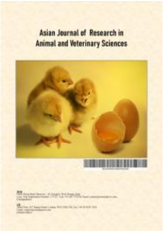

Asian Journal of Research in Animal and Veterinary Sciences

Volume 6, Issue 4, Page 369-379, 2023; Article no.AJRAVS.106221

Colour and Morphometric Characteristics of Ukerewe and Bunda Indigenous Cattle Populations in the Lake Victoria Basin, Tanzania

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/106221

Original Research Article

Received: 18/07/2023
Accepted: 22/09/2023
Published: 02/10/2023

ABSTRACT

This study was undertaken with the objective of comparing body colour and morphometric characteristics of indigenous cattle populations in Ukerewe and Bunda Districts located in the Lake Victoria basin area of Tanzania. A total of 169 adult cattle selected randomly from the study area were examined for colour and morphometric characteristics and then taken linear body measurements. Majority of the cattle had plain colour pattern (63.8% in Ukerewe and 67.4% in Bunda). Predominant coat colour in Ukerewe and Bunda Districts were black and brown, respectively. A considerable proportion of cattle in this study had small sized dewlaps and navel flaps. Ukerewe cattle population had significantly ($P < 0.05$) bigger heart girths and very highly significantly ($P < 0.001$) shorter horns than Bunda cattle. The rest of the physical body measurements and all external body appendages showed insignificant ($P > 0.05$) differences between the two strains. With the exception of ear length and muzzle circumference, all

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measurements were positively and highly (*P < 0.01*) correlated with the body weight estimated from heart girth. Thus, the strains under the study differed remarkably in phenotype. Genetic characterisation of the strains using molecular techniques is recommended in order to establish if they could have a common origin.

Keywords: Indigenous cattle populations; linear body measurements; colour characteristics; body appendages; Shorthorn Zebu.

1. INTRODUCTION

Tanzania Shorthorn Zebu (TSZ) is the dominant and widely spread indigenous breed of cattle in Tanzania. It belongs to the Small East African Shorthorn Zebu group of African cattle [1], which are said to be preferred by smallholder farmers due to their ability to tolerate diseases and rigorous tropical environment [2-3]. Descript strains under the TSZ breed include the Maasai, Mkalama Dun, Singida White, Mbulu, Gogo, Chaga, Iringa Red, Tarime and Pare [4]. Over 80% of TSZ cattle are kept by smallholder farmers under the agro-pastoral production system [5,6-7]. Despite their low production coefficients, they have been serving commendably as a source of income, food, draught power, transport, hides and manure [5,7-8]. Further, they act as a form of insurance and accumulation of wealth. Tanzania Shorthorn Zebu cattle are also considered to be a valuable animal genetic resource for breeding well adapted animals under tropical production environments [6].

Efficient utilization of TSZ cattle populations depends on accurate knowledge of their unique characteristics that differentiate them from other populations [9]. Knowledge of morphometric variation is useful for making inferences about farmers' roles in the evolution of TSZ cattle morphological diversity, landscape fitness and adaptation [10-11]. Colour characteristics have widely been used by farmers to define cattle breeds [12] and are useful for cattle identification in situations where permanent identification of individual animal is impractical [11, 13]. Likewise, body morphometric traits are useful for identification of breed qualities relevant to farming community utility needs [11,14].

Studies of indigenous cattle on morphometric diversity in different agro-ecological zones constitute an initial step in conservation of genetic resources and can be a basis for genetic improvement programs [15]. Determining whether or not a non-descript population is distinguishable from neighbouring ones on the basis of identifiable and stable phenotypic characteristics, that might warrant it being distinguished as a separate population is one of the roles of phenotypic characterization [13]. However, large proportion of indigenous cattle populations of the African continent, which harbors an important part of global cattle genetic resources are yet to be described [8, 16]. This applies to TSZ breed as some of its sub-populations are still non-descript in certain locations [17].

