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Research article

Assessment of indigenous Shaka cattle structural indices reared in Shaka zone, south west Ethiopia

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ABSTRACT

The study encompassed quantitative traits of the Shaka cattle reared in Shaka zone, Anderacha and Masha weredas of south western, Ethiopia. The study covered quantitative parameters which were taken from 240 cows and 120 bulls from randomly slected120 households. The means for the quantitative traits were compared using Duncan's Multiple Range test, the values were considered significant at $P < 0.05$ and $P < 0.01$. The results of morphometrical measurements of bulls reared at Masha wereda had wider ($P < 0.05$) values for their pelvic width and the Chest Depth for the bulls aged ≥7 years was higher ($P < 0.01$). While the canon bone circumference was also wider when compared to the bulls reared at Anderacha wereda. Contrary the bulls aged ≤5 years and reared at Anderacha wereda had higher ($P < 0.05$) for Body Weight, Height at Withers and Chest Depth. Morphometrical measurement for cows ≤5 year age group and reared at Masha wereda have longer ($P < 0.05$) Neck Length and for cows ≥7 years have wider ($P < 0.05$) Hock Bone Circumference and Pelvic Width. Contrary the cows aged ≤5 years raised at Anderacha wereda has wider ($P < 0.05$) for Cannon Bone Circumference, and ($P < 0.01$) for Chest Girth, higher Body Weight, Rump Length, Ear Length, Neck Circumference and Chest Depth. Among the cows aged ≥7 years have longer ($P < 0.01$) face length and deeper ($P < 0.05$) Chest. There is a significant difference in the length index (LI2) and body ratio (BR) ($P < 0.05$) throughout the research locations, with Anderacha wereda having the higher result, and Masha wereda having the higher depth index (DI) and transverse pelvic index (TPI) ($P < 0.05$).The results of body indices of both sex indicate that, the cattle is suited for grazing in the forest areas and are of dual type.

1. Introduction

Livestock are an integral part of the Ethiopian agricultural system (Behnke, 2010). Ethiopia is said to possess the largest cattle population in Africa with diversified genetic resources. It is estimated that the cattle population in the country is around 59.5 million heads (CSA, 2015/16).The cattle reared in the country are predominantly of the indigenous zebu type, which are well adapted to and distributed across the diverse agro-ecological zones and production environments in the country.

The diversity among the cattle breeds is indigenous to the specific regions of Ethiopia and thus quite vivid. The Fogera and Horro cattle, are raised for milk production, and are reared around Lake Tana and the Eastern Wellega regions (Aleme and Zemedu, 2015). The Boran cattle, is a beef breed, reared in the southern and eastern parts of the country, while the Sheko and Abigar breeds are considered to be trypanotolerant and are reared in the south-western part of Ethiopia and the Gambella region in the west of Ethiopia, respectively (Aleme and Zemedu, 2015).

Mulugeta (2015) in his study indicated that linear body measurement of cattle varies across breeds, sexes, and ages, which are also influenced by several non-genetic factors, viz. season, nutrition, and management. According to Godfrey (2013), and Mulugeta (2015), the live body weight of cattle was highly correlated with many of the linear body measurements (viz. chest girth and body length). Ermias (2007) reported that only live body weight varied significantly between sexes on Ogaden cattle.

According to Alderson (1999), linear body measurements are also used to calculate indices, which show the structure and proportions of each animal to provide indicators of type and function. The structural indices calculated from the morphometrical measurements are ratios of

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phenotypically correlated traits. The indices provide a more realistic indicator of which a particular livestock breed was developed or selected and therefore provide a directional approach for their further improvement (Mwambene et al., 2012).

Despite the fact that cattle are an important part of the vibrant livestock species reared in the study area, no research has been conducted to identify the type of cattle breed reared there. As a result, this study was carried out to evaluate the type and function of Shaka zebu cattle reared in the weredas of Masha and Anderacha in the Shaka zone. The study would therefore serve as a benchmark in assessment of the cattle of the studied location and also categorizing those depending on some predefine indices.

2. Materials and methods

2.1. Description of the study area

The current study was conducted in the Shaka zone (Figure 1). The Shaka zone is situated in the southwestern part of Ethiopia in the Southern Nations, Nationalities and Peoples Region (SNNPR). It is one of the eighteen zones of the SNNP Regional State. Administratively, it is divided into three weredas, namely, Masha, Yeki, and Anderacha, which are further divided into 57 peasant associations (SZFLDO, 2016). According to CSA (2007), the total land area of the zone is 2387.5 km^2. The zonal capital city, "Masha," is situated 650 km away from Addis Ababa and 951 km from the regional city of Hawasaa. The zone is bordered in the south by Bench Sheko Zone, in the west by Gambella Regional State, in the northwest by Oromia Regional State, and in the northeast by Kaffa Zone.

2.1.1. Animal care and ethical statement

Mizan-Tepi University, college of Agriculture and Natural resource ethics Committee approved the experiment (1953ET-16/2021) after careful assessment of ethical and animal care issues.Directive 2010/63/EU of the European Union guidelines (2010) concerning the treatment and use of animals in research and development purposes were employed.

2.2. Sampling design and data collection procedures

2.2.1. Sampling design

The woredas in the Shaka administrative zone are Yeki, Anderacha, and Masha. The two weredas were purposefully chosen based on the population of indigenous cattle. Purposive sampling techniques were used in order to select the kebeles, keeping in mind that the two woredas are properly represented. The woredas were selected based on the prevalence of indigenous cattle in the area, which information was obtained from the authorities of the agricultural office. Accordingly, 6 kebeles from Masha, with 19 kebeles, and 4 kebeles from Anderacha wereda, with 16 kebeles, were purposively selected based on the presence of indigenous cattle and motor able to the road. Thus, from each of the kebeles, 12 households possessing a minimum of 5 adult cattle (indigenous to the study weredas) were randomly selected from among those households. The respondents were further selected based on their

