NATIONAL AGRICULTURAL AND FOOD CENTRE
RESEARCH INSTITUTE FOR ANIMAL PRODUCTION NITRA

Slovak J. Anim. Sci., 54, 2021 (3): 130–139
ISSN 1337-9984, E-ISSN 1338-0095

MORPHOMETRIC CHARACTERIZATION OF BEGAIT COWS KEPT IN TWO DIFFERENT FARMING SYSTEMS AT WESTERN ZONE OF TIGRAY, ETHIOPIA

Widya Pintaka Bayu PUTRA[1]*, Teweldemedhn MEKONNEN[2]

[1]Research Center for Biotechnology – Research Organization for Life Sciences – National Research and Innovation Agency (BRIN), Cibinong, Indonesia
[2]Tigray Agricultural Research Institute – Humera Begait Animals Research Center, Tigray, Ethiopia

ABSTRACT

Breed characterization in the livestock is important to obtain the breed standard of livestock for selection program. This research was aimed to characterize the Begait cows (*Bos indicus*) reared in two different farming systems (on-farm and ranch) in Ethiopia using 15 body measurements. A total of 344 adult Begait cows kept in on-farm (n = 237) and ranch (n = 107) systems were involved in this study. The principal component analysis (PCA) was performed to describe the morphostucture of the animal study. Thus, the canonical discriminant analysis (CDA) was performed to classify the animals from two different farming systems. The PCA and CDA analyses were performed using SPSS 16.0 computer program. The results revealed three principal components (PC's) in animals reared in on-farm system, and four PC's were found in animals reared in the ranch system. Thus, the PCA in this study able to explain the morphostructure of cows about 52.01 % (on-farm) and 63.26 % (ranch). Morever, seven body measurements were detected as the discriminant variables for Begait cows with canonical correlation (r_c) of 0.57 (moderate). In addition, the discriminant analysis of body measurements able to classify Begait cows about 77.6 % (on-farm) and 82.2 % (ranch system) into their original farming system. It can be concluded that the morphostructure of Begait cows appears to be affected by the differences in management systems, indicating their usefulness for breeding programs in the future.

Key words: Begait cows; body measurements; canonical discriminant analysis; farming systems; principal component analysis

INTRODUCTION

Begait cattle (*Bos indicus*) is one of the African Zebu cattle breed that adapted well in many countries in Africa such as Nigeria, Sudan and Eritrea (DAGRIS, 2006). The Begait cattle was kept by smallholders in Africa for milk and meat productions (Teweldemedhn, 2018). Mezgebe *et al.* (2018) reported that the body weight at 18 months of age was 182 kg (male) and 171 kg (female). Thus, the milk production at 305 days of lactation in Begait cows was 1360 kg with 316 days of dry period, 600 days of calving interval (CI) and 1040 days of age at first calving (AFC). Gebru *et al.* (2017) reported that the average of AFC and CI in Begait cows were 50.80 ± 0.50 months and 18.40 ± 0.20 months, respectively. Thus the average daily milk yield, peak milk yield, lactation length and lactation milk yield were 2.49 ± 0.10 L, 3.21 ± 0.10 L, 5.39 ± 0.10 months and 459.52 ± 3.90 L, respectively.

In Ethiopia, cattle contribute a lot to improve the wellbeing of the farm family through food supply, balancing nutrition, family income, savings, insurance, ritual and other social purposes (Assefa and Hallu, 2018). Therefore, the genetic improvement in Begait cattle is very important to increase their

***Correspondence:** E-mail: widya.putra.lipi@gmail.com, Widya Pintaka Bayu Putra, Research Center for Biotechnology – Indonesian Institute of Science, Cibinong, Indonesia 16911
Received: January 15, 2021
Accepted: April 12, 2021

productivity or economic trait. Hence, the genetic improvement in Begait cattle can be achieved with a selection program. In addition, the selection program can be started with breed characterization that important to establish the breeds standard (Said *et al.*, 2017). Thus, the breed characterization can be established with several body measurements (morphometric traits) and phenotypic traits. A previous study reported that the characteristics of cattle can be affected by farming management system and geography area of breeding tract (Edouard *et al.*, 2018). In addition, the breed characterization can be performed with principal component analysis (PCA) or factor analysis and canonical discriminant analysis (CDA) or multivariate analysis.

The PCA has been used to explain the first component of the morphostructure of animals and has been assessed in many cattle breeds, i.e. White Fullani (Yakubu *et al.*, 2009), Kankrej (Pundir *et al.*, 2011), Manipur (Tolenkhomba *et al.*, 2012), Tonga (Parez-Casanova and Mwaanga, 2013), local Himalayan (Verma *et al.*, 2015), Cholistani (Shah *et al.*, 2018), White Taro (Heryani *et al.*, 2018) and Pasundan (Putra *et al.*, 2020a). Meanwhile, the CDA has been used to characterize the cattle breeds based on their body measurements (Yakubu *et al.*, 2010; Grema *et al.*, 2017; Putra *et al.*, 2020b). Morever, the CDA has been used to characterize an indigenous cattle breed kept at different breeding tracts (Pundir *et al.*, 2015; Edouard *et al.*, 2018).