The sub-population of cattle in the Islands of Lake Victoria including Ukerewe District constitute one of the non-descript populations deserving priority for characterization. This is because under the isolation, it might be among the TSZ sub-populations maintaining original blood while also being subjected to the risk of being easily genetically differentiated, inbred or lost through limited random mating (Wahlund's effects), epizootics, famine and civil strife [18]. The nearest offshore location from Ukerewe cattle is Bunda where TSZ cattle are also found. The present study compared morphometric and physical characteristics of the indigenous cattle populations in Ukerewe and Bunda Districts so as to assess the differences between TSZ cattle from the two Districts. The objective of this study was to investigate if the cattle in Ukerewe District represent a strain different from the TSZ strain in Bunda.

2. MATERIALS AND METHODS

2.1 Study Area

This study was conducted in Ukerewe and Bunda Districts located within the Lake Victoria Basin area in Tanzania (Fig. 1). Ukerewe District is an island in Lake Victoria lying between Longitudes 31^{o} 30' and 32^{o} 5' East of Greenwich and Latitudes 1^{o} 30' and 2^{o} 20' South of the Equator. The District covers an area of 6,400 km^2 and has a mean altitude of 1,410 m above sea level. The mean annual temperature and rainfall in Ukerewe District are 24.5^{o}C and 1,350 mm, respectively. The District has a human population of approximately 387,815 people and the population of cattle is estimated at 58,301

(Ukerewe District Advisor, 2022). The main production system for cattle is tethering and the dominant vegetation cover is closed shrub-land. Bunda District lies between Longitude 33º 30' and 34º 5' East of Greenwich and Latitude 1º 30' and 2º 45' South of Equator. It is situated at an altitude of 1,300 m above sea level and has a total area of 3,088 km^2. The mean annual rainfall and temperature in Bunda District are 940 mm and 28.5ºC, respectively (Bunda District Advisor, 2022). The human population in the District is estimated at 250,050 people and the number of cattle is estimated at 221,000 (Bunda District Advisor, 2022). The dominant vegetation cover in Bunda District is grassland and cattle are mainly extensive grazed.