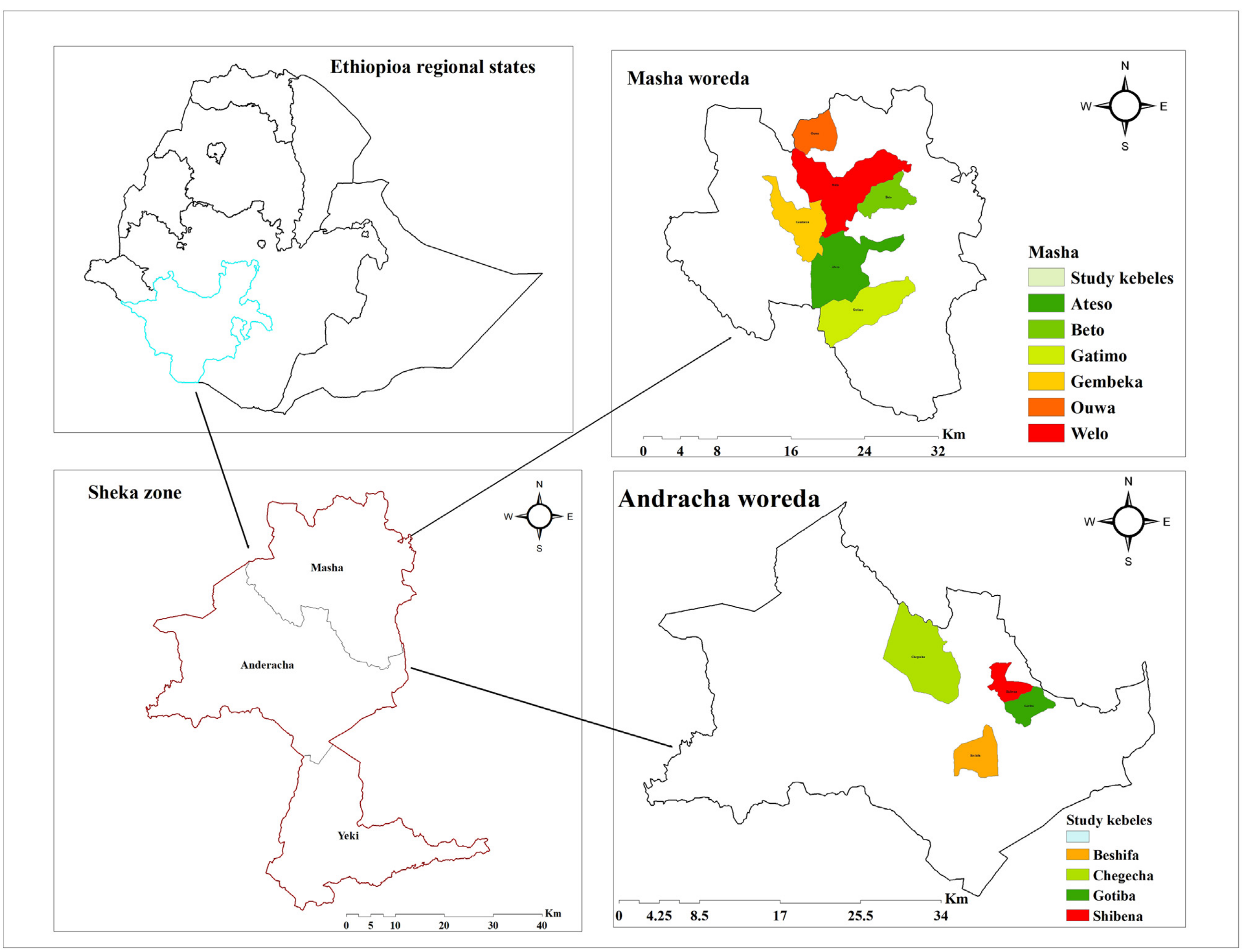

Figure 1. Location and altitude of the study area.

experience of rearing cattle and their willingness to participate in the study. From each 120 households, 3 adult cattle (1 bull and 2 cows) for a total of 360 cattle were considered for linear body measurement and calculation of structural indices.

2.2.2. Linear body measurements

The age of the cattle was identified using the dentition as suggested by Ensimenger (2002). Depending on dentition ≤5 years were 81cattle, 6 year age were 114 and ≥7 age were 115. Data on quantitative (body measurements) was collected and recorded in the format adopted from the standard description list developed by FAO (2012) as indicated in Table 1. The length and circumference measurements were carried out using a measuring tape. The animals' estimated body weights were obtained using a chest girth meter designed for local zebu cattle. Additionally; the width and depth measurements were taken using a calibrated wooden caliper.

2.2.3. Formula to assess structural indices

The quantitative traits from linear body measurement were used to identify the structural indices of Shaka cattle reared in both Anderacha and Masha weredas as indicate in Table 2.

2.2.4. Data management and statistical analysis

Quantitative variables measured and collected were summarized and described by descriptive statistics using the Statistical Package for Social Sciences (SPSS 14.0 for Windows 14.0 release, 2005). The quantitative parameters were assessed using one-way ANOVA and the significant means were compared by using Duncan's Multiple Range Test. Values were considered significant at $P < 0.05$ and $P < 0.01$. The effect of location, sex, and age on linear size measurements was analyzed using the following model.

$$Y_{ij} = \mu + a_i + b_j + c_k + \varepsilon_{iik}$$

Table 1. The standard breeds descriptor for quantitative trait of cattle developed by FAO (2012).

Quantitative traits	Descriptions
Ear length	Length (cm) of external part of ear from its root to the tip
Body length	Horizontal length (cm) from the point of shoulder to the pin bone
Chest girth	The distance around the animal (cm) is measured directly behind the front leg.
Horn length	Distance (cm) from the base of the tip of the horn to the tip of horn
Tail length	Distance (cm) from the base of the tip of the tail on the outer side of the tail
Muzzle circumference	The circumference (cm) of the mouth immediately behind the muzzle
Rump height	The (vertical) height (cm) from the bottom of the front foot to the highest point of the rump
Rump Length	Measured from the back of the rump to the hook bones
Height at withers	Height (cm) from the bottom of the front foot to the highest point of the shoulder between the withers. Measurement preferably taken with a sliding ruler.
Hock circumference	Measured as the circumference of the hock bone
Pelvic width	The horizontal distance (cm) between the extreme lateral points of the hook bone (tuber coxae) of the pelvis
Cannon bone circumference	The circumference (cm) of the cannon bone of the foreleg of the animal
Width of fore head	The point between the two polls (cm)
Neck length	The length between the atlas vertebrae and the first thoracic vertebrae (cm)
Neck circumference	Circumference of the neck at its widest point (cm)
Body weight	The weight of the animals using chest girth meter (tape meter) measurement (Kg)

Source: FAO (2012); Banerjee et al. (2014).

Table 2. Calculations for structural indices.

Type of index	Calculation
Height index	Height at withers/body length × 100
Rump length index	Length of rump/body length × 100
Over increase index	Height at rump/height at withersX100
Height slope	Rump height–withers height
Length index (1)	Body length/height at withers
Width slope	Hip width–chest width
Body weight index	Body weight/height at withers × 100
Length index (2)	body length/chest (thorax) depth
Balance:	(hip width x rump length)/(chest depth x chest width)
Depth index:	chest depth/withers height
Foreleg length:	withers height - chest depth
Body index[a]	Body length *100/chest girth
Body ratio[e]	Height at withers/Height at rump.
Transverse pelvic[e]	Pelvic width *100/height at rump
Weight[e]	HG[c]*80

Source: Alderson (1999); Banerjee et al. (2014).

