On-Farm Phenotypic Characterization of Begaria Cattle Population and Their Production System in Guba District, North Western Ethiopia

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ABSTRACT

Production system and phenotypic characterization study on Begaria cattle was carried out in Guba district of Metekel Zone, Benishangul Gumz Region of Ethiopia. Based on a result of a reconnaissance survey three different localities, namely, Mankush, Fanguso, and Almahal were purposively selected for the study. Questionnaires were administered to 40 cattle owners in the area to assess the production system and document the performance of Begaria cattle. Quantitative and qualitative measurements were made on a total of 134 (124 female and 10 male) adult cattle identified as Begaria by producers. Quantitative data were analyzed using PROC GLM procedure of SAS by fitting the three locations as a fixed factor and different body measurements as a dependent variable. Multivariate analysis of morphometric measurements was also done to quantify the distance between the sub-populations from the three sites. Sedentary and transhumant ways of life were practiced in the study area. Among livestock, cattle were ranked first in terms of importance with an index of 0.45 followed by goat and chicken with an index of 0.32 and 0.11, respectively. Chi-square goodness of fit test for coat colour pattern in Begaria cattle was significant (Chi-square=164.1, df=3, P<0.01). The majority (71.6%) of the cattle had plain or uniform coat colour pattern followed by shaded and pied 18.7% and 9%, respectively. There was also a highly significant association (Chi-square = 23.32, P<0.01) between study locations and coat colour pattern. White or cream coat colours were dominant among Begaria cattle and together they accounted for 58.2% of the total variation. Multivariate discriminant analysis has shown a high misclassification error of individuals belonging to the three different sites implying similarity among the populations and high within site variation. Begaria cattle had multipurpose roles and males were mainly kept for income generation, draught power, and breeding while females were mainly used for milk production, breeding and income generation. Lower milk yield was reported with high variation between villages. This calls for identification of the sources of variation and subsequent improvement of milk production. Mixing of Begaria cattle (large Zebu) with the short sized Zebu from adjacent highland districts in the region and Felata breed from the adjoining areas of the Republic of Sudan is considered as a potential threat for dilution of Begaria cattle population. Thus, setting up and implementing in-situ conservation and genetic improvement program is of high priority to conserve the diversity and sustainably utilize Begaria cattle.

***Keywords**: Begaria cattle, Ethiopia, Multivariate analysis, Phenotypic characterization, Production System,*

INTRODUCTION

Smallholder livestock production is an integral part of agriculture in Ethiopia and contributes tremendously to the livelihood and the national economy. When contribution to ploughing service is taken into consideration about 45% of the Agricultural GDP is estimated to be generated from livestock (Behnke, 2010). A total population of 59.5 million cattle (CSA, 2015) and 28 distinct populations (EBI, 2016) have been documented in Ethiopia. Due to the diverse agroecology and proximity to domestication route, Ethiopia is endowed with diverse animal genetic resources.

It is generally believed that most domestic animals were first domesticated in southwest Asia. The origin and development of African livestock have been a subject of studies in the past and

additional African origin has been forwarded for cattle by some of the studies (Grigson, 1991; Stock and Fifford-Gonzalez, 2013, Decker *et al.*, 2014; Okeyo *et al.*, 2015; Kim *et al.*, 2017). The presence of diverse breeds of livestock in the continent has called for characterizing the breeds for the purposes of utilization and conservation and, to date, numerous studies have been undertaken. However, there are still a population of livestock in some remote areas which have not been characterized. In Ethiopia, one such population is Begaria cattle in the northwestern part of the country. The breed is believed to have unique adaptive and productive traits suitable for survival and performance under the low-input and hot climatic condition of the area. In addition to that, the area is among parts of Ethiopia where Trypanosomiasis is prevalent (Solomon and Fitta, 2011; Samson *et al*., 2016) and the breed is possibly trypanotolerant.

Characterization of a population of livestock is necessary for proper identification of breeds and to command appropriate breeding program for sustainable improvement, conservation and sustainable utilization of animal genetic resources (FAO, (2015). The present study was undertaken to characterize Begaria cattle of Ethiopia with the objectives of assessing the morphological and quantitative characteristics of Begaria cattle; evaluating its productive and reproductive performances; and understanding the breed's status, breeding objectives, origin, distribution and production system.

MATERIALS AND METHODS

Study areas

The study was conducted in Guba district, Metekel zone of the Beneshangul Gumuz Regional State in northwestern Ethiopia. Three villages (Mankush, Fanguso and Almahal) which had higher and more homogenous population of Begaria cattle in terms of size and color were purposively selected. Study areas bordered with Sudan to the West, Amhara Regional State to the north and east and other districts of Beneshangul Gumuz Region in the South. The sampling frame was defined after a review of available secondary information on the presence of unique cattle populations in Metekel zone and a subsequent exploratory field visit. A rapid exploratory survey of farm animal genetic resources was conducted in Benishangul Gumuz Regional State from January to February 2012. The survey involved on-farm observations of cattle populations and key informant discussions (with livestock researchers, agricultural experts, and knowledgeable farmers) revealed the presence of an apparently distinct population of cattle in Guba district.

The climate of the study areas can be classified as hot and humid. Agro-ecologically the study area is found in the lowlands within an altitude ranging from 531 to 860 m a.s.l. The district receives mean annual precipitation of 965 mm during June to September with uni-modal distribution (Addisu, 2010).

