation (SD), coefficient of variation (CV) and Person's coefficient of correlation (r) were calculated through SPSS 16.0 software. Therefore, principal component analysis (PCA) was performed using a similar software. 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. The KMO should be greater than 0.50 for a satisfactory factor analysis to proceed. Rotation of principal components was through the transformation of the components to approximate a simple structure. The raw varimax criterion of the orthogonal rotation method was employed for the rotation of the factor matrix (the aim of the varimax rotation is to maximize the sum of variances of a quadratic weight). Cumulative proportion of variance criterion was finally employed to determine the number of components to extract.

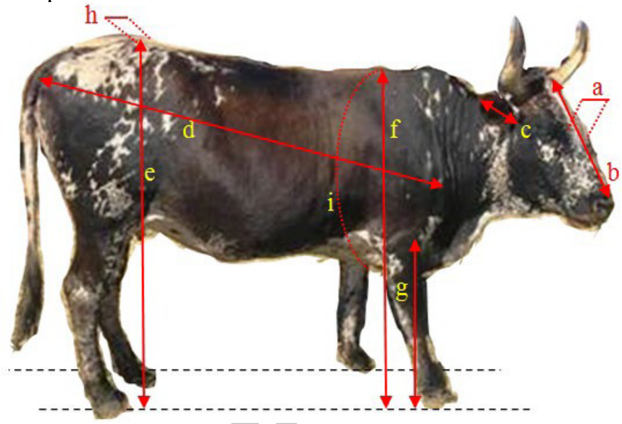

Fig. 1. The scheme of body measurements for face width (a), face length (b), ear length (c), body length (d), rump height (e), withers height (f), sternum height (g), rump width (h) and chest girth (i) in a Nguni cow.

Results and discussion

The CV value in the body measurements of Nguni cows was low (CV<10%) in FW, RH, SH; moderate (10%<CV<20%) in FL, BL, WH, RW, CG and high (CV>20%) in EL as presented in Table I. The r high value (0.60<r<0.80) was showed in FL-EL and RH-CG as presented in Table II. Meanwhile, the moderate r value (0.40<r<0.60) was showed in WH-FW, RH-FL, RH-BL, CG-BL, WH-RH, SH-RH, CG-WH and CG-SH. Meanwhile, the other correlation among body measurements were low (r<0.40). Contrast findings were reported by Verma *et al*. (2015) in local hill cattle of Himalayan state of Himachal Pradesh, India, where chest girth was highly correlated to all the measured traits including body length, heart girth, paunch girth, forelimb length, hind limb length, face length, forehead length, forehead width, height at hump, hump length, hook to hook distance, pin to pin distance. The differences may be due to breed variations. The findings of the study suggest that improvement of the RH, WH, FL, BL and SH might improve the CG in Nguni cows. The PCA of body measurements in Nguni cows was obtained three principal components (PC's) as presented in Table III. Three PC's in animals study capable to explain the morphostructure about 68.12%. In the Nguni cows, the first factor (PC1) accounted for 24.31% of total variation, containing high loading for FW, BL, RH and WH. The second factor (PC2) accounted for 22.07%, containing high loading for FL, EL and RW. Thus, the third factor (PC3) accounted for 21.74%, containing high loading for SH and CG. The current study is in agreement with the study of Török *et al*. (2021) in Hungarian Simmental cows, where principal component one explained 14.4% of variation, followed by principal component two with 9.2% and three with 9.0% and the study of Verma *et al*. (2015) in local hill cattle of Himalayan state of Himachal Pradesh, India, where principal component one described 34.7%, principal component two 10.3% and principal component three 7.6% of variation. In the several breeds of cattle, PCA of body measurements were explained the morphostructure about 86.47% (4PC's) in White Fullani (Yakubu *et al*., 2009); 66.02% (3PC's) in Kankrej (Pundir *et al*., 2011); 64.31% (7PC's) in local Manipur (Tolenkhomba *et al*., 2012); 65.84% (2PC's) in Pallaresa (Parez-Casanova *et al*., 2013); 54.40% (2PC's) in Tonga (Parez-Casanova and Mwaanga, 2013); 65.95% (5PC's) in local Himalayan (Verma *et al*., 2015); 83.62% (4PC's) in Cholistani (Shah *et al*., 2018); 91.08 (2PC's) in Taro (Heryani *et al*., 2018); 65.16% (3PC's) in Oulmes-Zaer; 54.70% (3PC's) in Tidili (Boujenane, 2015); 73.36% (2PC's) in Pasundan (Putra *et al*., 2020); and 75.05% (5PC's) in Zobawng (Tolenkhomba *et al*., 2021). The PCA findings of the current study suggest that FW, BL, RH and WH are the important traits which contribute more to the variation in Nguni cows. The contribution of each PC for explaining animals morph structure can be influenced by breed, sex, management and number of measurements. The KMO in this study was 0.74 with significant of Bartlett's test value ($P<0.01$). Hence, the results of PCA in the present study was accurate (KMO > 0.50).