Where:

- ≻ Y_{ij} = The value pertaining to the i^{th} Weredas (i = Masha, Anderacha)
- ≻ μ = Overall mean
- ≻ $a_{i=}$ Effect of location (i = Masha, Anderacha)
- ≻ $b_{j=}$ Effect of sex (j = Male, Female)
- ≻ $c_{k=}$ effect of age (k = ≤ 5, 6, ≥7)
- ≻ $\varepsilon_{iik=}$ Standard error

3. Result

3.1. Measurements of cattle in the two weredas

3.1.1. Linear body measurement

Table 3 summarizes, some morphometical features Shaka bulls reared in the study weredas. The results show that for ≤5 year bulls, there was a difference in body weight (BW), height at withers (HW) ($P < 0.05$), and chest depth (CD) ($P < 0.01$) between the two research sites. The bulls raised in the Anderacha area have higher values.

Differences in pelvic width (PW) and chest depth (CD) were also seen among the bulls aged 6 years ($P < 0.05$ and $P < 0.01$), respectively (Figure 2). As shown in Table 3 of results, the values were greater among the bulls raised in the Masha wereda than in Anderacha. Furthermore, the study found that the cannon bone circumferences and facial lengths of the bulls rose in Masha wereda significantly differed ($P < 0.05$).

When comparing the morphometrical traits of cows reared in both study areas, the results in Table 4 show that there were highly significant differences ($P < 0.01$) in chest girth (CG), body weight (BW), rump length (RL), neck circumference (NC), and ear length (EL) of cows aged (≤5 years) in Anderacha. The findings also show that cannon bone circumferences, neck length (NL), and chest depth differed ($P < 0.05$ and $P < 0.01$), neck length (NL) had higher value for Masha wereda. According to the data, there were also changes in the morphometrical features of the cows aged ≥7 years. The cows reared in the Anderacha area had longer facial length (FL) and chest depth ($P < 0.01$, $P < 0.05$), respectively. However, there were no variations in other morphometrical measures among the age groups tested.

3.1.2. Morphometrical/structural and functional/indices of cattle in the study areas

The structural indices of bulls and cows reared in the two areas are reported in Table 5 for bulls and Table 6 for cows. The results show that there were variations ($P < 0.05$) in the length index (LI2) between the bulls aged 6 years and raised in the Anderacha wereda. There is no

Table 3. Comparison of linear body measurement (Mean ± SE) between the bulls reared at the two weredas and across various age groups.

Traits	Masha	≤ 5 year			6 year			≥7 year	
		Anderacha	Overall	Masha	Anderacha	Overall	Masha	Anderacha	Overall
CG	145.64 ± 1.32	149.06 ± 1.1	147.4 ± .92	146.6 ± .95	145.2 ± 1.0	146.16 ± .7	142.9 ± 1.1	143.50 ± 1.4	143.1 ± .91
BW	227.85 ± 5.44	243.20 ± 5.0*	235.7 ± 3.9	232.5 ± 4.0	226.6 ± 4.4	230.6 ± 3.1	209.5 ± 6.5	219.33 ± 6.1	214.0 ± 4.5
BL	104.57 ± 1.18	107.26 ± .79	105.9 ± .73	106.4 ± .47	106.0 ± .82	106.29 ± .4	105.7 ± .68	105.91 ± .69	105.8 ± .47
HW	106.85 ± .86	109.53 ± .57*	108.24 ± .5	108.5 ± .47	108.1 ± .56	108.43 ± .3	106.5 ± .77	108.66 ± .81	107.5 ± .58
RH	109.64 ± .58	111.20 ± .66	110.44 ± .4	110.4 ± .4	110.6 ± .45	110.47 ± .3	109.2 ± .58	109.83 ± .95	109.5 ± .53
RL	19.71 ± .43	20.66 ± .27	20.20 ± .24	19.95 ± .25	19.66 ± .26	19.86 ± .18	19.21 ± .35	19.33 ± .432	19.26 ± .26
TL	75.21 ± 1.24	73.46 ± .99	74.31 ± .79	76.18 ± .66	74.42 ± .90	75.61 ± .54	75.07 ± 1.3	75.00 ± 1.30	75.03 ± .92
CBC	14.89 ± .11	15.06 ± .10	14.98 ± .08	14.86 ± .07	14.85 ± .12	14.86 ± .06	14.96 ± .12	14.70 ± .178	14.84 ± .10
MC	41.00 ± .44	41.06 ± .44	41.03 ± .30	41.47 ± .30	40.76 ± .16	41.24 ± .21	40.50 ± .45	40.66 ± .56	40.57 ± .35
EL	16.14 ± .09	15.86 ± .13	16.00 ± .08	15.81 ± .08	15.90 ± .15	15.84 ± .07	16.00 ± .18	16.00 ± .00	16.00 ± .09
HL	18.35 ± 1.37	19.60 ± 1.34	19.00 ± .94	19.65 ± .86	19.19 ± .88	19.50 ± .65	17.71 ± 1.4	21.58 ± 2.2	19.50 ± 1.3
NL	31.64 ± 1.01	32.66 ± 1.11	32.17 ± .75	33.63 ± .69	32.47 ± .61	33.26 ± .51	31.78 ± 1.0	32.16 ± 1.1	31.96 ± .73
HBC	16.10 ± .14	16.40 ± .17	16.25 ± .11	16.20 ± .08	16.30 ± .15	16.23 ± .07	16.17 ± .11*	15.79 ± .12	16.00 ± .09
PW	31.50 ± .35	32.0 ± .338	31.75 ± .24	32.36 ± .2*	31.42 ± .17	32.06 ± .18	31.42 ± .35	31.50 ± .58	31.46 ± .32
NC	88.35 ± 1.38	91.60 ± .83	90.03 ± .84	88.63 ± .92	89.09 ± 1.21	88.78 ± .73	89.2 ± 1.03	85.58 ± 1.9	87.53 ± 1.1
FW	18.35 ± .22	18.73 ± .24	18.55 ± .16	18.27 ± .16	18.14 ± .29	18.23 ± .14	18.28 ± .16	18.25 ± .32	18.26 ± .17
CW	28.78 ± .42	29.13 ± .67	28.96 ± .39	29.11 ± .37	28.95 ± .57	29.06 ± .31	28.14 ± .64	28.16 ± .61	28.15 ± .43
HW2	37.21 ± .90	39.13 ± .79	38.20 ± .61	38.15 ± .51	38.90 ± .77	38.40 ± .42	38.35 ± .65	38.16 ± .76	38.26 ± .49
CD	50.14 ± .81	52.66 ± .57*	51.44 ± .53	51.93 ± .3**	50.14 ± .48	51.35 ± .32	49.78 ± .67	51.08 ± .75	50.38 ± .50
FL	40.71 ± .38	41.00 ± .29	40.86 ± .23	40.77 ± .19	40.85 ± .31	40.80 ± .16	41.28 ± .36*	40.25 ± .30	40.80 ± .26