Data collection

Survey data

A formal survey was conducted in March, 2012 during which farmers were interviewed with the help of semi-structured questionnaires. Questionnaires were administered to 40 cattle owners (12 in Mankush, 12 in Fanguso and 16 in Almahal). The criteria used to select respondents were ownership of cattle, experience in cattle husbandry in the area, and willingness to participate in the study. The main issues addressed in the questions were herd structure; importance of cattle in the livelihoods of the community; management system; milk production, growth and reproductive performance; and resilience of the cattle population.

Qualitative and quantitative measurements

Measurements on qualitative and quantitative (linear) characters were performed on a total of 134 (124 female and 10 male) randomly selected adult cattle (Table 1) from herds encountered in a transect walk in each of the sites (villages). A limited number of animals were sampled due to their low population and difficulty in restraining animals with little contact with humans in the wilderness except for their keepers. The physical maturity of the cattle subject to measurements was confirmed from observation of their dentition and verification of age by their keepers. Data were collected according to the FAO guidelines (FAO, 2012).

Table 1. Number of animals sampled and questionnaires administered by study site

Site	Quantitative and qualitative traits		Questionnaires administered
	Males	Females	
Mankush	-	33	12
Fanguso	3	47	12
Almahal	7	44	16
Total	10	124	40

A total of 25 qualitative traits (including some size traits categorized qualitatively) and 9 quantitative measurements were recorded. Qualitative traits included in the study were: coat colour pattern, coat colour type, muzzle colour, eyelid colour, hoof colour, horn presence, horn condition, horn spacing, horn shape, horn orientation, ear shape, ear orientation, hump shape, hump size, hump position, udder size, teat size, facial profile, back profile, rump profile, testes size, tail length, naval flap width, preputial sheath, and dewlap width. Quantitative measurements were made on body length, heart girth, height at wither, pelvic width, mouth circumference, ear length, horn length, cannon bone length and hock circumference. Measurements were taken using a textile measuring tape to the nearest unit centimeter.

Data analysis

All data were entered, cleaned and managed on MS Excel© worksheet. Multiple range test was performed on all area means of body measurement traits of females. Cross-tabulation was performed with SPSS v. 22.0 (IBM Corp, 2013) on categorical data to describe the proportion and to test association among fixed factors (sites) and dependent (categorical) variables. Chi-square test was used to test the significance of the association. Fisher's exact test was used when the number of samples in each cell was less than the expected value (when 75 % have less than 5 counts).

Indices were calculated to provide ranking on the importance of domestic livestock species in the area. The formula used in the calculation of the indices is Index= sum of (3 x number of household ranked first + 2 x number of household ranked second + 1 x number of household ranked third) given for each species divided by sum of (3 x number of household ranked first + 2 x number of household ranked second + 1 x number of household ranked third) for all species ranking.

PROC FREQ in SAS was used to know the relative frequency of qualitative characters per sampling site. Quantitative data were analysed separately for the two sexes using the PROC GLM in SAS. Taking site and sex as fixed main effects, the following model was used in the analyses:

$$Y_{ijk}=\mu + S_i + D_j + e_{ijk}$$

where Y_{ijk} is the observed value of the linear body measurements, S_i is the fixed effect of site i (i=1, 2,3), D_j is the effect of the jth sex (j=1,2), and e_{ijk} is the residual error. Interaction effect of the ith site with the jth sex was not statistically significant and was dropped out from the final model.

Computation of Pearson correlations among body measurements was done with PROC CORR. Stepwise discriminant procedure was applied on female sample populations using PROC STEPDISC to determine which morphological traits had more discriminant power than the others. The CANDISC procedure was used to perform canonical analysis to derive canonical functions, linear combinations of the quantitative variables that summarize variation between areas and compute Mahalanobis distance matrix. The percent assignment of cattle populations into their sampling area was made by using DISCRIM procedure.

RESULTS AND DISCUSSION

Production system

All the cattle owners involved in this study practice mixed crop-livestock production. However, there was a significant association between the study site and priority in farming activity (Chi-square 8.865, $P<0.05$). For most of the farmers (91.7%) in Mankush, livestock production was their main activity. Contrary to this, crop production was considered as the main activity in the other two locations, 71.4% in Fanguso and 54.5% in Almahal. Cropland holding was highest in Almahal site with mean size of 9.5 ± 1.39 ha per household. This was significantly higher than the land holdings in Fanguso (3.2 ± 1.65 ha). Landholding in Mankush was intermediate between the two sites (6.0 ± 1.51 ha) and not significantly different from the other two sites. There was a significant association (Chi-square=19.336, P<0.01) between livestock mobility and study sites. Most of the cattle owners interviewed at Almahal were leading a sedentary way of life while all the cattle owners from Mankush were practicing transhumance. Both sedentary farming and transhumance were identified among cattle owners at Fanguso site (Table 2). Respondents in all sites reported the practice of communal grazing, which is a good opportunity to facilitate sharing of best bulls among herds if the communities are willing to cull unselected males.

