World Journal of Pharmaceutical and Life Sciences
WJPLS

www.wjpls.org

SJIF Impact Factor: 3.347

ON-FARM PHENOTYPIC CHARACTERIZATION OF INDIGENOUS CATTLE POPULATIONS IN METEKEL ZONE, BENISHANGL GUMUZ REGION, NORTHWESTERN ETHIOPIA

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Article Received on 22/09/2016 **Article Revised on 12/10/2016** **Article Accepted on 01/11/2016**

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ABSTRACT

This exploratory survey of indigenous cattle populations was carried out in Metekel zone of Benishangul Gumuz Region, Northwestern Ethiopia, with the aim to identify and phenotypically describe the indigenous cattle populations and design community-based breeding strategy. To collect the data, 180 sample cattle owners with different herd sizes were interviewed on their cattle husbandry practices and trait preference. Focus group discussions with key informants were held in six different sites. A total of eight quantitative measurements and eight qualitative records were taken from 540 mature cattle. Outcomes of the interviews and focus group discussions revealed that cattle are kept in a mixed crop-livestock production system. Cattle are the dominant livestock species in the area and have multi-functional roles in the production system. Farmers of the study area were interested to improve their indigenous cattle genotypes and suggested different target traits for improvement. Based on their trait preference, village breeding scheme is proposed through the provision of genetically selected breeding bulls. Among the reasons of keeping cattle, milk production, income generation from sell of live animals and animal products and draft power (traction purpose) are the prevailing ones. Results from analysis of variance (ANOVA) on quantitative variables showed significant differences between sites ($p<0.05$), sex ($p<0.01$) and age ($p<0.01$). The Chi-square results on qualitative records indicated that the level of association of site with most of the categorical variables was medium ($p<0.05$). The indigenous cattle population of

the study area was not homogenous and they are identified as significantly different in morphological characteristics. Hence, subsequent molecular investigations need to be made to confirm their genetic distinctiveness.

KEYWORDS: Indigenous breeds, Metekel Zone, Phenotypic Characterization.

INTRODUCTION

Ethiopia is generally believed to have the largest population of livestock in Africa. The total number of cattle in all regions of the country except the non-sedentary population of three zones of Afar and six zones of Somali region was estimated to be 53.99 million (CSA, 2013). The majority of these cattle (98.95%) are indigenous breeds which are kept under extensive management. Hybrid and exotic breeds accounted for about 0.94 percent and 0.11 percent, respectively (CSA, 2013). If we include the value of ploughing services, livestock provided about 16.5% of the national Gross Domestic Product (GDP) (Metaferia *et al.*, 2011) and 45% of the agricultural GDP in 2008-2009 (IGAD, 2010). It also contributed 15% of export earnings and 30% of agricultural employment (Behnke, 2010). Currently, the subsector supports and sustains livelihoods for 80% of all rural population. Despite the importance of cattle to the farming community in particular and to the national economy at large, the sector has remained underdeveloped and underutilized.

The Domestic Animal Genetic Resources Information System (DAGRIS) database (DAGRIS, 2011) summarized that there are at least 33 recognized indigenous cattle breeds in Ethiopia dispersed over a diverse range of ecological zones. Understanding the diversity, distribution, basic characteristics, comparative performance and the current status of a country's animal genetics resources is vital for their efficient and sustainable use, development and conservation (FAO, 2007). However, only a small number of recognized cattle breed types have a fair description of their physical appearance, indications of their level of production, reproduction and genetic attributes (Ayalew *et al.*, 2004). Thus, the first initial step for countries like Ethiopia is the identification and characterization of the available genetic resources, estimation and documentation of their population size, their common uses and description of the management system in which they are maintained (FAO, 2009).

Metekel zone, one of the three zones of Benishangul Gumuz region, consisted the highest (80%) cattle population in the region. The livestock production system of the area has been an important component of the livelihoods of smallholder farming communities. Even though

the zone is known for its highest cattle population with valuable traits, on-farm studies on phenotypic characteristics of the cattle population are lacking. Thus, this study was initiated to identify and phenotypically characterize indigenous cattle population and their production system in Metekel zone.