Conclusion

The objective of the study was to perform principal component analysis in the body measurements of adult Nguni cows kept with extensive management system in South Africa. The association outcomes revealed that chest girth had a positively high statistically significant association with rump height and withers height, and a positive statistically significant association with face length, body length and sternum height. The results of the study recommend that improvement of the RH, WH, FL, BL and SH might improve the CG in Nguni cows. The three PC's determine the source of shared variability to explain morphostructure in Nguni cows. About 20% of each PC contribute effectively to explain general morphostructure in Nguni cows. The PCA results of the study suggest that FW, BL, RH and WH are the significant traits which contribute more to the variation in Nguni cows. The results suggest that the PCA could be used in breeding programs with a drastic reduction in the number of body measurements to be recorded to explain the morphostructure. The study will assist cattle farmers to determine the source of shared variability to explain morphostructure in cattle. Further studies should be performed on PCA in Nguni cattle.

Table I. The descriptive statistic of body measurements in Nguni cows.

Body measurements (cm)	Mean±SD (Min-Max)	CV (%)
Face width	21.73±1.08 (20-24)	4.95
Face length	54.26±7.32 (38-67)	13.49
Ear length	14.81±3.17 (10-22)	21.42
Body length	131.61±18.02 (103-172)	13.69
Rump height	127.49±10.30 (104-147)	8.08
Withers height	119.53±12.79 (61-133)	10.70
Sternum height	68.41±5.15 (43-74)	7.53
Rump width	42.78±4.42 (35-50)	10.32
Chest girth	183.90±22.89 (137-220)	12.45

N, number of animals; SD, standard deviation; CV, coefficient of variation; Min., minimum; Max., maximum.

Table II. Pearson's coefficient of correlation among body measurements in Nguni cows.

Variable	FW	FL	EL	BL	RH	WH	SH	RW
Face width (HW)	-							
Face length (HL)	0.16	-						
Ear length (EL)	-0.03	-0.71**	-					
Body length (BL)	0.34*	0.29	-0.07	-				
Rump height (RH)	0.36*	0.54**	-0.32*	0.49*	-			
Withers height (WH)	0.41*	0.20	-0.05	0.37*	0.57**	-		
Sternum height (SH)	0.08	0.22	-0.09	0.12	0.43*	0.35*	-	
Rump width (RW)	-0.16	-0.19	0.33*	0.11	-0.19	-0.04	-0.12	-
Chest girth (CG)	0.25	0.40*	-0.13	0.47*	0.74**	0.57**	0.48	-0.11

*(P<0.05); **(P<0.01).

Table III. The results of principal component analysis (PCA) in the body measurements of Nguni cows.

Variable	PC1	PC2	PC3	Extraction
Face width	0.65*	0.04	0.06	0.43
Face length	0.34	0.82*	0.12	0.78
Ear length	-0.07	-0.92*	0.05	0.85
Body length	0.82*	0.03	0.08	0.69
Rump height	0.58*	0.38	0.57	0.80
Withers height	0.57*	-0.03	0.56	0.63
Sternum height	-0.05	0.09	0.87*	0.77
Rump width	0.23	-0.55*	-0.24	0.41
Chest girth	0.50	0.17	0.69*	0.76
Rotated sums squared loadings				
Total	2.19	1.99	1.96	-
Variance (%)	24.31	22.07	21.74	-
Cumulative (%)	24.31	46.38	68.12	-
KMO			0.74	
Bartlett's test			**	

PC, principal component; KMO, Kaiser-Meiyin-Olkin; *main component; **(P<0.01).

Statement of conflict of interests

The authors have declared no conflict of interest.

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