The values on the same row with same age group are significantly different *(P < 0.05) and **(p < 0.01); CG = Chest Girth(cm), BW = Bodyweight(kg), BL = Body Length(cm), HW = Height at Withers(cm), RH = Rump Height(cm), RL = Rump Length(cm), TL = Tail Length(cm), CBC = Canon bone circumference t(cm), MC = Muzzle circumference(cm), EL = Ear length (cm), HL = Horn length (cm), HBC = Hock bone circumference (cm), PW = Pelvic Width(cm), NL = Neck Length, NC = Neck Circumference(cm), FW = Fore head width(cm), CW = Chest width(cm), HW2 = Hip width(cm), CD = Chest depth(cm), FL = Face length(cm).

a b c

d e

Figure 2. a. Chest depth of Shaka bull b. Chest girth of Shaka bull c. Height at wither of Shaka cow. d. Height at wither of Shaka Cow e. Chest depth of Shaka Cow.

Table 4. Comparison of linear body measurement (Mean ± SE) between the cows reared at the two weredas and across various age groups.

Traits	≤ 5year			6 year			≥7 year		
	Masha	Anderacha	Overall	Masha	Anderacha	Overall	Masha	Anderacha	Overall
CG	142.8 ± .87	147.8 ± .8**	144.6 ± .72	143.8 ± .88	143.9 ± .93	143.8 ± .63	143.0 ± .67	142.1 ± 1.2	142.7 ± .61
BW	212.9 ± 3.3	233.3 ± 3.7**	220.3 ± 2.8	217.0 ± 3.4	217.7 ± 3.7	217.3 ± 2.5	213.7 ± 2.6	211.1 ± 4.9	212.8 ± 2.4
BL	102.7 ± .90	104.3 ± .65	103.3 ± .62	103.3 ± .61	104.5 ± .46	103.9 ± .39	102.5 ± .60	103.4 ± .53	102.8 ± .43
HW	105.0 ± .80	106.8 ± .74	105.7 ± .58	105.4 ± .61	106.0 ± .55	105.7 ± .41	104.6 ± .46	105.5 ± .67	104.9 ± .38
RH	106.4 ± .66	108.3 ± .91	107.1 ± .55	107.5 ± .67	107.6 ± .59	107.6 ± .43	106.6 ± .53	106.9 ± .63	106.7 ± .41
RL	18.87 ± .14	19.88 ± .2**	19.24 ± .14	19.42 ± .18	19.38 ± .20	19.40 ± .13	19.04 ± .14	19.05 ± .21	19.05 ± .11
TL	74.12 ± .88	76.88 ± .94	75.12 ± .67	76.08 ± .73	76.75 ± .61	76.39 ± .48	76.36 ± .62	75.32 ± .86	76.00 ± .50
CBC	13.53 ± .10	14.00 ± .19*	13.70 ± .09	13.76 ± .08	13.71 ± .08	13.74 ± .06	13.68 ± .09	13.42 ± .09	13.59 ± .06
MC	38.59 ± .28	39.33 ± .24	38.86 ± .20	39.06 ± .21	39.45 ± .31	39.24 ± .18	39.00 ± .30	39.11 ± .29	39.04 ± .21
EL	15.48 ± .09	15.88 ± .0**	15.63 ± .07	15.55 ± .07	15.68 ± .07	15.61 ± .05	15.59 ± .06	15.64 ± .08	15.61 ± .04
HL	27.28 ± .96	26.50 ± 1.4	27.00 ± .79	28.55 ± .76	27.38 ± .75	28.00 ± .53	27.93 ± .81	26.94 ± .82	27.58 ± .60
NL	37.00 ± .6*	34.50 ± .83	36.10 ± .51	37.91 ± .43	37.34 ± .46	37.64 ± .31	36.80 ± .45	36.20 ± .63	36.59 ± .36
HBC	15.03 ± .14	15.36 ± .18	15.15 ± .11	15.21 ± .11	15.12 ± .11	15.17 ± .08	15.10 ± .1*	14.76 ± .12	14.98 ± .07
PW	32.75 ± .35	33.11 ± .41	32.88 ± .27	33.18 ± .22	32.84 ± .32	33.02 ± .19	33.11 ± .2	33.00 ± .27	33.07 ± .19
NC	75.93 ± .90	80.94 ± 1**	77.74 ± .79	78.24 ± .76	78.20 ± .62	78.22 ± .49	78.15 ± .58	77.11 ± .91	77.79 ± .49
FW	16.46 ± .17	16.77 ± .15	16.58 ± .12	16.42 ± .10	16.65 ± .12	16.53 ± .08	16.52 ± .11	16.67 ± .17	16.57 ± .09
CW	28.93 ± .49	28.72 ± .41	28.86 ± .35	28.63 ± .29	28.50 ± .39	28.56 ± .24	28.03 ± .31	27.94 ± .45	28.00 ± .25
HW2	38.20 ± .63	40.05 ± .44	38.90 ± .45	38.95 ± .40	39.54 ± .33	39.23 ± .26	39.00 ± .35	38.76 ± .34	38.91 ± .25
CD	47.87 ± .84	52.11 ± .4**	49.40 ± .63	48.77 ± .54	49.95 ± .57	49.33 ± .39	48.03 ± .58	50.14 ± .5*	48.77 ± .44
FL	39.21 ± .22	39.61 ± .24	39.36 ± .16	39.22 ± .17	38.86 ± .16	39.05 ± .11	38.98 ± .17	39.79 ± .16**	39.26 ± .13

The values on the same row with same age group are significantly different *(P < 0.05) and **(p < 0.01); CG = Chest Girth(cm), BW = Bodyweight(kg), BL = Body Length(cm), HW = Height at Withers(cm), RH = Rump Height(cm), RL = Rump Length(cm), TL = Tail Length(cm), CBC = Canon bone circumference (cm), MC = Muzzle circumference(cm), EL = Ear length (cm), HL = Horn length (cm), HBC = Hock bone circumference (cm), PW = Pelvic Width(cm), NC = Neck Circumference(cm), FW = Fore head width(cm), CW = Chest width(cm), HW2 = Hip width(cm), CD = Chest depth(cm), FL = Face length(cm).

Table 5. Comparison of body indices (Mean ± SE) for assessment of type and function of the bulls reared at the two weredas and across various age groups.