MATERIALS AND METHODS

Study area and sampling procedure

The study was conducted in Metekel zone, Benishangul Gumuz region, Northwestern Ethiopia, comprising an area of 26, 560 Km^2. The topography of the zone presents undulating hills, reaching up to 2000 meter above sea level (masl), slightly sloping down to low land plateaus having an altitude ranging from 600-2800 masl (Engda, 2000). The zone has a wide climatic range contrasting very wet and very dry seasons (MoA, 1998). Meteorological data of Pawe Agricultural Research Center indicated that the zone receives an annual rainfall ranging from 900 to 1450 mm with annual minimum and maximum temperature of 20 and 35°C respectively (Isaias *et al.*, 2015). The total count of livestock reaches 444,595 cattle, 160,879 goats, 54,168 sheep, 1,207 horses, 2,375 mules, 29,766 donkeys, 547,136 chicken and 81,128 bee hives (CSA, 2013).

The sampling procedure followed in this survey was purposive random sampling. In selecting the representative districts, the cattle population of each district was considered. Out of 7 districts in Metekel zone, 3 districts (Wombera, Bullen and Dibate) that have the highest concentration of cattle population were selected purposively. In each of the selected districts, two kebeles having the highest cattle population were selected. Then, thirty households (in each of the selected kebeles) possessing cattle were selected at random. Finally, three matured indigenous cattle per household were measured for eight quantitative and eight qualitative characteristics. Thus, the total numbers of households as well as cattle used for measurements were 180 and 540, respectively.

Data collection and analysis procedures

Using multiple subject formal survey, data were collected on cattle production system through pre-tested and well-structured questionnaire. The questionnaire was administered to (60) randomly selected households' heads (cattle owners) or representatives in each of the three districts. The data was analyzed statistically and described by descriptive statistics using Statistical Package for Social Sciences (SPSS for window, version 16.0, 2006). To

substantiate the information collected from individual interviewee, focus group discussions with key informants were held in 6 different sites.

Linear body measurements like: Body Length (BL), Ear Length (EL), Horn Length (HL), Heart Girth (HG), Height at Wither (HW), Rump Height (RH), Pelvic Width (PW) and Scrotal Circumference (SC) were measured using tailors measuring tape and were subjected to the Generalized Linear Model (GLM) Procedure of SAS (SAS, 2008) to ascertain the existence of phenotypic differences among the sample cattle population. Simultaneously, qualitative characters like: coat color type, coat color pattern, udder size, teat size, horn orientation, facial profile, hump position and dewlap size were recorded in pre-coded format and were subjected to Chi-square test using the frequency (FREQ) Procedure of SAS (SAS, 2008).

Indices were calculated for all ranking data according to a formula: Index = sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) given for an individual characteristic divided by the sum of (3 for rank 1 + 2 for rank 2 + 1 for rank 3) for overall characteristics. Where, 1 was for the highest and 3 for the lowest.

The morphological characteristics and their differences for male and female cattle were analyzed using the following model: Yijk = μ+ ai + bj + ai*bj + eijk; where Y_{ijk} = is the observed value of trait of interest (body length (BL), ear length (EL), horn length (HL), heart girth (HG), height at wither (HW), rump height (RH), pelvic width (PW) and scrotal circumference (SC), μ = the overall mean, a_i = fixed effect of i^{th} sex (1 or 2); where sex 1 and 2 represents male or female, b_j = fixed effect of j^{th} age class (j=1…4), where age was classified in to age group 1=12-24 months, age group 2=24-36 months, age group 3=36-48 and age group 4=>48 months which represent eruption of the central, middle, lateral and corner incisors (M. E. Ensminger, 1983), ai*bj = the interaction effect of sex by age of cattle and e_{ijk} is the random residual effect.