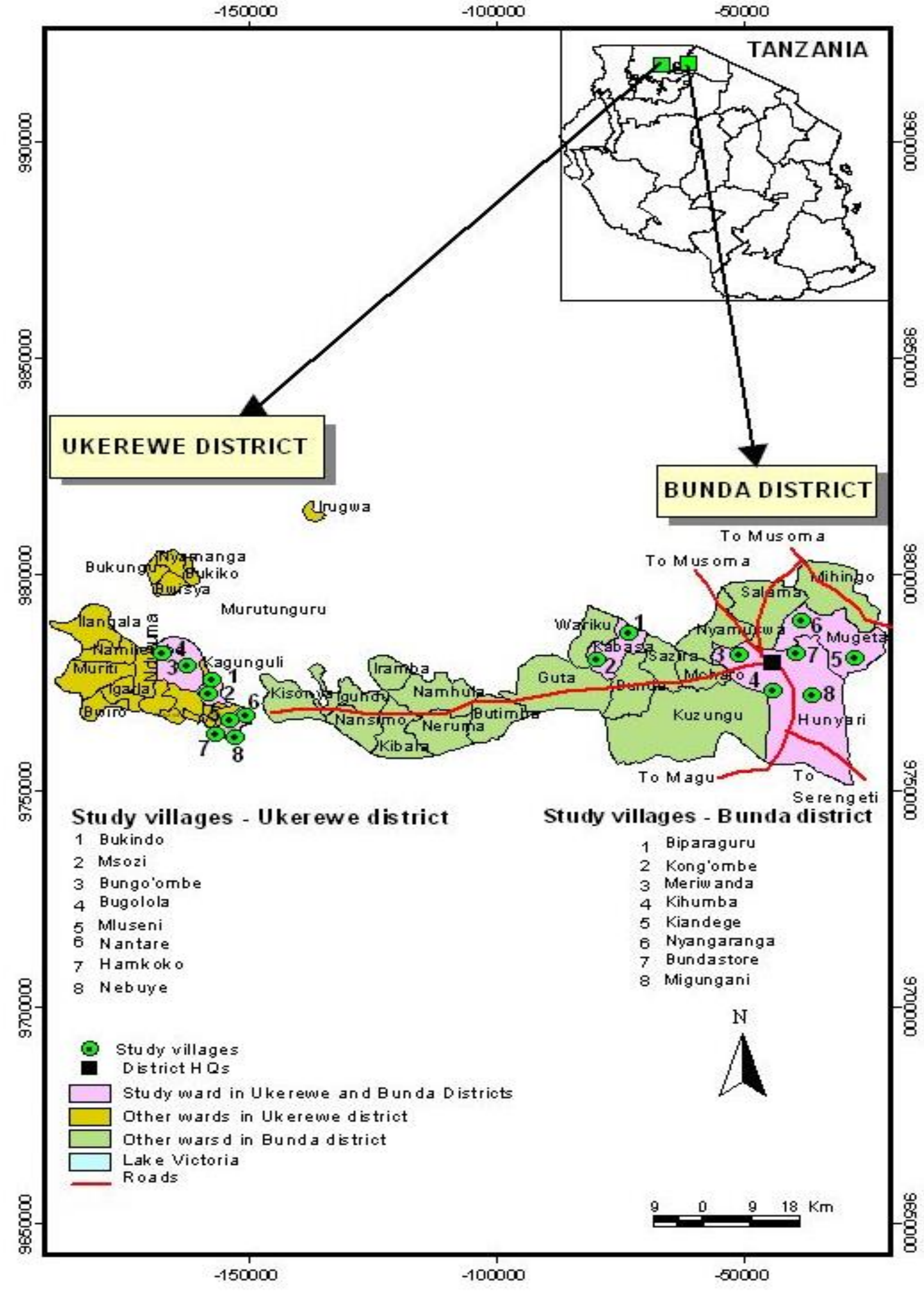

Fig.1. A map of Ukerewe and Bunda Districts showing the study area

2.2 Sampling and Data Collection

In order to attain well-represented and meaningful information from different ecological zones, a purposive sampling procedure using a multi-stage process was employed to select the study divisions, wards, and villages. This sampling approach was used to identify two study divisions in each district. For each division two wards were selected and for each ward two villages were sampled.

For each sampled village, households which had been keeping indigenous cattle for at least 10 years ago were identified and enlisted into a sampling frame from which a total of 46 households (23 per District) were randomly selected. A total of 169 adult cattle aged more than four years old in their natural environment were randomly picked from among the sampled household herds for examination of colour and morphology and taking linear measurements.

Colour traits that were examined include colour pattern, coat colour, skin colour, muzzle colour, eyelid colour and hoof colour. Morphological examination covered horn shape, dewlap size, and navel-flap size. The following linear body measurements were taken; heart girth (HG), body length (BL), withers height (WH), horn length (HL), ear length (EL), muzzle circumference (MC), hock circumference (HC) and tail length (TL). All linear body measurements were taken according to the procedure described by [13] and recorded to the nearest 0.5 cm. Measurements were done in the morning hours before animals were taken for grazing. District profile information was obtained as secondary data from respective District Agriculture and Livestock Development Offices. This study was approved by the Research Ethical Committee of Sokoine University of Agriculture.

2.3 Data Analysis

Descriptive Statistics of SPSS (2006) was used in the analysis of qualitative data in order to generate frequencies and percentages of specific variables by District. Crosstabs procedure was used to test for the existence of association between the variables and Districts. Linear body measurements were analysed using the General Linear Model (GLM) procedures of SAS (2000). Statistical significance was accepted at $P < 0.05$.