Table 2. Agricultural production system and livestock management practices in Guba district

Variable	Overall	Site			Chi-square	*P* values
		Mankush	Fanguso	Almahal		
Production system						
Crop livestock	40(100.0)*	12(100.0)	12(100.0)	16(100.0)		
Main farming activity					8.865	0.007
Livestock	18(60)	11(91.7)	2(28.6)	5(45.5)		
Crop	12(40)	1(8.3)	5(71.4)	6(54.5)		
Livestock management					4.542	0.152
Extensive	34(85.0)	11(91.7)	8(66.7)	15(93.8)		
Semi-intensive	6(15.0)	1(8.3)	4(33.3)	1(6.2)		
Mobility					19.336	0.000
Sedentary	19(57.6)	0(0.0)	4(40.0)	15(93.8)		
Transhumance	14(42.4)	7(100.0)	6(60.0)	1(6.2)		

*Number within parenthesis in the table indicate percent out of total respondents

Livestock species herd size and ranking

About 80%, 67.5%, 60% and 25% of cattle owners reported keeping goats, donkeys, chicken and sheep, respectively. Ownership of horse or mule was not reported except by one farmer. Based on the perception of the farmers, the population of Begaria cattle in the study area was reported to be increasing (75%), 11% reported that the population was stable whereas rh remaining14% said that it

was decreasing. The increasing trend was attributed to growing interest of farmers to maintain the breed due to its fast growth and good market price.

There was no significant difference (P>0.05) on cattle, equine and sheep holding per household among different sites (Table 3). However, goat and chicken holdings were affected by location where farmers in Fanguso had a larger number of goats and chickens. Overall mean livestock holding per household were 19.3, 11.2, 3.8, 8.6 and 1.3 for cattle, goat, sheep, chicken, and donkey, respectively. The number of cattle per household is higher than 2 to 4 and 10 to 15 animals reported by Asfaw *et al*. (2013) for the highland and pastoral lowland areas, respectively. Comparison of livestock holding within site revealed that cattle number was higher in Mankush and Almahal followed by goat and chicken. However, in Fanguso goat was largest in number followed by chicken and cattle. The larger possession of cattle per household indicates the availability of ample feed and grazing area, larger land holding (Table 3) as compared to other areas of the country and also the importance of cattle in the livelihood of the framers in the area.

Table 3. Mean domestic animal and land holding ± standard errors per household in Guba district

Species/land	Overall	Site			*P* value
		Mankush	Fanguso	Almahal	
Domestic animal					
Cattle	19.3 ± 3.08	19.25 ± 5.58	13.3 ± 5.58	25.3 ± 4.83	0.278
Goat	11.2 ± 1.43	7.5 ± 2.49^{a}	16.5 ± 2.73^{b}	9.6 ± 2.16^{a}	0.049
Sheep	3.8 ± 1.12	3.14 ± 1.97	6.2 ± 2.06	1.7 ± 1.76	0.263
Chicken	8.6 ± 1.20	5.1 ± 2.18^{a}	14.1 ± 2.18^{b}	6.1 ± 1.89^{a}	0.005
Equines	1.3 ± 0.21	0.8 ± 0.37	1.8 ± 0.37	1.3 ± 0.32	0.229
Land holding	6.2 ± 0.88	9.5 ± 1.39^{a}	3.2 ± 1.65^{b}	6.0 ± 1.51^{b,a}	0.020

Values with different superscript letter within a row are significantly different at P = 0.05.

Among livestock, cattle were ranked first in terms of importance with an index of 0.45 followed by goat and chicken with an index of 0.32 and 0.11, respectively (Table 4). Extensive livestock management system was predominant (85%) in all of the sites. However, 15% reported that they practiced semi-intensive management where supplementary feeding was given apart from grazing and shelters were provided.

Table 4. Ranking of livestock species based on perceived importance by households in Guba district

Species	Rank 1st	Rank 2nd	Rank 3rd	Index
Cattle	13	3	3	0.449
Sheep	1	0	5	0.075
Goat	5	9	1	0.318
Chicken	0	4	4	0.112
Equines	0	2	1	0.047
Sum	19	18	14	1.00

Index= sum of (3 x number of household ranked first + 2 x number of household ranked second + 1 x number of household ranked third) given for each species divided by sum of (3 x number of household ranked first + 2 x number of household ranked second + 1 x number of household ranked third) for all species ranking.

Cattle herd structure

Cattle holding per household observed in this area was higher than the average cattle holding of 9.54 in northwestern lowlands (Ftiwi and Tamir, 2015). With larger land holding per person in the area there is a possibility of establishing ranching type of production system. Herd composition of Begaria cattle are presented in Table 5. About 30% of the total cattle population were cows with above 3 years old.

Table 5. Cattle herd structure by age and sex reported by households in Guba district

Sex and age category	Mean	Percent
Male		
Less than 1 year	2.57	13.32
1 to 3 year	3.01	15.60
Above 3 years	2.35	12.20
Female		
Less than 1 year	2.51	12.98
1 to 3 year	3.01	15.61
Above 3 years	5.85	30.29
Total	19.3	100

Coat color pattern, type and other morphological characters

Chi-square test for coat colour pattern was significant (Chi-square=164.1, *df*=3, *P*<0.01). Majority (71.6%) of the cattle had plain or uniform coat colour pattern followed by shaded and pied 18.7% and 9%, respectively (Table 6). Spotty coat colour pattern was found rarely (0.7%). Coat colour pattern of Begaria cattle observed in this study area varied remarkably from the findings of Getachew (2006) who found predominantly uniform coat colour pattern (56.7%) among the adjacent West Gojjam Highland Zebu cattle populations. There was also highly significant association (Chi-square = 23.32, P<0.01) between study locations and coat colour pattern. Thus the odds of being uniform in colour were calculated as the ratio of frequency of uniform colour to frequency of non-uniform colour. The odds of being uniform colour in Begaria cattle was 2.52, 1.06, 2.57 and 5.38 for the overall location, Mankush, Fanguso and Almahal, respectively. This result showed cattle in Almahal were more likely to be uniform in colour as compared to cattle from other locations.