To date, no studies using PCA and CDA on Begait cattle (*Bos indicus*) reared at Ethiopia were reported. This study was carried out to perform PCA and CDA in Begait cows kept in two different farming systems using several body measurements. The obtained results can be used as the preliminary information to obtain the breed standard of Begait cattle in the future. Hence, the establishment of a breed standard is important to conserve the livestock's genetic resources of Ethiopia.

MATERIAL AND METHODS

Research site and the animals

A total of 344 adult Begait cows kept in on-farm (237 cows) and ranch (107 cows) systems were used in this study. The cows were located in Kafta Humera district and Setit Humera district of Western Zone of Tigray Regional State of Ethiopia. Kafta Humera district is located at 13° 40' and 14° 27' N of latitude, and 36° 27' and 37° 32' E of longitude and has altitude range of 515 to 1863 meter above sea level (masl). The annual rainfall of the district is 449 to 1100 mm/year. The annual temperature of 33 to 41.7 °C in the lowland areas and 17.5 to 22.2 °C in the highland areas. Setit Humera is located at 14° 16' N of latitude and 36° 37' E of longitude and has an altitude of 611 masl. Humera Ranch of Begait Cattle Multiplication, Improvement and Conservation Center is located within the coordinates of 13° 4' – 14° 27' N of latitude and 36° 27' − 37° 32' of longitude and has an altitude of 892 masl. The research was undertaken since October 2015 to February of 2016 (dry season).

Management of animals

Natural pasture was the first and the most common feed source used for all livestock species during wet and dry seasons. Grazing land in the studied area was entirely communally owned. Farmers used different feeding/grazing practices. Herding was the most common practice during wet and dry season in the studied area. In the on-farm system, a few farmers tethered their animals during dry and wet season. Free grazing was less practiced due to the fear of theft and predators. The natural pasture dries up and becomes standing hay and animals graze up on this. Moreover, feed conservation was practiced in the form of crop residue (sorghum stover teff straw, millet straw and maize). These conserved feeds were given to cattle during feed shortage (dry season) primarily to lactating cows and work oxens during the cropping season. Meanwhile, animals in the ranch system have permanent residence with their owners. They spend the night in kraals and travel to field for grazing. In this system, man-made water availability and crop residuesare utilized when feed is scarce but nutritional inadequacies remained unsolved because these animals depend on limited grazing area near the towns, where there is lack of grazing area due to over-cultivation of crops. Therefore, most of cows in both systems were naturally mated using own bull (bred and bought) or neighbor's bull.

Cattle age estimation

Age of the cattle was estimated by the stage of eruption of permanent pair of incisors (PPI) and used owner's reported animal ages. Therefore, total of 167 animals under 4 years age (135 – on-farm and 32 – ranch) and 177 animals over 4 years age (102 – on-farm and 75 – ranch) were identified in the animal sample.

Body measurements

The body measurement data were taken from animals in a standing position with a raised head. Body measurement of animals was performed using measuring stick and flexible measuring tape according to the FAO (2012) guidelines. Fiveteen body measurements of body length (BoL), chest girth (CG), height at withers (HW), neck length (NL), pelvic width (PW), rump length (RL), back length (BaL), teat length (TeL), ear length (EL), horn length (HL), muzzle circumference (MC), dewlap width (DW), naval flap width (NFW), hock circumference (HC), rear leg cannon length (RCL), front leg cannon length (FCL) and tail length (TaL) were done. The scheme of body measurements in Begait cows is presented in Figure 1.

Statistical analysis

The statistical parameters of means, standard deviation and Pearson's coefficient of correlation were calculated with SPSS 16.0 computer program. Two statistical analyses – principal component analysis (PCA) and canonical discriminant analysis (CDA) were performed using SPSS 16.0 software to characterize the Begait cows kept in different farming systems. In the PCA, Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy, Bartlett's test of sphericity and communality were computed as the test validity. The KMO statistics vary between 0 and 1. The value close to 0 indicates that there are large partial correlations compared to the total correlations. A value close to 1 indicates that the sampling is appropriate. It was possible to accept a measure of sampling adequacy greater than 0.50. The varimax criterion of the orthogonal rotation method was employed in the rotation of the factor matrix to enhance the interpretability of the factor analysis. In CDA, mahalanobis distance (D^2), tolerance (T), Wilk's lambda (λ) values and linear discriminant function were computed to obtain the discriminating variable for Kacang goats at two different areas. Here CDA was applied with the