3. RESULTS

3.1 Colour Characteristics

The majority (63.8% in Ukerewe and 67.4% in Bunda) of indigenous cattle in this study were observed to have a plain colour pattern (Table 1). Predominant coat colours in Ukerewe and Bunda Districts were brown and black, respectively (Fig. 2). Predominance of black colour type in Ukerewe was observed also in skin colour (58.8%), muzzle colour (65%), eyelids colour (63.8%) and hooves colour (60%). In Bunda District, brown colour type predominated as skin colour (59.6%), muzzle colour (60.7%), eyelid colour (57.3%) and hooves colour (60.7%). There was higher variation in coat colour in Ukerewe than in Bunda District. Additionally, in the former District more colour variants (grey, cream and white) were observed and the predominant black colour occurred at a lower frequency (26.2%) than the predominant brown colour (41.6%) in Bunda District. With the exception of colour pattern all the colour characteristics studied were associated significantly with location.

3.2 Morphometric Characteristics

Majority of cattle in this study had curved horns (Table 2). Bunda District had a higher proportion (97.8%) of cattle with curved horns than Ukerewe District (63.8%). A considerable proportion of cattle in this study had small sized dewlaps and navel flaps. There was very highly significant ($P < 0.01$) association between horn shape and Districts. The same was also true for Districts and navel flap size. Cattle in Ukerewe District were found to have significantly ($P < 0.05$) higher and smaller HG measurement and HL, respectively, than those in Bunda District (Table 3). Further, it was found that the mean values for HG and HL were found to be significantly higher in male than female cattle.

The results for the partial correlations among the various physical body measurements are presented in Table 4. In all cases the correlations were positive. Body weight and heart girth correlated significantly ($P < 0.01$) to all physical body measurements except ear length and muzzle circumference. Among the physical body measurements under the study, withers height correlated significantly ($P < 0.01$) to all except body length which correlated significantly ($P < 0.05$) to all the physical measurements except ear length, muzzle circumference and hock

Table 1. Distribution and association of colour characteristics in cattle examined at Ukerewe and Bunda Districts

Characteristic	Ukerewe		Bunda	
	n	%	n	%
Colour pattern:				
Shaded	9	11.2	9	10.1
Plain	51	63.8	60	67.4
Patchy	15	18.8	14	15.7
Spotted	5	6.2	6	6.7
	$X^2_{(df=3)} = 0.4^{ns}$			
Coat colour:				
Brown	18	22.5	37	41.6
White	4	5	15	16.9
Black	21	26.2	3	3.4
Grey	4	5	0	0
Cream	4	5	5	5.6
Brown and white	16	20	20	22.5
Cream and white	1	1.2	0	0
Brown and black	5	6.2	5	5.6
Black and white	7	8.8	4	4.5
	$X^2_{(df=11)} = 36.2^{***}$			
Skin colour:				
Black	47	58.8	36	40.4
Brown	33	41.2	53	59.6
	$X^2_{(df=1)} = 5.7^{*}$			
Muzzle colour:				
Black	52	65	35	39.3
Brown	28	35	54	60.7
	$X^2_{(df=1)} = 11.1^{**}$			
Eyelid colour:				
Black	51	63.8	38	42.7
Brown	29	36.2	51	57.3
	$X^2_{(df=1)} = 7.5^{**}$			
Hoof colour:				
Grey	48	60	35	39.3
brown	32	40	54	60.7
	$X^2_{(df=1)} = 7.21^{**}$			

Note: n=number of observations; df=degrees of freedom; *=significant at P < 0.05; **=highly significant at P < 0.01; ***=very highly significant at P < 0.001; ns=not significant at P ≥ 0.05

circumference. Ear length correlated significantly to muzzle circumference and hock circumference and non-significantly (*P > 0.05*) to horn length and tail length, while horn length correlated significantly (*P < 0.05*) to muzzle circumference and hock circumference and non-significantly (*P < 0.05*) to tail length. Tail length correlated significantly (*P < 0.05*) to muzzle circumference and hock circumference. There was also a significant (*P < 0.05*) correlation between muzzle circumference and hock circumference.