Table 6. Colour pattern and type of Begaria cattle in different districts

Coat colour pattern and type	Overall	Site			Chi-square	P value
		Mankush	Fanguso	Almahal		
Pattern						
Plain	96(71.6)	17(51.5)	36(72.0)	43(84.3)	23.316	<0.0003
Pied	12(9.0)	1(3.0)	6(12.0)	5(9.8)		
Spotty	1(0.7)	-	-	1(2.0)		
Shaded	25(18.7)	15(45.0)	8(16.0)	2(3.9)		
Odds of being uniform	2.5	1.06	2.57	5.38		
Muzzle colour						
Non-pigmented	14(10.7)	7(14.0)	2(4.0)	5(16.1)	3.879	0.136
Pigmeneted	117(89.3)	43(86.0)	48(96.0)	26(83.9)		
Eyelid colour						
Non-pigmented	10(7.5)	4(7.8)	1(2.0)	5(15.6)	5.222	0.063
Pigmeneted	123(92.5)	47(92.2)	49(98.0)	27(84.4)		
Hoof colour						
Non-pigmented	2(1.5)	1(2.0)	0(0.0)	1(3.0)	1.364	0.714
Pigmeneted	132(98.5)	50(98.0)	50(100.0)	32(97.0)		

White or cream colour (Figure 1) were the dominant coat colour in Begaria cattle and accounted for 58.2% of the coat colour variation (Table 7). Association between coat colour type and location was at the margin of significance level (*P*=0.05). White or creamy colour was most frequent in Fanguso

and Almahal with a percentage value of 64.7 and 60.0 %, respectively compared to in Mankush (45.5 %). Based on a study on two Sub-types of Baggara cattle in Sudan Alsiddig *et al*. (2010) reported about 45% of the cattle to be of white colour while 34% were light to dark red brown. Albeit in different proportions, all the colour types indicated in the study of Alsiddig *et al*. (2010) were also found in the current study. In addition to coat colour, cervico-thoracic hump position and white and medium to small horn size with curved shape observed in this study was in agreement with the description of Baggara breed reported in Sudan (Alsiddig *et al.*, 2010).

The cattle breeds of Ethiopia in areas adjacent to the study area include Horro and Begait cattle. Horro cattle which is distributed along the eastern and south-eastern borders of Benishangul-Gumuz region are dominated by uniform brown and reddish colour (Hassen *et al.*, 2007) while the Begait breed found in the far North Ethiopia along the Sudan border and managed in similar production environment, are of predominantly non- uniform coat colour pattern with black and white combination (Ftiwi, 2015). This is an indication of the uniqueness of the breed to the other breeds in adjacent areas. However, the dominant coat color of Begaria cattle has similarity with the white and grey colour of Ogaden and Boran cattle breed found in south eastern part of Ethiopia and inhabiting similar lowland agro-ecology (Sisay, 1996; Getnet *et al*., 2009; Getachew *et al*., 2014, Mekuriaw and Kebede, 2015). Begaria breed had shown some similarity in coat colour with the Mahebere Selassie composite cattle population (Zewdu *et al.*, 2008) indicating the later could belong a sub-population of the Begaria breed. Further molecular study considering the similar transboundary or inland populations would give clue on the ancestral similarity among populations.

Table 7. Coat colour type of Begaria cattle in different sites in Guba district

Coat colour type	Overall	Site			*P* value
		Mankush	Almahal	Fanguso	
White or creamy	78 (58.2)	15 (45.5)	33 (64.7)	30 (60.0)	0.05
Black	2 (1.5)	0 (0.0)	0 (0.0)	2 (4.0)	
Red or brown	15 (11.2)	2 (6.06)	9 (17.7)	4 (8.0)	
White and black or grey	23 (17.2)	10 (30.3)	4 (7.8)	9 (18.0)	
White and red or brown	16 (11.2)	6 (18.2)	5 (9.8)	5 (10.0)	

Light colour of the breed might be associated with thermoregulation. Light-colored hair coats and hair coats that are sleek and shiny reflect a greater proportion of incident solar radiation than hair coats that are dark in color or more dense and wooly (Hansen, 2004). Finch and Western (1977) also found that the proportion of light colour increased with heat stress telling us cattle evolved in high-temperature area become progressively lighter in colour. Pigmentation on the muzzle, eyelid, and hoof had no association with study sites (P>0.05). Pigmentations were common on the muzzle (89.3%), eyelid (92.5%) and hoof (98.5%) of the Begaria cattle population in the study area.

All of the Begaria cattle sampled during the study had horns, flat facial profile, lateral ear orientation with straight-edged shape and erect cervico-thoracically positioned hump (Table 8). Majority (89.23%) had narrow (<30 cm) horn spacing. Most (79.89%) of the cattle were characterized by possessing curved horns. Predominantly the breed had small humps (84.96 percent). A large number of the cows had small udder (59.68%) with medium teat size (37.90%). Most of the cattle (96.27%) had straight back profile with sloppy ramp (98.51%). A considerable number (57.14%) of mature Begaria bulls had large testes and large preputial sheath (40.00%). On the other hand, a large proportion (48.39%) of the cows were observed to have medium naval flap width. Long tail length (well below the hocks) was common (86.47%) among the cattle population while almost half of them (50.75%) exhibited medium dewlap width. The horns of Begaria cattle is short 18.7 and

20.8 cm for male and female, respectively. Males included in the sample were small in number and relatively younger than the females. Horn growth continues throughout the animals life and that might explain the larger horn length in females than males. Loose horns/lateral orientation of horns is commonly found with 21.6% of the total population. Despite the extensive variation, morphological features observed here are similar with Baggara and Kenana cattle breed found in western and southern Sudan (Yousif and Moula, 2006; Alsiddig *et al.*, 2010) and Borena and Ogaden breeds in Ethiopia (Mekuriaw and Kebede, 2015). Baggara cattle of Sudan which the population of cattle under investigation is believed to have originated from have been reported not to be a uniform type of cattle (Elkhalifa *et al*.,1985 Cit. Bashir and El Zubeir, 2013a).