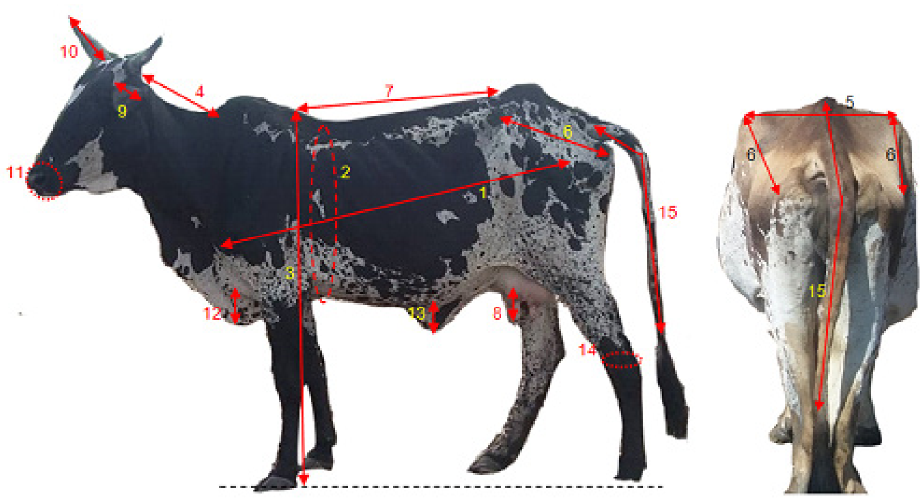

Figure 1. The scheme of body measurements in a Begait cow consisted of body length (1), chest girth (2), height at withers (3), neck length (4), pelvic width (5), rump length (6), back length (7), teat length (8), ear length (9), horn length (10), muzzle circumference (11), dewlap width (12), naval flap width (13), hock circumference (14) and tail length (15)

method of backward stepping automatic elimination of the variables, with F value entry = 3.84 and F value removal = 2.71. The T value (0 to 1) was computed to detect the level correlation among variable in the discriminant function. If a variable is highly correlated with one or more of the others, the T value is very small and the resulting estimates of the discriminant function coefficients may be unstable.

RESULTS AND DISCUSSION

Body measurements and phenotypic correlation

Seven body measurements of Begait cows in on-farm system i.e. BoL, HW, NL, RL, TeL, HL and MC were higher than that in ranch system ($P < 0.05$), as presented in Table 1. Gebreyohanes (2015) obtained the following body measurements of female Begait cattle: 128.10 ± 0.16 cm (BoL), 159.60 ± 0.24 cm (CG), 131.50 ± 0.25 cm (HW), 44.70 ± 0.27 cm (NL), 40.00 ± 0.31 cm (PW), 11.50 ± 0.03 cm (TeL), 18.40 ± 0.34 cm (EL), 21.10 ± 0.11 cm (HL), 18.60 ± 0.24 cm (DW), 12.10 ± 0.07 cm (NFW) and 97.70 ± 0.37 cm (TaL). Thus, body measurements of NL, HL and TaL in on-farm system were similar to those reported by Gebreyohanes (2015). In each age group, three measurements of RL, TeL and HL in cattle kept either in on-farm or in ranch systems were similar, as presented in Table 2.

Commonly, the animal morphometry in on-farm systems is better than that in the ranch system. In the on-farm system, cattle can be kept intensively with appropriate feed ration. Hence, most of the morphometric values in cattle with on-farm system showed to be higher than in the ranch system. The difference between the results of this study and previous study can be explained by farming system and geographical area factors. In addition, Pearson's coefficient of correlation (r) for CG and MC had moderate r value (about 0.60) in both farming systems (Table 3). The difference of r value among body measurements in both farming systems can be affected by many factors of farming management system, such as selection, feed nutrition, climate and season, presence of subpopulation and gene admixtures.

Principal component analysis

The PCA results of Begait cows are presented in the Table 4 (on-farm) and Table 5 (ranch). Total of three principal components (PC's) and four

Table 1. Means and standard deviation in body measurements of adult Begait cows

Body measurements (cm)	Farming system		*P*-value
	On-farm	Ranch	
N	237	107	-
Body length	116.22 ± 6.83	113.43 ± 5.01	0.000
Chest girth	154.70 ± 6.92	148.62 ± 6.56	0.133
Height at withers	129.26 ± 5.48	128.64 ± 4.70	0.027
Neck length	44.78 ± 4.27	42.19 ± 3.09	0.000
Pelvic width	38.25 ± 2.40	37.58 ± 2.18	0.210
Rump length	21.46 ± 2.23	22.20 ± 3.19	0.000
Back length	89.01 ± 4.75	87.05 ± 4.86	0.475
Teat length	6.28 ± 1.90	5.21 ± 1.39	0.000
Ear length	22.80 ± 1.75	22.86 ± 1.84	0.209
Horn length	21.76 ± 8.31	17.65 ± 5.79	0.000
Muzzle circumference	38.06 ± 2.14	37.21 ± 1.80	0.025
Dewlap width	15.40 ± 3.20	14.17 ± 3.42	0.347
Naval flap width	7.94 ± 3.20	7.50 ± 3.11	0.934
Hock circumference	33.94 ± 1.91	34.38 ± 1.93	0.603
Tail length	97.40 ± 7.68	93.36 ± 8.65	0.849

N: number of animal

Table 2. Means (± SD) in body measurements of Begait cows at two different age groups