4. DISCUSSION

The frequency distribution of coat colour pattern observed in this study suggests that across the study area cattle herders prefer plain coloured coats and have possibly been selecting for the trait. This is because most local communities keeping cattle have preferences for coat colour pattern [13]. With regard to colour type, Ukerewe cattle can be distinguished from Bunda cattle by high diversity and predominance of black colour. Dominance of brown as a colour for body coat, muzzle and hooves in Bunda as opposed to that of black in Ukerewe was possibly a result of introgression from west by the brown coloured Ankole cattle. The predominance of brown as a colour for muzzles and hooves, which was observed in Bunda cattle in this study was also reported in Tarime cattle by Chenyambuga et al. [19]. Considering that Bunda and Tarime are in vicinity, the results suggest that the cattle in Bunda were also of Tarime strain.

Of the external body appendages under study, horn shape and navel flap size have shown to differ significantly between Ukerewe and Bunda TSZ. Since the two traits are highly heritable then these results suggest that the Ukerewe and the Bunda TSZ might differ even at genetic level. The genetic difference is most likely due to differential artificial selection that has happened in the two locations over a long time. It is apparent from the results of this study that there were no differences between Ukerewe and Bunda TSZ with respect to the sizes of their udders, dewlaps, testicles and prepuces. The predominant occurrence of small sized udders, dewlaps, testicles and prepuces is a well-known characteristic of the small sized TSZ breed. Results on udder size observed in this work are similar to those reported by Chenyambuga et al. [19] for Tarime cattle.

From the results of this study, it is apparent that of all the physical body measurements considered in the study only body weight, heart girth and horn length differ between Ukerewe and Bunda TSZ cattle. The differences in performance between the two TSZ sub-populations with respect to body weight and heart girth are in part due to differences in health status and degree of activity of the animals. These two factors might have influenced heavier and deeper bodies for Ukerewe TSZ than Bunda TSZ. Since the animals in Ukerewe are tethered and are not used for draught power, they may also tend to be healthier with lower degree of activity than those in Bunda which graze and are used for draught power extensively. It is also a fact that in Bunda TSZ farmers castrated fast growing male animals for use in draught power and in that way selected for slow growth rate and hence smaller mature weight than in Ukerewe where TSZ farmers don't select for draught power. Bunda TSZ cattle are considered to have developed long horns also as a result of introgression from the long-horned Ankole cattle. The TSZ subpopulations in the two locations did not differ with respect to body length, muzzle circumference, hock circumference, tail length and withers height. Mean values for body length and withers height obtained in both of the locations were lower than those of the Iringa Red reported by Sungael [20] and those of Kamba and Maasai zebu reported by Mwacharo et al. [21]. This suggests further that the TSZ cattle in