Table 8. Frequency of discrete variables in Begaria cattle of sampled populations

Discrete variable		Number	Per cent
Horn presence	Present	134	100.00
Horn condition	Horned	115	85.82
	Scurs	14	14.18
Horn spacing	Narrow (<30cm)	116	89.23
	Wide (>30cm)	14	10.77
Horn shape	Curved	107	79.89
	Straight	27	20.15
Horn orientation	Upright	63	47.01
	Lateral	29	21.64
	Forward	27	20.15
Ear shape	Straight edged	134	100.00
Ear orientation	Lateral	134	100.00
Hump shape	Erect	134	100.00
Hump size	Small	113	84.96
	Medium	16	12.03
	Absent	3	2.26
Hump position	Cervico-thoracic	134	100.00
Udder size	Small	74	59.68
	Medium	47	37.90
	Large	3	2.42
Teat size	Small	41	33.06
	Medium	47	37.90
	Large	36	29.03
Face profile	Flat	134	100.00
Back profile	Straight	129	96.27
	Curved	5	3.73
Rump profile	Sloppy	132	98.51
Testes size	Medium	3	42.86
	Large	4	57.14
Tail length	Nearly below hocks (medium)	11	8.27
	Well below hocks (long)	115	86.47
Naval flap width	Small	38	30.65
	Medium	60	48.39
	Large	21	16.94
Preputial sheath	Small	1	20.00
	Medium	2	40.00
	Large	2	40.00
Dewlap width	Small	8	5.97
	Medium	68	50.75
	Large	57	42.54

Figure 1. Begaria cow (left) and Begaria bull (right) from Almahal site.

Linear body measurements

The analysis was done for male and female separately. Descriptive statistics for linear body measurement and least square means with a standard error by district for both and female Begaria cattle are presented in Table 9, and 10, respectively. As expected males were larger (P<0.05) in size (body length, heart girth, and height at wither) than females (results not presented here). Among linear body measurements, body length, heart girth, height at wither and pelvic width were not affected by the study districts (P>0.05). On the other hand, among the variables, ear length (EL), horn length (HL), hock cirumference (HC) and cannon bone length (CBL) were significantly affected by district (P < 0.01) for females.

Table 9. Least square means (± SE) of quantitative body measurements (cm) for all sites by sex

Dependent variable	Sex		
	Male (N=10)	Female (N=124)	Probability of difference
	119.00 ± 2.28	111.44± 0.61	P<0.0017**
EL	21.67 ± 0.67	22.02 ± 0.18	P<0.6169
HL	18.67 ± 2.70	20.70 ± 0.72	P<0.4676
HC	37.89 ± 0.73	34.45 ± 0.20	P<0.0001**
HG	172.89 ± 2.75	156.17 ± 0.74	P<0.0001**
HW	131.56 ± 1.93	125.31 ± 0.52	P<0.0022**
PW	40.11 ± 0.84	39.56 ± 0.22	P<0.5263
CL	25.11 ± 0.58	24.10 ± 0.15	P<0.0938
MC	42.67 ± 1.04	40.02 ± 0.28	P<0.0153*

*P<0.05, **P<0.01; BL=Body length, HG=Heart girth, HW=Height at withers, PW=Pelvic width, MC=Mouth circumference, EL=Ear length, HL=Horn length, CL=Cannon bone length, HC=Hock circumference

Table 10. Least square means ± standard errors and coefficient of variation (CV) of different linear body measurements of female Begaria cattle by study site.

	Overall	CV (%)	Site			Signifcance level (P)
			Mankush	Funguso	Almahal	
BL	111.5±0.64	6.3	112.3 ± 1.23	111.1 ± 1.03	111.2 ± 1.06	0.7148
HG	155.6±0.76	5.3	153.4 ± 1.45	156.7 ± 1.20	157.7 ± 1.26	0.0765
HW	125.1±0.50	4.4	124.4 ± 0.97	124.9 ± 0.79	125.9 ± 0.83	0.4855
PW	39.6±0.20	5.6	39.1 ± 0.39	40.2 ± 0.32	39.5 ± 0.33	0.0891
MC	40.2±0.19	5.3	39.8 ± 0.37	40.1 ± 0.32	40.6 ± 0.32	0.265
EL	22.2±0.14	6.8	22.8 ± 0.26[a]	22.4 ± 0.22[a]	21.3 ± 0.23[b]	0.0001
HL	20.8±0.69	37.7	21.1 ± 1.32[a]	17.3 ± 1.11[b]	24.0 ± 1.14[a]	0.0003
HC	34.4±0.19	6.1	34.0 ± 0.37[a]	35.4 ± 0.31[b]	33.8 ± 0.32[a]	0.0007
CBL	24.0±0.15	6.8	23.4 ± 0.29[a]	23.9 ± 0.24[a]	24.8 ± 0.25[b]	0.0011

BL= body length, HG= heart girth, HW= height at wither, PW= pelvic width, MC= mouth circumference, EL= ear length, HL= horn length, HC= hock circumference, CBL= cannon bone length

Body length, height at wither and heart girth of female Begaria cattle were lower than 128.1 cm, 131.5 and 159.6 cm, respectively, reported for the Begayit breed (Ftiwi and Tamir, 2015). However, Begaria was found to be larger than Gojjam Highland Zebu and Horro cattle in the adjoining areas and Ogaden cattle in eastern Ethiopia (Getachew and Ayalew, 2014; Dereje, 2015; Getachew *et al*., 2014). Begaria cattle was shorter in body length compared to the composite Mahibere selassie (Zewdu *et al.*, 2008), and Mursi breeds (Terefe *et al.* 2015). However, Begaria was larger in height at wither and heart girth than these breeds.