Indices	≤5 year			6 year			≥7 year		
	Masha	Anderacha	Overall	Masha	Anderacha	Overall	Masha	Anderacha	Overall
HI	102.2 ± .70	102.14 ± .48	102.2 ± .41	102.1 ± .54	101.9 ± .43	102.0 ± .39	101.79 ± .60	103.5 ± .74	102.6 ± .40
RLI	18.87 ± .42	19.28 ± .30	19.08 ± .26	18.74 ± .20	18.55 ± .24	18.68 ± .16	18.3 ± .30	18.4 ± .31	18.37 ± .21
OII	102.6 ± .59	101.5 ± .32	102.0 ± .34	101.6 ± .22	102.3 ± .26	101.9 ± .17	102.5 ± .40	101.0 ± .59	101.8 ± .38
HS	2.78 ± .59	1.66 ± .36	2.20 ± .35	1.81 ± .23	2.52 ± .28	2.04 ± .18	2.64 ± .46	1.16 ± .63	1.96 ± .40
LI1	.97 ± .00	.97 ± .00	.97 ± .00	.98 ± .00	.98 ± .00	.98 ± .00	.98 ± .00	.96 ± .00	.975 ± .00
WS	8.42 ± 1.05	10.0 ± .76	9.24 ± .65	9.0 ± .51	9.9 ± .57	9.3 ± .39	10.1 ± .90	10.0 ± .87	10.1 ± .65
BWI	213.2 ± .48	222.1 ± 4.8	217.8 ± 3.4	214.3 ± 3.9	209.6 ± 3.7	212.7 ± 2.9	196.7 ± .60	201.6 ± 4.9	199.0 ± .3
LI2	2.090 ± .03	2.039 ± .02	2.06 ± .01	2.05 ± .01	2.11 ± .02*	2.07 ± .01	2.10 ± .02	2.05 ± .03	2.08 ± .01
Ba	.510 ± .01	.531 ± .01	.521 ± .01	.50 ± .00	.52 ± .01	.51 ± .00	.53 ± .01	.51 ± .01	.52 ± .01
DI	.469 ± .00	.481 ± .00	.47 ± .00	.47 ± .00*	.46 ± .00	.47 ± .00	.46 ± .00	.47 ± .00	.46 ± .00
FL	56.7 ± .94	56.8 ± .77	56.7 ± .59	56.6 ± .60	57.9 ± .50	57.0 ± .40	56.7 ± .56	57.5 ± 1.0	57.1 ± .50
BI	71.8 ± .91	72.0 ± .72	71.9 ± .56	72.6 ± .30	73.0 ± .50	72.7 ± .30	73.3 ± .74	73.1 ± .36	73.2 ± .40
BR	.974 ± .00	.985 ± .00	.98 ± .00	.98 ± .00	.97 ± .00	.98 ± .00	.97 ± .00	.98 ± .00*	.98 ± .00
TP	28.7 ± .30	28.7 ± .36	28.7 ± .23	29.3 ± .20*	28.4 ± .10	29.0 ± .10	28.7 ± .34	28.6 ± .35	28.7 ± .20
W	11651.4 ± .1	11925.3 ± .9	11793.1 ± .7	11729.0 ± .7	11619.0 ± .85	11693.5 ± .5	11434.2 ± .9	11480.0 ± .11	11455.3 ± .7

The values on the same row with same age group are significantly different *(P < 0.05); HI = Height index, RLI = Rump length index, OII = Over increase index, HS = Height slope, LI1 = Length index (1), WS = Width slope, BWI = Body weight index, LI2 = Length index (2), Ba=Balance, DI = Depth index, FL = Foreleg length:, BI = Body index[a], BR = Body ratio[e], TP = Transverse pelvic[e], W=Weight[e].

significant difference between the weredas for bulls under the age of ≤5 years. However, the depth index (DI) and transverse pelvic index (TPI) were greater (p < 0.05) in bulls raised in Masha wereda. When compared to its Masha wereda counterparts, bulls aged ≥7-years in Anderacha wereda had a greater body ratio (BR) (P < 0.05).

Table 6 further shows that among the cows aged ≤5 years raised in Anderacha wereda, there were significant differences in rump length index (RLI) at (P < 0.05). Similarly, bodyweight index (BWI) and depth index (DI) significantly higher at (P < 0.01), between the woredas, the values were higher for Anderacha wereda. On the other hand, cattle raised in Masha wereda showed higher (P < 0.01) length index 2 values (LI2). As shown in the Table below, there were no significant differences across weredas for cows aged 6 and ≥7 years old.

3.1.3. Predicting the value of body weight from correlated linear body measurements

Table 7 shows that the chest girth (CG) and muzzle circumference (MC) were the best estimates for estimating the weight of bulls aged ≤5

Table 6. Comparison of body indices (Mean ± SE) for assessment of type and function of the cows reared at the two weredas and across various age groups.

Indices	≤5year			6 year			≥7year		
	Masha	Anderacha	Overall	Masha	Anderacha	Overall	Masha	Anderacha	Overall
HI	102.4 ± .81	102.4 ± .48	102.4 ± .54	102.1 ± .53	101.3 ± .4	101.7 ± .34	102.4 ± .72	102s.0 ± .51	102.2 ± .44
RLI	18.40 ± .18	19.06 ± .20*	18.6 ± .14	18.8 ± .18	18.5 ± .16	18.67 ± .12	18.61 ± .21	18.42 ± .17	18.52 ± .13
OII	101.2 ± .34	101.4 ± .45	101.3 ± .2	101.9 ± .2	101.5 ± .2	101.7 ± .19	101.9 ± .33	101.3 ± .30	101.6 ± .2
HS	1.31 ± .36	1.50 ± .47	1.38 ± .28	2.0 ± .263	1.65 ± .31	1.86 ± .20	2.05 ± .35	1.44 ± .31	1.75 ± .2
LI1	.97 ± .00	.97 ± .00	.97 ± .00	.9 ± .00	.98 ± .00	.98 ± .00	.977 ± .00	.98 ± .005	.97 ± .00
WS	9.3 ± .71	11.3 ± .4	10.0 ± .5	10.3 ± .5	11.0 ± .4	10.6 ± .3	10.7 ± .69	10.8 ± .52	10.7 ± .43
BWI	202.4 ± 2.5	218.3 ± 2**	208.1 ± 2.1	205.5 ± 2.6	204.9 ± 2.6	205.2 ± 1.8	205.3 ± 2.9	199.6 ± 3.8	202.5 ± 2.4
LI2	2.16 ± .0**	2.00 ± .01	2.10 ± .02	2.1 ± .02	2.116 ± .0	2.12 ± .02	2.14 ± .03	2.07 ± .02	2.10 ± .02
Ba	.53 ± .01	.53 ± .01	.53 ± .01	.5 ± .014	.55 ± .01	.54 ± .010	.55 ± .016	.53 ± .012	.54 ± .010
DI	.45 ± .00	.48 ± .00**	.46 ± .00	.4 ± .00	.47 ± .00	.46 ± .00	.45 ± .00	.47 ± .00	.46 ± .004
FL	57.2 ± 1.0	54.7 ± .8	56.3 ± .7	56.7 ± .9	56.0682 ± .8	56.4 ± .6	56.7 ± .9	55.3 ± .7	56.05 ± .6
BI	71.9 ± .66	70.5 ± .4	71.4 ± .4	71.38 ± .4	72.7466 ± .3	72.3 ± .3	71.4 ± .6	72.8 ± .5	72.1 ± .41
BR	.98 ± .00	.98 ± .0	.98 ± .00	.9 ± .002	.9848 ± .00	.98 ± .00	.98 ± .00	.98 ± .00	.98 ± .00
TP	30.7 ± .3	30.2 ± .3	30.7 ± .2	30.8 ± .2	30.5 ± .2	30.7 ± .1	31.09 ± .32	30.85 ± .2	30.9 ± .21
W	11425.0 ± 70	11831.1 ± 68**	11571.2 ± 57	11506.9 ± 70	11514.5 ± 74	11510.5 ± 51	11475.29 ± 6	11369.4 ± 97	11422.35 ± 59