Age / Management	N	Body measurements (cm)														
		BoL	CG	HW	NL	PW	RL	BaL	TeL	EL	HL	MC	DW	NFW	HC	TaL
<4 years																
On-farm	135	112.86±5.75	152.28±6.78	127.54±5.28	43.52±4.05	37.39±2.23	21.25±2.21	87.86±4.45	5.50±1.52	22.51±1.66	20.23±8.16	37.13±1.85	13.95±2.77	6.79±3.04	33.32±1.73	95.80±7.31
Ranch	32	109.45±3.46	145.10±3.44	126.65±3.95	40.74±2.41	36.32±2.15	21.65±3.51	85.19±4.03	4.13±0.88	21.94±1.65	15.23±4.84	36.13±1.12	11.81±2.56	6.48±3.71	33.58±1.52	91.45±11.46
P-value	-	0.001	0.002	0.156	0.002	0.918	0.000	0.631	0.001	0.918	0.005	0.005	0.284	0.171	0.107	0.031
<4 years																
On-farm	102	120.58±5.67	157.95±5.75	131.49±4.97	46.42±3.96	39.40±2.18	21.73±2.24	90.44±4.77	7.23±1.89	23.19±1.81	23.70±8.25	39.21±1.92	17.22±2.76	9.40±2.80	34.73±1.86	99.55±7.75
Ranch	75	114.97±4.61	149.92±6.94	129.41±4.78	42.72±3.14	38.05±1.97	22.40±3.06	87.76±5.00	5.61±1.29	23.23±1.80	18.60±5.90	37.60±1.82	15.09±3.26	7.91±2.77	34.72±1.99	94.09±7.19
P-value	-	0.202	0.889	0.537	0.078	0.152	0.003	0.862	0.000	0.249	0.002	0.653	0.103	0.999	0.758	0.234

N: number of animal; BoL: body length; CG: chest girth; HW: height at withers; NL: neck length; PW: pelvic width; RL: rump length; BaL: back length; TeL: teat length; EL: ear length; HL: horn length; MC: muzzle circumference; DW: dewlap width; NFW: naval flap width; HC: hock circumference; TL: tail length.

Table 3. Pearson's coefficient of correlation (r) among body measurements of Begait cows kept in on-farm (above diagonal) and ranch (under diagonal) management systems

Body measurements	BoL	CG	HW	NL	PW	RL	BaL	TeL	EL	HL	MC	DW	NFW	HC	TaL
Body length (BoL)	-	0.45**	0.50**	0.33**	0.50**	0.17**	0.43**	0.44**	0.19**	0.20**	0.42**	0.40**	0.34**	0.45**	0.28**
Chest girth (CG)	0.41**	-	0.60**	0.36**	0.61**	0.21**	0.37**	0.43**	0.26**	0.14*	0.60**	0.43**	0.31**	0.59**	0.38**
Height at withers (HW)	0.53**	0.41**	-	0.26**	0.55**	0.23**	0.40**	0.43**	0.38**	0.14*	0.49**	0.37**	0.33**	0.53**	0.39**
Neck length (NL)	0.50**	0.52**	0.42**	-	0.37**	0.07	0.40**	0.31**	0.17**	0.12	0.31**	0.30**	0.16*	0.22**	0.30**
Pelvic width (PW)	0.46**	0.54**	0.38**	0.46**	-	0.09	0.32**	0.40**	0.26**	0.22**	0.57**	0.44**	0.34**	0.53**	0.39**
Rump length (RL)	0.15	0.32**	0.11	0.24**	0.28**	-	0.20**	0.17**	0.06**	0.03	0.09	0.08**	0.09	0.24**	0.03
Back length (BaL)	0.18	0.11	0.13	0.15	0.33**	-0.21*	-	0.38**	0.19**	0.02	0.32**	0.19**	0.24**	0.35**	0.35**
Teat length (TeL)	0.50**	0.30**	0.34**	0.41**	0.40**	0.03	0.48**	-	0.24**	0.23**	0.47**	0.38**	0.40**	0.37**	0.26**
Ear length (EL)	0.46**	0.30**	0.29**	0.31**	0.43**	0.02	0.41**	0.32**	-	0.06	0.34**	0.16*	0.21**	0.25**	0.25**
Horn length (HL)	0.16	0.35**	0.26**	0.20*	0.32**	-0.02	0.29*	0.21*	0.26**	-	0.30**	0.15*	0.05	0.11	0.17**
Muzzle circumference (MC)	0.54**	0.61**	0.51**	0.48**	0.47**	0.21*	0.28*	0.47**	0.39**	0.33**	-	0.39**	0.36**	0.51**	0.30**
Dewlap width (DW)	0.55**	0.65**	0.44**	0.61**	0.53**	0.21*	0.08	0.39**	0.35**	0.21*	0.56**	-	0.39**	0.37**	0.22**
Naval flap width (NFW)	0.19	0.22**	0.20**	0.30**	0.21**	0.15	0.07	0.15	0.30**	0.15	0.22**	0.23**	-	0.36**	0.15*
Hock circumference (HC)	0.41**	0.38**	0.57**	0.39**	0.24**	0.05	0.19*	0.28**	0.26**	0.16	0.43**	0.36**	0.17	-	0.35**
Tail length (TaL)	0.32**	0.13	0.26**	0.20*	0.21**	-0.23*	0.33**	0.28**	0.57**	0.18	0.23**	0.19	0.20*	0.22**	-