RESULTS AND DISCUSSION

Cattle breeding and other management practices

Cattle owners in the study area have limited control over breeding practices of their cattle and most often mating is natural and uncontrolled and this would result in non-descript herd structure. Natural and uncontrolled breeding practice of cattle was reported by 67.8% of the households. The result is in line with what has been reported by Workneh and Rowlands

(2004) in Oromia region and Oumer *et al. (*2013) in Jimma zone. As reported by the sampled households across the districts, the sources of bull/s used for breeding within the previous 12 months were neighbor's bull (55.6%), own bull breed at home (35.6%), unknown bull (8.9%).

Making a house or shelter for cattle is not a usual practice in the study area. Hence, 87.2% of farmers housed their cattle in yard during the night and early hours of the morning. However, young calves (1-3 years) were provided day and night shelters and separated from the herd to protect them from suckling their dams, trampling and bad weather and joined their dams only during the morning and evening hours soon after milking. Housing cattle alone was practiced by 82.8% of the farmers where as 11.7% of the farmers housed their cattle with sheep and 5.5% with goats.

Culling of undesired male and female cattle was practiced by 36.1% of the farmers. Culling of male cattle in the study area was usually practiced at an average age of ten years, after using the animal for both draught and breeding purpose for six years. However, female cattle were culled, after eight years of service in the farm, at an average age of thirteen years. The reasons for culling cattle were old age (56.9%), health problem (29.2%), need for some cash for the family (10.8%) and need for meat (3.1%). Selling, castration and slaughter accounted for 73.8%, 16.9% and 9.3% of culling methods, respectively. The present study has identified seven major constraints related to cattle production in the three districts. Feed shortage was the major constraint followed by disease mainly trypanosomaisis (local name: gendi) and drought. Other constraints included water shortage, predator attack, lack of market access and land shortage. These constraints would result in poor productive and reproductive performance of cattle in the study area.

Trait preference of cattle owners

Cattle owners in the study area had their own trait preference. Traits like large body size, good fertility, fast growth rate, disease resistance and color, in favor of black and white with black dominant, were all considered as desirable traits across the study area and given due emphasis in selecting cattle (Table 1). The present result is in line with the results of studies conducted in different parts of Ethiopia like western Wollega (ICRA, 1998; Laval and Assegid, 2002), west Shewa (Jiregna, 2007) and Jimma zone (Oumer *et al.,* 2013).

Farmers' trait preference in the current study revealed the cattle production objectives, in mixed crop-livestock production system, were not only focusing on marketable products such as milk and generation of income from sale of live animals and animal products but also non-marketable functions such as fertility, growth rate and disease resistance. The use of indigenous cattle as multipurpose animals in Ethiopia was also reported by Mukasa-Mugerwa (1981) and Van Dorland *et al.* (2004), also in Kenya (Mosi *et al.*, 1996; Rege *et al.*, 2001) and in Sudan (Musa *et al.*, 2005).

Table 1: Trait preference of cattle in three districts of Metekel Zone, Ethiopia (N=180)

Traits	Districts											
	Wombera				Bullen				Dibate			
	R 1	R 2	R3	Index	R 1	R 2	R3	Index	R 1	R 2	R3	Index
Body size	29	13	5	0.33	28	15	6	0.33	21	16	4	0.28
Fertility	-	5	20	0.08	-	6	20	0.09	-	4	15	0.06
Growth rate	15	15	4	0.22	12	15	5	0.20	16	14	9	0.24
Disease resistance	-	7	18	0.09	-	6	14	0.07	6	13	15	0.16
Color	16	20	13	0.28	20	18	15	0.31	17	13	17	0.26

Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular purpose divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all purpose. R1=number of respondents who select the variable as rank one; R2=number of respondents who select the variable as rank two and R3=number of respondents who select the variable as rank three, N=Number of respondents

Variability in the Sample Cattle Population

Qualitative Variation

The Chi-square test showed significant difference ($p<0.05$) among cattle population in the study area for all qualitative variables except face profile ($p>0.05$) (Table 2). Generally, most of the variables had medium to high association values with the study sites, the strongest association existed between study sites and dewlap size followed by coat color and the weakest association existed between study sites and face profile. Of all the qualitative variables, thick and medium dewlap was preferred by most of the respondents and this was exhibited in 75% of the cattle population. Similarly, coat color, in favor of black and white with black dominant, was considered as the second selection criterion for breeding males and females. This was substantiated by the fact that 51.48% of the cattle population had black and white with black dominant color. Cattle population in the study area was also characterized by uniform, patchy and spotty coat color pattern; large, small and medium udder; large,

medium and small teat; forward, straight and backward horn orientation; straight and convex face and straight upward and inclined backward hump (Table 2).