Correlation coefficients among morphological traits of Begaria cattle combined from the three site are shown in Table 11. High and significant correlations were found between BL and HG; and HW and HG (0.42). The lowest and significant correlation coefficient was recorded between MC and EL (0.17). Nakachew (2009) reported higher correlation (0.49) between HG and BL in Abigar cattle than the correlation obtained in the current study. Edouard *et al*. (2018) also reported higher (0.59) correlation between HG and BL.

Table 11. Phenotypic correlation coefficient values (r) among body measurements in Begaria cattle populations of both sexes (n=132)

Trait	**BL**	**HG**	**HW**	**PW**	**MC**	**EL**	**HL**	**CL**
HG	0.41**							
HW	0.33**	0.42**						
PW	0.25**	0.33**	0.38**					
MC	0.28**	0.47**	0.31**	0.18*				
EL	0.15	0.18*	0.10	0.15	0.17*			
HL	0.21*	0.15	0.19*	-0.03	0.26**	0.14		
CL	0.27**	0.38**	0.49**	0.30**	0.22*	-0.02	0.15	
HC	0.33**	0.49**	0.47**	0.36**	0.24**	0.24**	0.02	0.34**

*P<0.05, **P<0.01; BL=Body length, HG=Heart girth, HW=Height at withers, PW=Pelvic width, MC=Mouth circumference, EL=Ear length, HL=Horn length, CL=Cannon bone length, HC=Hock circumference

Multivariate analyses

Stepwise discriminant analysis

Out of the nine quantitative variables separately subjected to the STEPDISC procedure of SAS (2003) from females (Table 12), five were found significant ($P < 0.01$) and more important in differentiating cattle between sites. However, CL followed by HC had more discriminant power as shown by their higher R^2 and *F*-values. The variable in the model that contributed the least to the discriminatory power of the model as measured by Wilks' lambda failed to meet the criterion to stay, then that variable was removed. Similarly, the importance of ear length as a discriminant variable has been observed in the study of three different indigenous cattle populations from North East states of India (Pundir *et al*. 2015).

Table 12. Stepwise selection summary table for female sample population

Step	Entered	Partial R^2	*F* value	*Pr >F*	Wilk's Lambda	Pr<lambda	Average squared canonical correlation	ASCC
1	HL	0.12	8.31	*P*=0.0004	0.88	*P*=0.0004	0.06	*P*=0.0004
2	HC	0.13	8.83	*P*=0.0003	0.76	*P*<0.0001	0.12	*P*<0.0001
3	CL	0.15	10.26	*P*<0.0001	0.65	*P*<0.0001	0.18	*P*<0.0001
4	EL	0.09	5.63	0.0046	0.59	*P*<0.0001	0.22	*P*<0.0001
5	HG	0.04	2.22	0.1135	0.57	*P*<0.0001	0.24	*P*<0.0001

Note: HL=horn length; HC=hock circumference; CL=cannon bone length; EL=ear length; HG=heart girth

Discriminant analysis

The variables with low discriminatory power from STEPDISC procedure were observed to be useful in improving the correct classification percentage and Mahalanobis distances and hence were not removed from the model used in DISCRIM and CANDISC procedures. The discriminant analysis showed a high misclassification error of individuals (Table 13) belonging to Mankush (36.4 percent), Fanguso (30.4 percent), and Almahal (20.4 percent) indicating similarity among the three sample populations on morphological basis and the existence sizeable within site variation. Animals sampled from Almahal were relatively more homogenous than animals from the other two sites. For two population of N'Dama cattle, Edouard *et al*. (2018) have reported a very high percentage (96.3) of correct classification of animals in their respective populations. Elkhalifa *et al*. (1985 Cit. Bashir and El Zubeir, 2013a) indicated that Baggara cattle of Sudan (which is assumed to be the main origin of Begraia cattle) not to be a uniform type of cattle with sizeable variation within the breed.

Table 13. Number of observations and percent classified (below) in different sites for the female sample population using discriminant analysis

From site	Mankush	Fanguso	Almahal	Total
Mankush	21 (63.6)	5 (15.5)	7 (21.2)	33 (100.00)
Fanguso	7 (15.2)	32 (69.6)	7 (15.22)	46 (100.00)
Almahal	3 (6.8)	6 (13.6)	35 (79.6)	44 (100.00)

Canonical discriminant analysis

The Mahalanobis distance between sites for female sample populations was generally low. The pair-wise squared Mahalanobis distance between sites for female sample populations were significant ($P<0.01$) at Almahal when measured from samples at Mankush (2.4) and Fanguso (2.7) indicating that populations from this site were slightly different from the other two. The distance ($P<0.01$) between Mankush and Fanguso was even shorter (1.45). Unlike in the current study, Edouard *et al*. (2018) have reported higher distance (3.69) between two populations of N'Dama cattle in Côte d'Ivoire.