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

Table 4. The results of principal component analysis in the body measurements of Begait cows kept in on-farm system

Body measurements	PC1	PC2	PC3	Communality
Body length	0.58*	0.38	0.08	0.49
Chest girth	0.64*	0.45	0.07	0.62
Height at withers	0.61*	0.44	0.15	0.59
Neck length	0.15	0.68*	-0.06	0.49
Pelvic width	0.64*	0.43	-0.14	0.61
Rump length	0.27	0.03	0.67*	0.53
Back length	0.21	0.68*	0.34	0.62
Teat length	0.62*	0.28	-0.004	0.46
Ear length	0.28	0.35	-0.02	0.20
Horn length	0.31	0.08	-0.62*	0.48
Muzzle circumference	0.69*	0.33	-0.20	0.62
Dewlap width	0.67*	0.10	-0.12	0.48
Naval flap width	0.69*	-0.06	0.09	0.49
Hock circumference	0.65*	0.32	0.20	0.56
Tail length	0.15	0.72*	-0.16	0.57
Rotated sums squared loadings				
Total	4.07	2.60	1.13	-
Variance (%)	27.12	17.34	7.55	-
Cumulative (%)	27.12	44.47	52.01	-
KMO			0.91	
Bartlett's test			**	

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

PC's were obtained in on-farm and ranch systems, respectively. Thus, about 52.01 % (on-farm) and 63.26 % (ranch) of the total variance of morphostucture of Begait cows can be described with 17 body measurements. In addition, the KMO values in both PCA's were 0.91 (on-farm) and 0.86 (ranch) suggesting that the PCA results are accurate (KMO > 0.50). The KMO values in this study were higher than reported in Kankrej (0.81), Manipur (0.60), local Himalayan (0.75) and Pasundan (0.72) cattle (Pundir *et al.*, 2011; Tolenkhomba *et al.*, 2012; Verma *et al.*, 2015; Putra *et al.*, 2020a). Hence, the Bartlett's test in both PCA's was significant ($P < 0.01$) confirming the validity of factor analysis data. Therefore, previous studies reported that the morphostructure in many cattle breeds has been described by PCA about 86.47 % (4 PC's) in White Fullani (Yakubu *et al.*, 2009), 66.02 % (3 PC's) in Kankrej (Pundir *et al.*, 2011), 64.31 % (7 PC's) in Manipur (Tolenkhomba *et al.*, 2012), 65.84 % (2 PC's) in Pallaresa (Pares-Casanova *et al.*, 2013), 54.40 % (2 PC's) in Tonga (Pares-Casanova and Mwaanga, 2013), 65.95 % (5 PC's) in local Himalayan (Verma *et al.*, 2015); 65.16 % (3 PC's) in Oulmes-Zaer, 54.70 % (3 PC's) in Tidili (Boujenane *et al.*, 2016), 83.62 % (4 PC's) in Cholistani (Shah *et al.*, 2018), 91.08 % (2 PC's) in White Taro (Heryani *et al.*, 2018), 73.36 % (2 PC's) in Pasundan (Putra *et al.*, 2020a) and 78.37 % (5 PC's) in Zobawng (Tolenkhomba *et al.*, 2021). Five body measurements of BoL, HW, MC, DW and HC were categorized as the first component in Begait cows at both farming systems. It can be concluded that the morphostructure of Begait cows could be affected by the difference in management systems, presence of subpopulations and gene mixtures of the animals.

Canonical discriminant analysis

The CDA in this study reveals that the canonical correlation (r_c) in Begait cows at two different farming systems belongs to moderate category ($r_c = 0.57$), as presented in Table 6. Yakubu *et al.* (2010) obtained $r_c = 0.77$ in CDA to characterize

Table 5. The results of principal component analysis in the body measurements of Begait cows kept in ranch system

Body measurements	PC 1	C 2	C 3	C 4	Communality
Body length	0.71*	0.18	0.13	0.25	0.62
Chest girth	0.48	0.34	0.58*	0.07	0.68
Height at withers	0.79*	0.08	0.06	0.11	0.64
Neck length	0.57*	0.18	0.40	0.22	0.57
Pelvic width	0.32	0.55*	0.45	0.20	0.64
Rump length	0.05	-0.11	0.78*	-0.02	0.63
Back length	0.10	0.77*	-0.30	0.17	0.73
Teat length	0.47	0.54*	-0.03	0.09	0.53
Ear length	0.26	0.39	-0.02	0.69*	0.70
Horn length	0.05	0.66*	0.17	0.06	0.47
Muzzle circumference	0.62*	0.40	0.29	0.10	0.64
Dewlap width	0.61*	0.22	0.45	0.16	0.64
Naval flap width	0.05	-0.06	0.33	0.74*	0.66
Hock circumference	0.78*	0.01	-0.06	0.06	0.62
Tail length	0.27	0.24	-0.36	0.67*	0.71
Rotated sums squared loadings					
Total	3.54	2.25	1.98	1.72	-
Variance (%)	23.61	15.00	13.19	11.46	-
Cumulative (%)	23.61	38.61	51.80	63.26	-
KMO			0.86		
Bartlett's test			**		