The values on the same row with same age group are significantly different *(P < 0.05) and **(p < 0.01); HI = Height index, RLI = Rump length index, DI = Depth index, OII = Over increase index, HS = Height slope, LI1 = Length index (1), WS = Width slope, BWI = Body weight index, LI2 = Length index (2), Ba=Balance, DI = Depth index, FL = Foreleg length:, BI = Body index[a], BR = Body ratio[e], TP = Transverse pelvic[e], W=Weight[e].

Table 7. Body weight estimation from different morphometric traits of bulls of different age groups reared across the studied weredas.

Location	≤5 year		6 year		≥7 year	
	R^2_{adj}	Equation	R^2_{adj}	Equation	R^2_{adj}	Equation
Masha	.997	Y = -369.966 + 4.105(CG)	.997	Y = -388.843 + 4.238(CG)	.586	Y = 272.793–3.569(HL)
	.999	Y = -350.171 + 4.134(CG)-.587(MC)	.997	Y = -379.918 + 4.265(CG) -.169(TL)	.762	Y = 582.566–3.112(HL)+ 7.699(FL)
	.999	Y = -345.893 + 4.113(CG)-.662(MC)+.101(HL)				
	1.000	Y = -341.728 + 4.159(CG)-.737(MC)+ 095(HL)+ -.267(CW)				
Anderacha	.999	Y = -399.917 + 4.314(CG)	.999	Y = -383.720 + 4.203(CG)	.999	Y = -376.857 + 4.155(CG)
	1.000	Y = -394.917 + 4.329(CG)+-.385(FW)	1.000	Y = 388.932 + 4.198(CG)+ .182(NL)		

R^2adj. = adjusted coefficient of determination; CG = chest girth, MC = muzzle circumference, HLL = Horn length left, CW = Chest width, TL = Tail length, NL = Neck length, HLR = Horn length right, FL = Face length, FW = for head width.

years raised in Masha wereda using the regression equation. The weight of 6-year-old bulls was best assessed/estimated using the bulls' CG and tail length (TL). Face length (FL) and horn length (HL) were used to determine the weight of the bulls aged ≥7 years. The findings from Anderacha wereda indicate that the bulls, irrespective of all ages, are best assessed using their chest girth (CG). The findings from Table 8 indicate that, for cows aged ≤5 chest girth (HG), the best estimates of body weight were found in both study weredas. For the 6-year age group, chest girth (HG) and rump length (RL) were the best estimates for Masha wereda. While chest girth (HG) and hip width (HW2) are the best approximates for the Anderacha wereda. For ≥7 year cow age group, body weight estimated through chest girths (HG), rump length (RL) and hip width (HW2) in Masha wereda and chest girth (CG) for Anderacha wereda.

The findings pertaining to the estimation of body weight of the cows (non pregnant) and reared at both the weredas are presented in.

4. Discussion

4.1. Morphometric/quantitative measurements of cattle reared in the two weredas

The findings of the morphometrical characteristics of indigenous Shaka cattle of both sexes and of various ages are provided in Tables 3 and 4.

In both locations, height at wither (HW) values for bulls aged ≤5, 6, and ≥7 years are comparable (Masha and Anderacha) Table 3. However,

Table 8. Body weight estimation from different morphometric traits of cows of different age groups reared across the studied woredas.

Location	≤5 year		6 year		≥7 year	
	R^2_{adj}	Equation	R^2_{adj}	Equation	R^2_{adj}	Equation
Masha	.999	Y = 339.990 + 3.872(CG)	.999	Y = -339.166 + 3.867(CG)	1.000	Y = -339.851 + 3.871(CG)
			.999	Y = 335.501 + .3.784(CG)+ 425 (RL)	1.000	Y = -337.274 + 3.807(CG)+ .342 (RL)
					1.000	Y = -334.843 + 3.822(CG)+ .361(RL) -.047(HW2)
Anderacha	.984	Y = -408.173 + 4.338(CG)	.994	Y = -363.460 + 4.038(CG)	.995	Y = -363.446 + 4.043(CG)
			.995	Y = 360.544 + 4.148(CG)+-.476(HW)		

R^2adj. = adjusted coefficient of determination; CG = chest girth, RL = rump length; WH = height at withers, HW2 = Hip width.

these values were lower than those reported by Mwambene et al. (2012), Chencha et al. (2013), Chali (2014), Mulugeta (2015), Tewelde (2016) and Tariku et al., (2019). Conversely, the HW of the Shaka bulls was greater than that reported by Takele et al. (2009), Godfrey (2013), and Dereje (2015). The HW of Shaka cows aged ≤5, 6, and ≥7 years is lower than that of Chali (2014), Dereje (2015), and Tewelde (2016). This study's finding was also higher than those of Takele et al. (2009), and Chencha et al. (2013). The differences in HW between bulls and cows may be due to genetic makeup rather than genotype as a result of environmental interaction. Height at the withers is a highly heritable trait and is critical for breed classification (Udeh et al., 2003; Godfrey, 2013). Tall cattle are frequently able to graze over long distances and fend off predators (Sungael, 2005). It has also been noted that tropical cattle breeds often have lower HW than temperate cattle breeds (Godfrey, 2013). Cattle breed in humid areas are often smaller than those in dry areas (Mwacharo et al., 2006). It has also been noted that HW is typically associated with a greater body weight; however, this is also, dependent on the breed's adaptability (Alsiddig et al., 2010).