Table 2: Summary of the percentages of qualitative traits of cattle in the three districts.

Characters	Wombera		Bullen		Dibate		Overall	
	N	%	N	%	N	%	N	%
Coat color type								
Black	6	3.33	60	36.67	8	4.44	74	13.95
Red	17	9.44	10	5.56	16	8.89	43	7.96
Black and white with black dominant	113	62.78	73	40.56	92	51.11	278	51.48
Red and white with white dominant	41	22.78	29	16.11	31	17.22	101	18.95
Black and red mix	3	1.67	2	1.11	33	18.33	40	7.66
X^2=208.46*								
Coat color pattern								
Uniform	54	30.00	61	33.89	95	52.78	210	38.89
Patchy	33	18.33	100	55.56	56	31.11	189	35.00
Spotty	93	51.67	19	10.56	29	16.11	141	26.11
X^2=119.13*								
Udder size								
Large	10	10.99	16	19.05	18	20.69	44	16.79
Medium	48	52.74	38	45.23	39	44.83	125	47.71
small	33	36.26	30	35.71	30	34.48	93	35.50
X^2=110.56*								
Teat size								
Large	12	13.19	17	20.24	15	17.24	44	16.79
Medium	41	45.05	31	36.90	37	42.53	109	41.60
small	38	41.76	36	42.86	35	40.23	109	41.60
X^2=103.97*								
Horn orientation								
Forward	3	1.67	1	0.56	10	5.55	14	2.59
Upright	155	86.11	151	83.89	142	78.89	448	82.96
Backward	22	12.22	28	15.56	28	15.56	78	14.45
X^2=11.09*								
Facial profile								
Strait	133	73.89	121	67.22	129	71.67	383	70.93
Convex	47	26.11	59	32.78	51	28.33	157	29.07
2.01^{ns}								
Hump position								
Strait upward	136	75.56	131	72.78	140	77.78	407	75.37
Inclined back	44	24.44	49	27.22	40	22.22	133	24.63
1.21*								
Dewlap size								
Large	45	25.00	37	20.56	29	16.11	111	20.55
Medium	128	71.11	134	74.44	144	80.00	406	75.19
Small	7	3.89	9	5.00	7	3.89	23	4.26
X^2=412.33*								

Note: x^2=chi-square test, *=significant and ns=non-significant

Quantitative variation

The overall phenotypic variation in most quantitative traits, except heart girth ($p>0.05$) and ear length ($p<0.01$), both in male and female cattle was significantly ($p<0.05$) affected by site (Table 4). Coefficients of variability ranged from 9.92 for height at withers to 22.74 for scrotal circumference. Pair-wise comparisons of the least square means between sites showed that the sample populations from Wombera had the largest measurements for all variables. Cattle sampled from Bullen district stood next to Wombera in all measurements. All the quantitative dependent variables were significantly affected by sex ($P < 0.05$) of the animal (Table 4), confirming the widely accepted belief that male and female populations have markedly different body form as measured in the quantitative variables. Hence, adult males of all age classes have overall larger measurements than their female counterparts of similar age classes for all of the quantitative variables. Moreover, cattle in age class 4 had higher values than those in age class 1, 2 and 3. Cattle in age class 1, on the other hand, had the lowest values for all the measurements. This showed that older cattle had higher values than younger ones in all of the parameters considered. This scenario is however not surprising since the size and shape of the animal is expected to increase as the animal is growing with age.