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

Table 6. Factors selected by stepwise discriminant analysis to characterize Begait cows kept in two different farming systems ($r_c = 0.57$)

Step	Variable entered	Tolerance	F_{remove}	D^2	Wilk's λ
1	Chest girth	0.52	57.52	1.19	0.80
2	Hock circumference	0.68	35.14	1.54	0.75
3	Rump length	0.94	12.14	1.95	0.70
4	Teat length	0.75	6.21	2.07	0.69
5	Neck length	0.78	6.21	2.07	0.69
6	Horn length	0.92	5.93	2.07	0.69
7	Pelvic width	0.58	4.96	2.09	0.69

D^2: Mahalanobis distance.

Table 7. Percentage (%) of individual classification per breed based on discriminant analysis

Farming system	Predicted group membership (N)		Total (N)
	On-farm	Ranch	
On-farm	77.6 % (184)	22.4 % (53)	100 % (237)
Ranch	17.8 % (19)	82.2 % (88)	100 % (107)

N: number of animal.

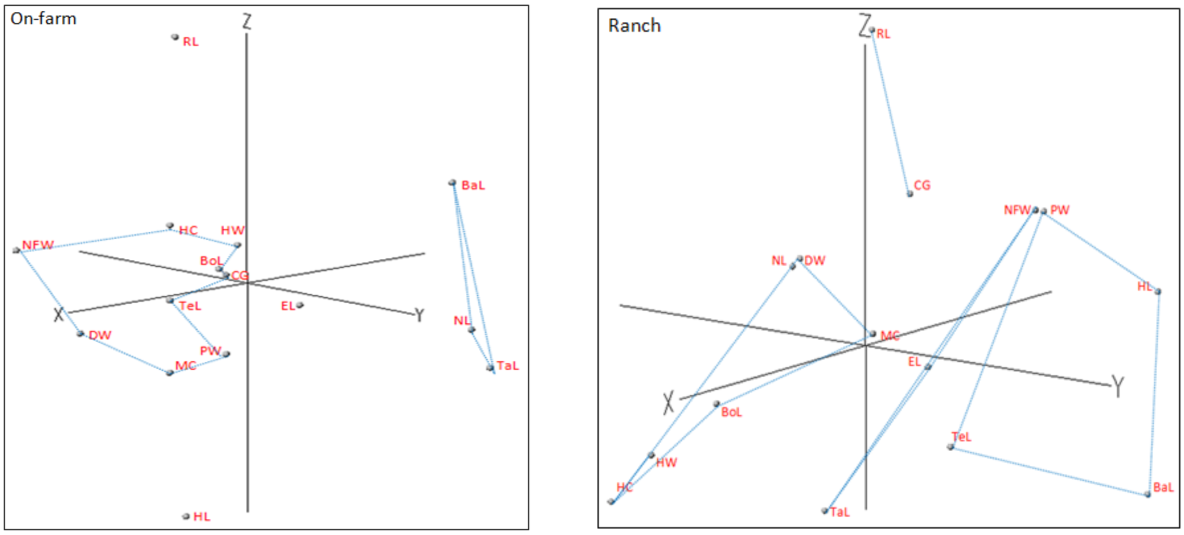

Figure 2. The component score plots of body length (BoL), chest girth (CG), height at withers (HW), neck length (NL), pelvic width (PW), rump length (RL), back length (BaL), teat length (TeL), ear length (EL), horn length (HL), muzzle circumference (MC), dewlap width (DW), naval flap width (NFW), hock circumference (HC) and tail length (TaL) on the 3D graphic for Begait cows kept in two different farming systems.

two indigenous cattle breeds of Nigeria with three discriminant variables entered (rump width, height at wither and face length). Pundir *et al.* (2015) obtained $r_c = 0.69$ in CDA to characterize the indigenous cattle breeds kept at three regions of India with six discriminant variables entered (height at wither, body length, ear length, tail length, paunch girth and face length). In addition, Putra *et al.* (2020b) obtained $r_c = 0.81$ in CDA to characterize two Indonesian *Bos indicus* cattle breeds with three discriminant variables entered (chest girth, body length and chest depth). The tolerance values (T) obtained in the present study were greater than 0.1 and indicated no collinearity problem among discriminator variables (Yakubu *et al.*, 2010). The stepwise discriminate analysis showed that seven body measurements of CG, HC, RL TeL, NL, HL and PW were the most discriminating variables between Begait cows kept in two different farming systems (Table 6). These seven morphometrical variables obtained in the present study are more important and informative and could be used to assign the three cattle populations into distinct populations, thereby reducing the error of selection in future breeding and selection programmes. The seven discriminant variables in this study increase the Mahalonobis distance (D^2) value from 1.19 to 2.09. Edouard *et al.* (2018) obtained nine discriminant variabels entered of head length, head width, skull length, skull width, chest girth, height at wither, chest depth, body length and muzzle length as the discriminant variables to characterize N'dama cattle kept at two different agro-ecological zones of Cote d' Ivoire.