Milla et al. (2012), Chencha et al. (2013), Chali (2014), Mulugeta (2015), and Tewelde (2016) all reported higher chest girth (CG) values than Shaka bulls aged ≤5, 6, and ≥7 years raised in both sites. However, when compared to the findings of Takele et al. (2009), Godfrey (2013), and Dereje (2015), the current finding is higher. The current research output is in accordance with Tariku et al. (2019). The CG of Shaka cows aged ≤5, 6, and ≥7 years was lower than that reported by Mulugeta (2015), Getinet et al. (2009), and Tewelde (2016), but greater than that of several other cattle breeds, including Takele et al. (2009), Chali (2014), Dereje (2015), and Tariku et al.(2019). The chest girth is crucial in cattle categorization because the greater the thoracic cavity, the more space there is for critical organs like the lungs and chest. These organs are vital to the animals' health and differ amongst breeds of cattle (Karume, 2013). One of the hallmarks of sexual dimorphism is that bulls/bullocks have a larger chest girth than heifers/cows (Godfrey 2013). Cows with reduced CG have also been observed to have less stamina when grazing over extended distances. CG measures have also been linked to body weight and are frequently employed as indicators for determining latter (Mwacharo et al., 2006; Godfrey 2013).

The body length (BL) values of the bulls studied were lower than those reported by Mulugeta (2015), Takele et al. (2009), Godfrey (2013), Chali (2014), Chencha et al. (2013), Tewelde (2016) and Tariku et al.(2019). The BL of Shaka bulls was greater than that of Gilbert et al. (1993). The results for the BL of Shaka cows aged ≤5, 6, and ≥7 years were lower than those published by Chencha et al. (2013), Chali (2014) and Tariku et al.(2019), but higher than those reported by Dereje (2015). Body length in cattle is a skeletal characteristic that is moderately to highly heritable (Godfrey, 2013). The body weight of cattle with a longer body length is generally higher. The length of the animals allows them adequate room for the important organs to develop (Karume, 2013). If appropriately maintained, cows with a higher BL have a greater potential as meat animals (Lawrence and Pearce, 1964). Cows with a higher BL generally require more up keep (Mwambene et al., 2012; Banerjee et al., 2014). These cows can also be used as surrogates since they generally have enough area for the calves to grow (Karume, 2013).

The facial length (FL) of bulls aged ≤5, 6, and ≥7 years raised in the two sites is less than that reported by Nakachew (2009), (Aamir et al. (2010), and Abdulmojeed et al., (2010). (2010). The FL of the Shaka bulls was greater than that found by Dereje (2015) and Endashaw (2015). The finding for current finding was in accordance with Tariku et al., (2019). The FL of the Shaka cows of the same age group is lower than in the reports of Mulugeta (2015) and Tewelde (2016), which is consistent with the findings of Takele et al. (2009), Dereje (2015) and Tariku et al.(2019). Face length is another crucial metric to consider when evaluating a breed, since it is linked to its usefulness (Aamir et al., 2010). According to Banerjee et al. (2014), FL is a functional feature, and animals with short FL have respiratory issues, making them unsuited to the highland agro-ecology. Endeshaw, 2010 found that there is sexual dimorphism in the FL, with male having a shorter FL than females.

Bulls aged ≤5, 6, and ≥7 years had shorter neck lengths (NL) than Mulugeta (2015), Shiferaw (2006), Nakachew (2009), and Chencha et al. (2013). Takele et al. (2009) and Dereje (2015), on the other hand, reported shorter NL than the current result. The NL of the designated cows was lower than that reported by Tewelde (2016) and higher than that reported by Dereje (2015) and Takele et al. (2009). The length of the cervical bones is measured in neck length (NL), and bulls have shorter values than cows (Mohammed, 1997; Dereje 2015). The former is associated with masculinity, whilst the latter is associated with feminism (Hammond, 1984). According to Banerjee et al. (2014), shorter NL is associated with body weight in animals. The Shaka bull's neck length was shorter than the cows', showing masculinity and assistance; thus, the bulls had high drought resistance.

The results for head width (HW) values for bulls aged ≤5, 6, and ≥7 years raised on both sites are lower than those found by Bene et al. (2007). The Shaka cows have wider heads than Gilbert et al. (1993) and Tolenkhomba et al. (2012). While beef breeds have broader heads than dairy breeds, there is sexual dimorphism in this characteristic as well (Tewelde, 2016). The breadth of the cranial cavity is used to determine the head width, which is related to the neck width and body weight (Hammond, 1984; Banerjee et al., 2014).

The results for height at rump (HR) values for bulls aged ≤5, 6, and ≥7 years raised at both research sites were lower than those reported by Abdulmojeed et al., (2010), Nakachew (2009), and Chali (2014), Dereje (2015), and Tariku et al. (2019). The HR values for cows/heifers observed in this study are lower than those found by Chali (2014) and Tewelde (2016), but are equivalent to those found by Dereje (2015) and Tariku et al. (2019). Height at the rump (HR) has a special relevance in cattle morphometrics, since it is connected to the height of the animals' posterior area (Geremew et al., 2019; Alderson, 1999). Animals with a higher HR have also been found to be better acclimated to the tropics.

The results for chest width (CW) value for Shaka bulls were lower than those reported by Park et al. (1993), Tallis et al. (1959), Alderson (1999), Getinet (2005), and Tariku et al.(2019). The values, however, are larger than those found by Abdulmojeed et al., (2010). The chest width for female cattle in the research site is lower than the finding of Tariku et al. (2019). Cattle's chest breadth is proportional to their shoulder width (Banerjee et al., 2014). Animals with a wider chest have a larger thoracic space and a larger chest circumference (Banerjee et al., 2014). This attribute, too, demonstrates sexual dimorphism, with males having a greater chest breadth than females, which is linked to animal masculinity (Tewelde, 2016). There are also differences in the attributes across various breeds of cattle, with taurine-bred cattle having greater chest widths (Banerjee et al., 2014).

The results for bulls show that the rump length is less than that reported by Chali (2014), Bene et al. (2007), and Abdulmojeed et al., (2010). The current findings are consistent with those of Dereje (2015). As reported by Chali (2014), female rump length is less than that of Arsi cattle, as reported by Chali (2014); however, the values are comparable to those found by Dereje (2015). The length of a cattle's rump is significant for both sexes (Dereje, 2015). Because the fetus has ample room to grow, a cow with an ideal rump length has a decreased incidence of abortion and dystocia (Mekete, 2016). Bulls with longer rump lengths are often more and have better prime cuts of meat, as well as superior draft ability (Alderson 1999).