Table 3: Quantitative variables of Cattle and their Description

Parameter	Description
Body length (BL)	The horizontal distance from the point of shoulder to the pin bone to the nearest centimeter.
Heart girth (HG)	The distance around the animal measured directly behind the front leg to the nearest centimeter.
Ear length (EL)	The length of the ear on its exterior side from its root at the poll to the tip to the nearest centimeter.
Height at wither (WH)	The height from the bottom of the front foot to the highest point of the shoulder between the withers to the nearest cm.
Horn length (HL)	The length of the horn to the nearest centimeter.
Rump Height (RH)	The height from the bottom of the rear foot to the pin bone to the nearest cm.
Pelvic width (PW)	The distance between the pelvic bones, across dorsum to the nearest centimeter.
Scrotal Circumference (SC)	The circumference of the testis at the widest part to the nearest centimeter

Table 4: Least squares means ± standard errors of linear body measurements (cm) for the effects of district and age for male and female cattle.

Effects and level	BL	HG	WH	RH	HL	PW	EL	SC
	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall	**142.78±0.87**	**149.52±1.23**	**118.75±0.51**	**117.41±0.58**	**17.14±0.26**	**26.18±0.23**	**13.59±0.09**	**20.81±0.38**
CV(%)	14.23	19.23	9.92	11.42	22.58	20.21	14.94	22.74
District	*	ns	*	*	*	*	**	*
Wombera	143.73±1.40 [a]	150.77±0.92 [a]	120.09±0.81 [a]	118.67±1.16 [a]	18.09±0.46 [a]	26.62±0.40 [a]	14.61±0.14 [a]	22.75±0.56 [a]
Bullen	141.22± 1.51 [b]	149.38± 0.95[a]	118.24± 1.00[b]	117.52± 0.79[ab]	17.08± 0.44[b]	26.34± 0.39ab	13.54±0.14 [b]	20.26± 0.66[b]
Dibate	140.40± 1.51[b]	148.42±0.98 [a]	117.91±0.81 [b]	116.04±0.99 [b]	16.25±0.45 [b]	25.58±0.38 [b]	12.62±0.13 [c]	19.33±0.68 [b]
Sex	**	**	**	**	**	**	**	
Female	134.46± 0.86[a]	135.06±0.73 [a]	115.86*±0.51 [a]	114.25±0.69 [a]	16.47±0.30 [a]	24.74 ±0.23[a]	16.47±0.10 [a]	
Male	156.57±1.40 [b]	178.69±2.15 [b]	124.57±0.99 [b]	123.79±0.83 [b]	18.48±0.47 [b]	29.09±0.42 [b]	18.48±0.16 [b]	
Age	**	**	**	**	**	**	**	**
1 PPI	122.16±1.28 [a]	124.22±1.21 [a]	105.38±0.07 [a]	105.72±0.76 [a]	13.31±0.41 [a]	23.35±0.47 [a]	12.21±0.21 [a]	16.75± [0.83a]
2 PPI	129.53±0.89 [b]	145.05±1.09 [b]	113.45±0.52 [b]	110.38±1.54 [b]	13.67± 0.27[a]	23.86±0.31 [a]	13.00±0.15 [a]	19.19 ±0.45[b]
3 PPI	152.23±1.28 [c]	159.26±1.12 [c]	123.52±o.43 [c]	122.38±0.42 [c]	17.75±0.37 [b]	27.54±0.38 [b]	14.24± 0.09[b]	22.25 ±0.45[c]
≥4 PPI	157.14 ±1.18[d]	163.70±1.69 [d]	129.66 ±0.63[d]	128.14±0.75 [d]	23.26±0.54 [c]	29.16±0.42 [c]	14.45± 0.18[c]	27.00 ±0.72[d]
age * sex	**	**	**	**	**	**	**	
1PPI*f	118.04±1.45 [a]	121.57±1.47 [a]	103.05±0.48 [a]	103.28±0.57 [a]	13.49±0.55 [a]	21.61 ±0.61[a]	11.55 ±0.19[a]	
2PPI*f	123.72±0.65 [b]	130.92 ±0.88[b]	110.46 ±0.22[b]	106.95 ±0.23[b]	13.58 ±0.36[a]	24.19 ±0.30[b]	13.58 ±0.16[ab]	
3PPI*f	141.06 ±1.00[c]	140.09 ±1.26[c]	120.72 ±0.45[c]	119.39 ±0.41[c]	16.00 ±0.36[b]	25.06 ±0.32[b]	14.03 ±0.12[b]	
4PPI*f	150.92 ±1.09[d]	144.89 ±0.55[d]	126.41 ±0.49[d]	124.40 ±0.65[d]	22.52 ±0.66[c]	27.64 ±0.37[c]	14.260.22 ±[c]	
1PPI*m	131.83 ±0.77[a]	130.43 ±1.47[a]	110.80 ±0.25[a]	111.46 ±0.84[a]	12.91 ±0.43[a]	23.11 ±0.69[a]	11.93 ±0.42[a]	
2PPI*m	140.33 ±0.87[b]	171.28 ±1.42[b]	119.00 ±0.97[b]	116.76 ±0.93[b]	13.86±0.42 [a]	26.57 ±0.36[b]	13.74 ±0.26[b]	
3PPI*m	171.52 ±0.56[c]	192.36 ±1.57[c]	128.36 ±0.49[c]	127.52 ±0.41[c]	20.77 ±0.64[b]	31.82 ±0.59[c]	14.75 ±0.16[c]	
4PPI*m	172.17 ±0.72[c]	209.16±1.03 [c]	137.50 ±0.95[d]	137.17 ±1.01[d]	25.08±0.87 [c]	32.83± 0.88[c]	14.77±0.32 [c]	