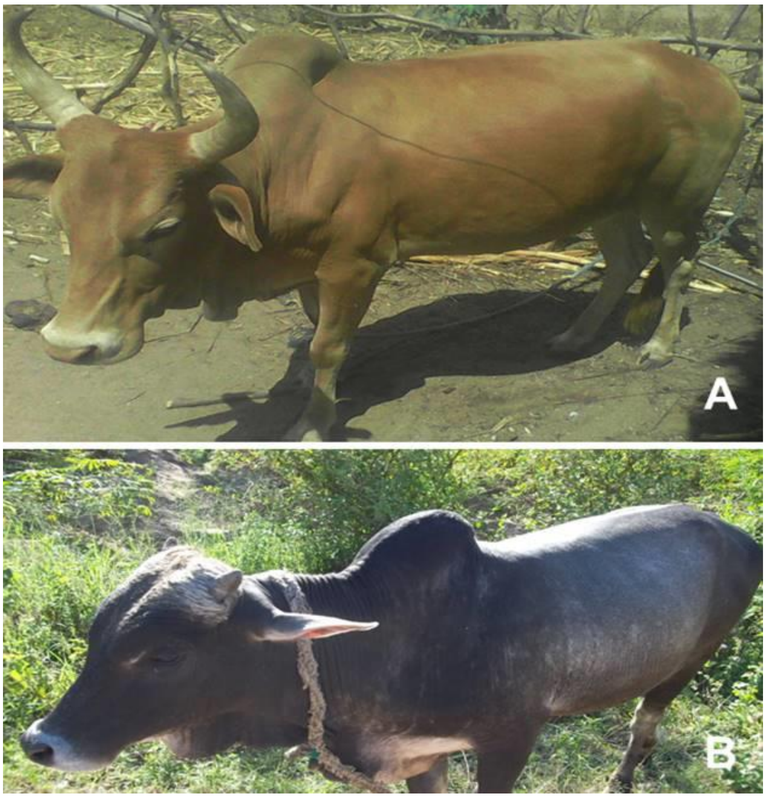

Fig. 2. Photographs of Tanzania Shorthorn Zebu from Bunda (A) and Ukerewe (B) Districts

Ukerewe and Bunda are relatively small sized. It is probable that the TSZ cattle in Ukerewe and Bunda acquired small body sizes in adaptation to relatively hot climatic condition of the region covered in the study. The mean values for ear length in both Ukerewe and Bunda were larger than those reported by Sungael [20] for Iringa Red. This again suggests some adaptation to relatively hot climatic condition of the region covered in the study. It is contended that large sized ears would enhance body heat dissipation.

The observed significant differences between males and females with respect to body weight, heart girth and horn length are consistent with findings from many other similar studies. According to Mwacharo et al. [21], the differences are attributed to sexual dimorphism. This is normally associated with differences in cell number and hormonal balances which in mammals are well known to promote larger body sizes in males than females. The significant interaction between sex district can be explained by the existence of larger sex effects on body weight, heart girth, and horn length in Ukerewe than in Bunda. This is because in Ukerewe bulls are not used for draught power and they therefore tend to be thicker-bodied than those in Bunda.

Within Ukerewe and Bunda there are remarkable environmental differences between villages to which are attributed the observed differences between villages in physical body measurements. For instance, in Ukerewe, the climate in the western part is cooler and forage is denser than in the eastern part. Therefore, the TSZ cattle in villages found in the western part are on a higher plane of nutrition than those in the eastern zone and consequently they tend to be in better condition than those in the eastern part. In Bunda the plane of nutrition decreases and cattle condition deteriorates as one move away from the lake shore. This is because forage biomass density decreases and stocking rate increases with distance from the lake.

The observed highest correlation between heart girth and body weight in this study is in line with findings by Kashoma et al. [22]. This also applies to correlation of body weight with withers height and body length, a point which was also observed by Mwacharo et al. [21]. Based on its correlation with body weight, body length seems to be the second best estimator of body weight after heart girth. Correlation between horn length and body weight observed in this study was significant but lower than that reported by Kugonza et al. [10] for Ankole cattle. This may suggest correlation between body weight and horn length increases as horn length increases across cattle types. It was also observed in this study that hock circumference and tail length are moderately correlated to body weight in the population under the study. This indicates that these two linear measurements are fairly good predictors of body weight. However, from their insignificant correlations to body weight, muzzle circumference and ear length are not good predictors of body weight for Ukerewe and Bunda TSZ cattle.

Table 2. Distribution and association of appendages characteristics in cattle examined at Ukerewe and Bunda Districts

Trait	Ukerewe		Bunde	
	n	Percentage	n	Percentage
Horn shape				
Curved	51	63.8	87	97.8
Straight	29	36.2	2	2.2
$X^2_{(df=1)} = 32.51^{***}$				
Dewlap size				
Small	52	65	65	73
Medium	23	28.8	19	21.3
Large	5	6.2	5	5.6
$X^2_{(df=2)} = 1.4^{ns}$				
Navel flap size				
Small	58	72.5	78	87.6
Medium	22	27.5	11	12.4
$X^2_{(df=1)} = 6.2^{*}$				

Note: n=number of observations; df=degrees of freedom; * =significant at $P < 0.05$; *** =very highly significant at $P < 0.001$; ns=not significant at $P \geq 0.05$

Table 3. Least square means ± SE for linear body measurements in cattle examined at Ukerewe and Bunda Districts