Purpose of keeping Begaria cattle

Results of this survey revealed that Begaria cattle had multi-purpose roles. Males were mainly kept for income generation, as sources of draught power and for breeding purpose, in their order, with ranking index (I) of 0.299, 0.266 and 0.179, respectively (Table, 14). Draught power was more important in areas where crop production was a main agricultural activity. However, during the group discussion, respondents reported that Begaria cattle, despite its large size, is not as good as cattle from adjacent areas in terms of ploughing performance. The reason could be Begaria cattle has its origin from the Baggara and other cattle of Sudan which are mainly developed under pastoral livestock production system (FAO, 1957) and selection (natural and/or artificial) for draught purpose is unlikely to take place. The main purpose of keeping female Begaria cattle was for milk production (I = 0.396), followed by use as breeding animal (I = 0.358) and source of income (I = 0.139). Multipurpose role of cattle observed in this study is also well documented in many tropical countries (Mekonnen *et al.*, 2012). However, Begaria cattle are mainly preferred for income generation from the sale of male animals and for milk production as opposed to major use for draught power of Horro (Dereje, 2015) and Gojjam Highland Zebu (Getachew, 2006) cattle found in the adjoining areas. Use of cattle mainly for sale and consumption than traction power implies that livestock production is predominant in the area as compared to crop production. This is in agreement with the use of Begayit cattle in the northwestern lowland part of Ethiopia which are also kept for breeding and milk production (Ftiwi and Tamir, 2015) and Butana and Kenana cattle breed in Sudan primarily kept for income and milk rather than traction power (Musa *et al.*, 2006). Fast growth of males and milk yield traits can be identified as the two most important traits of Begaria cattle. These traits and associated traits like adaptation and reproductive performances need to be incorporated in designing breeding program for the improvement of Begaria cattle which has lived for many generations at extremely low altitude characterized by high temperature and shortage of water.

Table 14. Ranking of purpose of keeping male and female Begaria cattle

Purpose	Males				Females			
	Rank 1st	Rank 2nd	Rank 3rd	Index	Rank 1st	Rank 2nd	Rank 3rd	Index
Meat	1	5	6	0.103	0	1	3	0.027
Milk	0	0	0	0.000	15	13	3	0.396
Draught power	13	4	2	0.266	0	1	0	0.011
Breeding	4	8	5	0.179	15	11	0	0.358
Saving	3	5	4	0.125	0	3	6	0.064
Wealth status	0	0	1	0.005	0	0	0	
Ceremony	0	2		0.022	0	0	1	0.005
Income source	10	7	11	0.299	2	3	14	0.139
Sum	31	31	29	1.000	32	32	27	1.000

Index= sum of (3 x number of household ranked first + 2 x number of household ranked second + 1 x number of household ranked third) given for each purpose divided by sum of (3 x number of household ranked first + 2 x number of household ranked second + 1 x number of household ranked third) for all purpose ranking.

Breed origin, distribution and mating practices

The source of Begaria breed in the area is reported to be within the same district, (47.1%), from the neighboring district (20.6%) or from the adjoining areas of the republic of Sudan (29.4%). The majority (65 %) of the respondents believed that the breed was kept in the area for more than 30 years. Begaria cattle producers describe the breed to have short horn size and white or creamy coat colour with dark gray shades to the neck, head, and hump. They perceived that the breed is large as compared to the breeds in the adjoining areas. They also recognized the breed has fast growth and is highly demanded for meat by the domestic market and export market in the adjoining Sudanese areas. Cross of Begaria cattle with the cattle from the adjoining areas (called by producers as Habesha) is given a name Beladi Cattle. Baggara breed in Republic of Sudan have similar physical appearance with Begaria cattle characterized in this study. Furthermore, dissimilarity of this breed to the other breeds in the adjoining areas of Ethiopia confirmed that the breed might have diverged from the Baggara breed of Sudan and later developed unique features.

Natural mating was the only mating system and predominantly uncontrolled due to communal grazing land and scarcity of labor. Majority of the farmers (82.9%) were reported to have Begaria bulls and the remaining proportion of farmers (14.3%) had mixed (Beladi) and 2.9% had Habesha bulls. Almost half (45.9%) of farmers practiced castration. Better draught power, improve fattening for better market price and controlled breeding were mentioned by farmers as reasons for castration.

Currently use of exotic breeds for crossbreeding is limited in the area however mixing with surrounding short sized Zebu and Felata breed introduced from Sudan has been a potential threat for the dilution of Begaria cattle. Farmers in the area have been introducing the highland Zebu for draught purpose because of the relatively cheaper price and better traction performance of the highland zebu as compared to Begaria cattle.

Performance levels

Age at sexual maturity, first calving and market age

Mean (SE) of age at sexual maturity for male and female Begaria cattle was 30.1 (1.48) and 30.1 (1.06) months, respectively (Table 15). Location has significant ($p<0.05$) effect on this trait for both male and female, where the value for Almahal was higher than for the other two locations. Overall

age at first calving (AFC) and calving interval (CI) for Begaria cattle was 40.7 and 17.3 months, respectively. This was better than a value of 59.8 and 22.6 reported for Horro breed in the adjoining highland areas (Dereje, 2015), 48.8 and 23.5 months, for breeds in Gojjam Highland (Getachew, 2006) and 52 months for Baggara cattle in the South Kordofan state of Sudan (Bashir and El Zubeir, 2013b).