Totally of 184 heads (77.6 %) of Begait cows kept in on-farm system were successfully classified into their origin population. Meanwhile, 88 heads (82.2 %) of Begait cows kept in ranch system were successfully classified into their original population (Table 7). Previous studies were successful to classify many cattle of Bunaji (85.48 %), Sokoto Gudali (96.55 %), Pasundan (87.5 %) and Ongole (100 %) breeds (Yakubu *et al.*, 2010; Putra *et al.*, 2020b). Pundir *et al.* (2015) has been worked with CDA to classify indigenous cattle into their original population at Tripura (84.13 %), Mizoram (82.09 %) and Manipur (79.87 %). Moreover, previous studies reported that about 90 % of N'Dama cattle and 70 % of Ethiopian indigenous cattle (Arsi, Kerayu and Arsi × Kerayu) can be classified into their original population

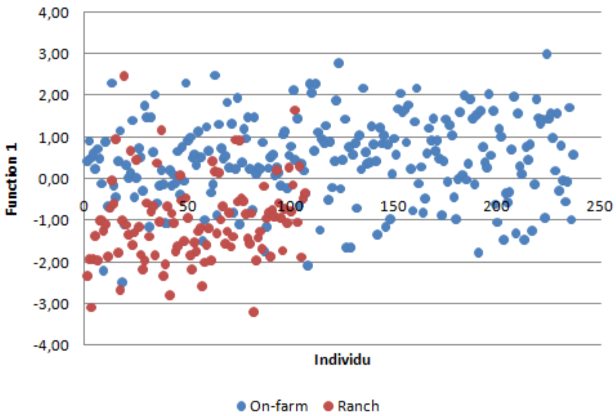

Figure 3. Canonical discriminant plot of body measurements to characterize Begait cows kept in two different farming systems

with CDA of body measurements (Edouard *et al.*, 2018; Merga and Tadesse, 2020). The canonical discriminant plots of Begait cows in two different farming systems were illustrated in Figure 3. According to Figure 3, the positive and negative values in the function 1 axis represent the on-farm and the ranch systems, respectively.

CONCLUSION

Begait cows kept in on-farm and ranch systems were successfully classified into their original farming system. The morphostructure of animals could be affected by the differences in the management systems, presence of subpopulations and gene admixtures of the animals. The results of this study can be used for field assessment, management and conservation of Begait cattle to obtain breed standard of pure local genetic resources and breeding improvement strategies in the future.

REFERENCES

Assefa, A. & Hallu, A. (2018). Ethiopian indigenous cattle breed's diversity, distribution, purpose of keeping, and their potential threats. *Journal of Bio Innovation*, 7(5), 770–789.

Boujenane, I. (2014). Multivariate characterisation of Oulmes-Zaer and Tidili cattle using the morphological traits. *Iranian Journal of Applied Animal Science*, 5(2), 293–299.

DAGRIS. (2006). *Domestic Animal Genetic Resource Information System (DAGRIS)*. International Livestock Institute. Addis Ababa, Ethiopia.

Edouard, N. K., Lacine, B. K., Cyrille, K. N., Etienne, L. N., Guiguigbaza-Kossigan, D. & Yapi-Gnaore, C. V. (2018). Multivariate anaysis for morphological characteristics of N'dama cattle breed in two agro-ecological zones of Cote d'Ivoire. *European Scientific Journal*, 14(3), 602–621. https://doi.org/10.19044/esj.2018.v14n3p602.

Gebreyohanes, M. F. (2015). *Production system and phenotypic characterization of Begait cattle, and effects of suplementation with concentrate feeds on milk yield and composition of Begait cows in Humera ranch*. Western Tigray, Ethiopia. Ph.D Thesis. Addis Ababa University, Ethiopia.

Gebru, T., Yigrem, S. & Banerjee, S. (2017). Some morphometrical, production and reproduction traits of Begait cattle reared in Tigray Region of Ethiopia. *Wayamba Journal of Animal Science*, 9, 1571–1585.

Grema, M., Traore, A., Issa, M., Hamani, M., Abdou, M., Fernandez, I., Soudre, A., Alvarez I., Sanou, M., Tamboura, H. H., Alhassane, Y. & Goyache, F. (2017). Morphological assessement of Niger Kuri cattle using multivariate methods. *South African Journal of Animal Science*, 47(4), 505–515. https://doi.org/ 10.4314/sajas/v47i4.9.