Factor	HG (cm)	WH (cm)	BL (cm)	EL (cm)	HL (cm)	MC (cm)	HC (cm)	TL (cm)
Location								
Ukerewe	138.0±1[a]	105.0±1[a]	108.00±1.3[a]	18.0±0.3[a]	12.1±0.84[a]	40.40±0.8[a]	30.6±0.35[a]	72.8±1[a]
Bunda	135±0.96[b]	104.04±1[a]	108.00-±1.2[a]	18.5±0.3[a]	21.3±0.79[b]	38.34±0.7[a]	31.2±0.33[a]	70.6±1[a]
Significance	*	NS	NS	NS	***	NS	NS	NS
Sex								
Male	139.0±0.8[a]	104.00±0.8[a]	110.00[a]	18.0±0.2[a]	19.3±0.66[a]	38.6±0.6[a]	30.7±0.3[a]	72.4±0.76[a]
Female	134.0±1.2[b]	105.0±1.2[b]	106.00±1.6[b]	18.3±0.34[a]	14.1±0.94[b]	40.16±0.87[a]	31.1±0.4[a]	71.0±1[a]
Significance	**	NS	NS	NS	***	NS	NS	NS

*Note: Within a column least square means with different superscripts differ *=significantly (P < 0.05); **=highly significantly (P < 0.01); ***=very highly significantly (P < 0.001); NS=not significant (P ≥ 0.05)*

Table 4. Partial correlation coefficients and significance levels among various physical body measurements of TSZ cattle in Ukerewe and Bunda

Traits	BW	HG	WH	BL	EL	HL	MC	HC	TL
BW		0.97***	O.29***	0.44***	0.02ns	0.23**	0.11ns	0.33***	0.38***
HG			0.29***	0.45***	0.02ns	0.21**	0.12ns	0.33***	0.41***
WH				0.07ns	0.22**	0.23**	0.42***	0.45***	0.29***
BL					0.11ns	0.36***	0.13ns	0.1ns	0.17*
EL						0.07ns	0.4***	0.15*	0.1ns
HL							0.19*	0.21**	0.1ns
MC								0.45***	0.22**
HC									0.22**
TL									

*Note: * significant at P < 0.05; ** highly significant at P < 0.01; *** very highly significant at P < 0.001; ns not significant at P > 0.05. BW= Matureweight; HG= heart girth; WH= withers height; BL= body length; EL= ear length; HL= horn length; MC= muzzle circumference; HC= hock circumference; TL= tail length*

The correlation results observed in this study between body weight and ear length are contrary to those reported by Kugonza et al. [10] who reported significant correlation between body weight and ear length in Ankole cattle. The difference is probably due to breed differences. The correlations between withers height and ear and horn length observed in this study agree with those reported by Kugonzaet al. [10] for females but not for males. Probably this is because in the sample population cows (which constituted 67%) were predominantly many more than bulls (which constituted 33%) by number. The significant correlation between body length and horn length observed in this study is a result which differs from the insignificant correlation between the linear measurements that was reported by Kugonza et al. [10]. This may also be due to breed difference. The observation that there is insignificant correlation between body length and ear length is similar to what was observed by Kugonza et al. (10) despite the breeds being different. Since ear length, horn length and tail length were all observed to be significantly correlated to muzzle circumference and hock circumference in TSZ cattle in the area of study then the former three measurements can be used to estimate with reasonable accuracy the latter two measurements.

5. CONCLUSION

It has been found that the Ukerewe TSZ strain differs remarkably from the Bunda TSZ strain with regard to a number of standard morphological, colour and performance traits. Coat colour tends to be more frequently black whereas heart girth and horn size tend to be bigger in Ukerewe than in Bunda. In order to establish if the two strains could have a common origin, there is the need to undertake advanced characterisation with a closer look at the differences highlighted in this study. That will need the use of more sensitive tools so as to analyse the differences more precisely. Genetic characterization involving use of molecular techniques is recommended in order to establish if they could have a common origin.

ETHICAL APPROVAL

This study was approved by the Research Ethical Committee of Sokoine University of Agriculture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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