AFC and CI were also significantly influenced by location. AFC at Almahal (46.3 ± 1.32) was higher ($p<0.05$) than the AFC for the other two locations (39.3±1.60 at Fanguso and 36.5 ± 1.45 at Mankush). The AFC for the latter two locations were not different from each other. Significantly lower CI, (13 ± 1.9 months) was reported in Fanguso site compared to the other locations (18.2 and 20.6 months in Almahal and Mankush, respectively.) In addition to the smaller average cattle holding in Fanguso as compared to the other sites (Table 3) the semi-intensive type of management being practiced in more households (Table 2) than in the other sites may partly explain for the difference in CI.

Milk production performance

Mean milk yield of Begaria cattle was 1.9 ± 0.24 litter per day (Table 15). There was no significant difference ($P>0.05$) in the mean milk yield among the different sites. However, lactation length and milking frequencies were significantly affected ($P<0.05$) by study site. Lactation length of Begaria cattle in Almahal was lower compared to the Fanguso and Mankush. Milking frequency was higher in Mankush than the other two locations (Almahal and Fanguso). Longer lactation length and more frequent milking in Mankush is in line with the report of higher dependency of farmers in Mankush on livestock than crop as compared to other sites (Table 2). The mean daily milk yield obtained in the current study is similar with reports of Nakachew (2009) for early lactation yield in Abigar Cattle of Gambela region, Ethiopia.

Table 15. Least square means ± standard errors for some productive and reproductive performance of Begaria cattle by study site

Performance	N	Overall	Site			Sig
			Almahal	Fanguso	Mankush	
ASM_M (months)	30	30.05±1.48	34.4±2.41	27.3±2.41	28.5±2.83	0.10
ASM_F (months)	32	30.1±1.06	35.1±1.55[a]	25.7±2.19[b]	29.5±1.74[b]	0.0035
AFC (months)	33	40.7±0.84	46.3±1.33[a]	39.3±1.60[b]	36.5±1.45[b]	<0.0001
CI (months)	37	17.3±1.04	18.2±1.69a	13.0±1.90b	20.6±1.82a	0.02
MA_M (months)	32	32.5±2.79	38.7±4.73	34.0±5.23	24.8±4.53	0.11
MA_F (months)	30	34.5±2.89	37.6±4.66[a]	42.0±5.84[a]	24.0±4.46[b]	0.0374
MY (litter)	38	1.9±0.24	1.8±0.39	1.5±0.43	2.4±0.43	0.28
LL (months)	36	4.7±0.24	3.5±0.41[a]	5.8±0.41[b]	4.8±0.41[b]	0.0017
MF	36	1.5±0.07	1.3±0.12[a]	1.3±0.12[a]	1.9±0.12[b]	0.0008
Weaning age	36	3.8±0.06	3.7±0.11	4.0±0.12	3.8±0.11	0.13

ASM_M=age at sexual maturity for males, ASM_F= age at sexual maturity for females, AFC= age at first calving, CI= calving interval, MA_M= market age for males, MA_F= market age for females, MY= milk yield, LL=lactation length, MF= milking frequency.

Average lactation milk yield varied from 189 litres for cattle sampled in Almahal to 345.6 for those sampled in Mankush. In the former case, milking is limited to the rainy season as animals are taken to other areas during the dry season while in the latter case milking is practiced throughout the year s, and this may account for the difference in milk yield. The estimated mean lactation yield at Mankush

corroborates with the findings of Getachew (2006) and Abdel Rahman (2007) who reported lactation yield ranging from 326-339 litres under on-farm *condition* for Gojjam Highland Zebu in central Ethiopia and 356 liters for Baggara cattle in Souther Kordofan State of Sudan. The mean values, however, were much lower than the value of 538.26 and 598.73 kg reported for Butana and Kenana cattle under farmers management in Sudan (Musa *et al.*, 2006). Identifying the sources of variation in milk yield between districts can serve in designing ways of improving milk production.

CONCLUSION

The coat colour pattern and type, and the performance and size of the Begaria cattle have shown the uniqueness of the breed from other cattle in the adjoining areas. The breed was found to be larger in size mainly in height at withers and heart girth than many other Ethiopian breeds. However, the productivity in terms of milk yield per lactation was lower and variation exists between study sites. The current practice of increased introduction of small-sized Zebu from the surrounding areas for draught purpose associated with new settlement would be a potential threat for dilution of this genetic resource.

Growth and milk production traits appear to be important in the production system and need to be considered along with associated traits of adaptation and reproductive performances. Breeding objectives of the producers need also to be considered in designing a breeding program for the improvement of the Begaria cattle. Design of a breeding program considering the current production system and the levels of inputs and services used (feeding, health, mating system, extension, marketing, and culture) is crucial to achieve sustainable livestock development.

It is noted that due to the high availability of feed from the grassland, the growing demand for beef and milk from increased population as a result of the construction of the renaissance dam, the potential of the breed for beef production and the potential of the area for live animal export to the Republic of Sudan indicate the presence of conducive condition for increased cattle production.

Due to the small number of mature males in the population, the sample size for males was small and results pertaining to the male are likely to be less dependable. Molecular characterization, further performance evaluation, and genetic studies should be carried out to understand the magnitude of the distinctiveness from, and the relationship of this cattle population with already identified cattle populations within the country and the adjoining areas of the Republic of Sudan. Such information would be of importance in making a decision with regard to conservation. The existing difference in performance traits between sites need to be verified and factors accounting for the difference need to be identified for use in improving the performance of the breed through improved genetics and management. Possession of large land holding per person in excess of that can be covered by crop production is very common in the area and there is a possibility of establishing commercial ranching type of production.

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