Means with different superscripts within the same column and class are statistically different. Ns = Non significant; *significant at 0.05 and **significant at 0.01. Age group 1=12-24 months of age; age group 2=24-36 months of age, age group 3=36-48 months and age group 4=≥48 months of age. BL=Body Length; HG= heart-girth; WH= Wither height; PW=pelvic width; RH=rump height, HL=horn length, EL=ear length, and SC=scrotal circumference.

CONCLUSIONS AND RECOMMENDATIONS

In the study area, mating of cattle is predominantly natural and uncontrolled, making a house/shelter for cattle is not a common practice and culling of undesired male and female cattle was practiced by farmers. Traits like large body size, good fertility, fast growth rate, disease resistance and color, in favor of black and white with black dominant, were all considered as desirable traits in the study area and were given due emphasis in selecting cattle. Feed shortage, disease, particularly trypanosomiasis and drought, in that order of importance, were the major constraints of cattle production. Other constraints included water scarcity, predator attack, lack of market access and land scarcity. These constraints would result in poor productive and reproductive performance of cattle in the study area and decreased the direct benefit of the farmers. In the present study, dewlap size and coat color had the highest association value or discriminating power. The Chi-square test showed significant difference ($p<0.05$) among cattle population in the study area for most of the qualitative variables. ANOVA on most of the quantitative variables showed significant ($P< 0.05$) differences between districts and age groups, both for female and male populations.

To obtain suitable performance of cattle, breed improvement programs should not be focused only on few traits such as lactation yield but on overall performance including reproduction efficiency, growth rate, disease resistance and color. To alleviate the prevailing constraints of cattle production and bring a sustainable development to the local farmers, intervention options need to be based on the production systems and identified and prioritized constraints in the study area. The indigenous cattle population of the study area was not homogenous and they are identified as significantly different in morphological characteristics. Hence, subsequent molecular investigations need to be made to confirm their genetic distinctiveness.

ACKNOWLEDGMENTS

The authors thank Assosa University for covering the research cost, agricultural experts in the three district and key informants of the community in the study area for understanding and passing the purpose of the project to the subordinates down to livestock farmers to the Kebele

level. The authors are also grateful to the interviewed farmers for their active participation in sharing their knowledge, experience and time.

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