Heryani, L. G. S. S., Susari, N. N. W. & Gunawan, I. W. N. F. (2018). Principals components variables of Taro white cattle morphometrics based on body measurements. *Buletin Veteriner Udayana*, 10(1), 93–99. https://doi.org/ 10.24843/bulvet.2018.v10.i01.p15.

FAO. (2012). *Phenotypic Characterisation of Animal Genetic Resources*. FAO Animal Production and Health Guidelines No. 11. Commission on Genetic Resources for Food and Agriculture. Rome, Italy.

Merga, T. N. & Tadesse, Y. (2020) Morphological variations of Arsi, Kerayu and their crossbred cattle under current climate change in Mid Rift Valley of Oromia, Ethiopia. *Academic Research Journal of Agricultural Science and Research*, 8(6), 630–648. https://doi.org/10.14662/ARJASR2020.440.

Mezgebe, G., Gizaw, S. & Urge, M. (2018). Growth, reproductive, and productive performance of Begait cattle under different herd management systems in northern Ethiopia. *Tropical Animal Health and Production*, 50(1). https://doi.org/10.1007/s11250-018-1560-4.

Pares-Casanova, P. M. & Mwaanga, E. S. (2013). Factor analysis of biometric traits of Tonga cattle for body conformation characterization. *Global Journal of Multidisciplinary Applied Science*, 1(2), 41–46.

Pares-Casanova, P. M., Sinfreu, I. & Villalba, D. (2013). Application of verimax rotated principal component analysis in quantifying some zoometrical traits of a relic cow. *Korean Journal of Veterinary Research*, 53(1), 7–10. https://doi.org/ 10.14405/kjvr.2013.53.1.007.

Pundir, R. K., Singh, P. K. & Sadama, D. K. (2015). Multivariate analysis of morphometric traits of three different indigenous cattle populations from North East state of India. *Journal Ilmu Ternak dan Veteriner*, 20(2), 79–86. https://doi.org/10.14334/jitv.v.2012.1162.

Pundir, R. K., Singh, P. K., Singh, K. P. & Dangi, P. S. (2011). Factor analysis of biometric traits of Kankrej cows to explain body conformation. *Asian-Australasian Journal of Animal Science*, 24(4), 449–456.

Putra, W. P. B., Said, S. & Johar, A. (2020a). Principal component analysis (PCA) of body measurements and body indices in the Pasundan cows. *Black Sea Journal of Agriculture*, 3(1), 49–55.

Putra, W. P. B., Hilmawan, F. & Johar, A. (2020b). Characterization in two Indonesian *Bos indicus* cattle breeds based on morphometrical measurements. *Turkish Journal of Veterinary Research*, 4(1), 29–32.

Said, S., Putra, W. P. B., Anwar, S., Agung, P. P. & Yuhani, H. (2017). Phenotypic, morphometric characterization and population structure of Pasundan cattle at West Java, Indonesia. *Biodiversitas*, 18(4), 1638–1645. https://doi.org/10.13057/biodiv/d180443.

Shah, W. A., Ahmad, N., Javed, K., Saadullah, M., Babar, M. E., Pasha, T. N., Ahmad, S., Nasrullah, A. A., Farooq, M. Z. & Saleem, A. H. (2018). Multivariate analysis of Cholistani cattle in Punjab Pakistan. *Journal of Animal and Plant Sciences*, 28(3), 940–944.

Teweldemedhn, M. W. (2018). Characterization of productive and reproductive performances, morphometric and challenges and opportunities of indigenous cattle breeds of Ethiopia: A review. *International Journal of Livestock Production*, 9(3), 29–41. https://doi.org/ 10.5897/IJLP2017.0426.

Tolenkhomba, T. C., Konsam, D. S., Singh, N. S., Prava, M., Singh, Y. D., Ali, M. A. & Motina, E. (2012). Factor analysis of body measurements of local cows of Manipur. *International Multidisciplinary Research Journal*, 2(2): 77–82.

Tolenkhomba, T. C., Anal, W., Singh, N. S., Chaudhury, J. K. & Mayengbam, P. (2021). Principal component analysis of body measurements of Zobawng bulls: A local hill cattle of Mizoram, India. *Journal of Entomology and Zoology Studies*, 9(1), 2022–2026.

Verma, D., Varun, S., Sanjeet, K. & Yash, P. T. (2015). Principal component analysis of biometric traits to reveal body conformation in local hill cattle of Himalayan state of Himachal Pradesh, India. *Veterinary World*, 8(12), 1453–1457. https://doi.org/10.14202/ vetworld.2015.1453-1457.

Yakubu, A., Idahor, K. O., Haruna, H. S., Wheto, M. & Amusan, S. (2010). Multivariate analysis of phenotypic differentiation in Bunaji and Sokoto Gudali cattle. *Acta Agriculturae Slovenica*, 96(2), 75–80. https://doi. org/10.2487/v10014-010-0018-9.

Yakubu, A., Ogah, D. M. & Idahor, K. O. (2009). Principal component analysis of the morphostructural indices of White Fullani cattle. *Trakia Journal of Science*, 7(2), 67–73.