The findings from the study indicate that the values for the current trait (HW2) are lower than some scholars finding such as Lee et al. (2007), Dawson et al. (1955) and Suriya et al. (2011). The hip width of the Shaka bulls were however, higher than the report of Gilbert et al. (1993). In cows, the breadth of the hip area is also linked to dystocia (Mekete, 2016). Cattle with broader hips have a larger pelvic girdle, which results in increased pelvic breadth (Ebegbulem et al., 2011). Furthermore, cattle with broader hips are typically more diligent and have greater endurance (Banerjee et al., 2014).

Tables 3 and 4 show that bulls bred in both localities had lower weights than those reported by Abdelhadi and Babiker (2009), Khalafalla et al. (2011), Nakachew (2009), Milla et al. (2012), Mwambene et al. (2012), Tewelde (2016) and Tariku et al.(2019). The data also showed that the cows/heifers had a lower body weight than (Tewelde, 2016) but a greater body weight than Dereje (2015). Body weight is one of the features that have various uses in livestock (including cattle), including veterinary treatment, feed formulation, and other management, as well as evaluating a cattle's market worth (Godfrey, 2013). Body weight is one of the most essential factors in determining the market value of animals, particularly those raised for meat (Mwambene et al., 2012). The rise in body weight of the cattle is also used to determine their overall growth (Davis and Hathaway, 1955).

The results for bulls aged ≤5, 6, and ≥7 years raised on both sites show that the values are lower than those found by Takele et al. (2009), Chencha et al. (2013), Mulugeta (2015), and Tewelde (2016) for the pelvic width (PW) trait. The values, however, were consistent with those reported by Dereje (2015) and Chali (2014). However, the pelvic width of the cows/heifers is smaller than that reported by Mulugeta (2015), and Tewelde (2016). The findings of this study are also consistent with those of Takele et al. (2009) and Chencha et al. (2013). The breadth of the two pelvic bones is known as pelvic width, and its value is closely connected to the occurrence of dystocia in animals (Mekete, 2016). Cattle with a smaller pelvic girth have been linked to birth abnormalities, and the feature also exhibits sexual dimorphism, with females' values being higher (Takele et al., 2009; Dereje 2015; Tewelde 2016).

4.2. Morphometrical/structural and functional/indices of the cattle reared in the study areas

Structural indices calculate the ratio of different morphometrical traits and the type and function for which the cattle were developed can be assessed through the same (Alderson 1999). The results of structural indices as indicated in Table 5 for bulls of the age groups of ≤5, 6, and ≥7 years indicate that, the height index (HI) of Shaka bulls is higher than what was reported by Banerjee et al. (2014) for Boran bulls and Tewelde (2016) for Begait cattle. This indicates that the Shaka bulls are taller when compared to their body length, which is good for grazing in the forests and for longer durations (Alderson, 1999). The present results are also in accordance with the observations of Shackelford et al., (1995), who observed that the HI of the bulls remains more or less unchanged after skeletal development, which occurs around 2 years of age.

The values for the two length indexes (LI-1 and 2) too indicate that the ratio of body length vs height at withers and body length vs chest depth is higher than Begait cattle (Tewelde 2016). Therefore, it indicates that the cattle are well placed and proportionate in their morphology when compared to Begait cattle. These indicate that the animals are well adapted to the forest areas where long legs and less chest depth are preferred against predators and parasites (Mwambene et al., 2012). The values for the rump length index too indicate that the height of the rump is proportionately less when compared to the body length of the cattle, which indicates that the cattle are lowly placed, which may be ascribed to the adaptation of the cattle in the forest areas (Mwambene et al., 2012). The rump length index for this study is lower than that of Boran bulls as reported by (Banerjee et al., 2014). As reported by Banerjee et al. (2014) and Tewelde (2016), the over-increase index of the bulls has higher values when compared to the Boran and Begait bulls. The importance of this trait lies in the fact that the front part of the cattle is lower than the rear part. The animals with a lower fore part have fewer chances of respiratory distress (Alderson, 1999; Salako, 2006). The value of the HS index is lower than the Boran bulls (Banerjee et al., 2014), while the values are concurrent with the findings of Tewelde (2016) for Begait cattle; the BWI and FL among the Shaka cattle are lower than those of Begait cattle (Tewelde, 2016). The balance index (BI) of the Shaka bulls are higher than those of Begait cattle (Tewelde, 2016), while the reverse was true for the depth index (DI).

The studies pertaining to the index of Shaka cows of different ages are presented in Table 6. The results indicate that the HI of the Shaka cows is lower than those of Begait cattle as reported by (Tewelde, 2016). However, the reverse was true for the length index (LI1). The results pertaining to LI1 were higher in the White Park cattle, according to Alderson (1999), while the reverse was true for the LI2. As reported by Alderson (1999), the values for the balance and depth index of the White Park cattle were higher than Shaka cows. The results also show that the OII, HS, and FL are higher in Begait cattle (Tewelde 2016) when compared to those of cows in the study area, while, Begait cows had lower DI and BI. Thus, the results indicate that, the those cattle are well adapted to the study area and are small, well balanced cattle well suited for forest grazing, and can therefore be classified as dual-purpose cattle.

4.3. Body weight estimation of the bulls and cows reared across the studied locations

The findings pertaining to the estimation of the body weight of the bulls and cows using linear measurements as presented in Tables 7 and 8. The findings indicate that the chest girth (CG) and muzzle circumference (MC) were the best predictors for the bulls aged ≤5 years, while the body weight of the bulls aged 6 years were assessed through CG. However, for the bulls aged 7, it indicates that besides the CG, muzzle circumference and horn lengths were also predictors of body weight. The importance of horn length, muzzle circumference, and tail length as predictors of body weight has been reported by (Tewelde, 2016). Studies by Mwambene et al. (2012) also indicated that animals with a higher body weight usually have longer tails and horns.

5. Conclusions

Shaka bulls are taller than their body length, making them ideal for grazing in the forests for extended periods of time. The two length indexes (LI-1 and 2) also show that the ratio of body length to height at the withers and body length to chest depth is greater, implying that the cattle are well-placed and proportional in their morphology. These results demonstrate that the animals are well suited to forest environments, where predators and parasites both favor long legs and low chest depth. The OII, HS, and FL results show that those cattle are well acclimated to the study location and are tiny, well-balanced cows well suited for forest grazing, and hence may be categorized as dual purpose cattle. The features of sexual dimorphism are those in which bulls have a larger chest girth than heifers/cows.

Declarations

Author contribution statement

Worku Masho: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Sandip Banerjee: Conceived and designed the experiments; Wrote the paper.

Mestawet Taye: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Zelalem Admasu: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Mekuanent Baye: Analyzed and interpreted the data; Wrote the paper.

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The data that has been used is confidential.

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The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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