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Phenotypic Assessments of Cattle and Buffalo through Body Linear Measurements and their Correlations

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ABSTRACT

Buffalo is an emerging species after cattle though they have some phenotypic difference. To assess differentiation between species based on body measurements a factorial experiment (2 species × 3 ages) of CRD conducted in Bangladesh. Live weight of buffalo (464.2 kg) differed ($P < 0.001$) with cattle (388.5 kg) and it increased ($P < 0.001$) with the increase of age. A significant difference ($P < 0.01$) was observed in the case of body condition score (BCS). The skin of buffalo was found thicker ($P < 0.001$) than cattle. Nine of the body measurements of buffalo (heart girth (HG), barrel (Ba), horn length (HL), horn circumference (HC), thigh circumference (ThC), hind shank circumference (HsC), fore shank circumference (FsC), hook to hook distance (HHD), and pin to pin distance (PPD) were higher ($P < 0.001$) than cattle. Wither height (WH), muzzle (Mz), tail circumference (TC), and hook to pin distance (HPD) differed ($P < 0.01$) between the species. Hip height (HH) differed significantly ($P < 0.05$). All the body parameters and skin thickness showed age effects. Live weights of the two species had a strong correlation with HG and Ba (0.79 and 0.74, respectively). HG showed strong correlation with Ba, HC, HsC and HHD (0.84, 0.72, 0.73 and 0.78, respectively). The correlation coefficient between WH and HH were 0.84, and HsC and FsC was 0.78. HL had strong correlation with HC, FsC and HHD (0.88, 0.71 and 0.79, respectively). So, various phenotypic traits were responsible for the change of other traits positively.

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Introduction

Conservation of available farm animal genetic resources is precisely achieved only when the phenotypic and morphometric traits of targeted species are addressed well. In Bangladesh, cattle and buffalo meet around half of the beef market demand (Rahman, 2012) and it is growing uphill. Through the developmental plan of Bangladesh, beef fattening is given importance to promote sustainable development (Seventh Five Year Plan, 2015). Nowadays, buffalo reckon with as a supreme source of meat, better average daily gain and feed conversion ratio (ADG and FCR) which then considered as a profitable fattening business criterion (Lapitan *et al.*, 2008; Azary *et al.*, 2016). Buffalo is taking the positions of other bovines (Bertoni *et al.*, 2020). Though the cattle and buffalo belong to the same Bovidae family, they signify phenotypic, morphometric, and behavioral differences due to their different karyotypes (Mattapallil and Ali, 1999). Crossbreeding among them also not possible because cattle and river buffalo belong to the different Bovinae and Bubalinae sub-family, respectively (Bertoni *et al.*, 2019). Between these two species, major differences were identified in digestive, reproductive, and thermoregulating systems which actually distinguish them and put effects on production as well (Kandeepan *et al.*, 2009; Bertoni *et al.*, 2019; Mota-Rojas *et al.*, 2021). So, assessment of body measurements of cattle and buffalo and the impact of different traits on production performances need to know. Large animal like cattle and buffalo could be judged by body linear measurements, which produced from visual assessment or scoring (Essien and Adesope, 2003). This type of measurement brings consistency in the production of figures even though those values are coming only from a measuring tape by following the simplest way of measurements with low cost (Heinrichs *et al.*, 2007).

Considering beef, dairy, and indigenous cattle breed, several studies conducted to estimate the live weights of animals, body condition score, and exact age, and so on by using different body linear measurements (Nesamvuni *et al.*, 2000; Kuria *et al.*, 2007; Ozkaya and Bozkurt 2009). Similarly, the potentials of different phenotypic and morphometric traits and their internal correlation, as well as impacts on meat production, are essential to know for ensuring sustainable beef production. Therefore, this study was undertaken to find out the phenotypic difference of local cattle and buffalo through their correlation of different traits and their degree of effects on live weight.

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Materials and methods

Eighteen native buffalo (swamp type) and 18 Cattle bulls (Pabna; local) of three different ages were fattened in a single plane of nutrition for 120 days long. Animals subjected to six treatments (each treatment comprises five animals) in a factorial experiment (2× 3: species × ages) of completely randomized design (CRD) at Bangladesh Livestock Research Institute. At the time of slaughter ages of both species were 28, 34, and 40 months. Before the slaughter, all the bulls fasted for 24 hours, and just before the slaughter, the body weight (BW) of each bull was recorded by a platform digital electronic scale (weighing range 0.00 kg to 1000 kg and minimum graduation ±0.1 kg).

Different pre-slaughter body measurements including body length (BL, distance from the highest point of the shoulders to the pin bone (Brown *et al*., 1973), heart girth (HG, circumference immediately behind the front shoulder at the fourth ribs (Sawanon *et al*., 2011), barrel (Ba), wither height (WH, distance from the ground to the highest point of the withers (Touchberry and Lush, 1950), hip height (HH), horn length (HL), horn circumference (HC), muzzle (Mz), thigh circumference (ThC), hind shank circumference (HsC), fore shank circumference (FsC), tail length (TL), tail circumference (TC), hook to pin distance (HPD), hook to hook distance (HHD) and pin to pin distance (PPD) also recorded before slaughter.

All the measurements were taken by two observers using an ordinary measuring tape and recorded in centimeters. Body condition score was performed following visual plus palpation techniques (BCS, 1-6 scale) according to the guideline described by Prasad (1994). Bulls were slaughtered in the experimental abattoir of BLRI following the `Halal' method. The conventional procedure of flaying followed and the skin thickness of six different regions of each animal was measured by Digital Slide Calipers Metal with LCD (Retired) and recorded in millimeters. The data collected were subjected to analysis of variance (Steel and Torrie, 1980) using univariate GLM procedure based on Completely Randomized Design (CRD).

A least-squares regression approach in SPSS, 17 computer software packages used to describe statistical relations between the treatment responses of a 2×3 factorial experiment with two species and three age groups as the main factors. The Least Significant Difference (LSD) test at 5% level, applied as a post hoc test to compare the differences among treatment means. The statistical model applied for all parameters was; $y_{ijk} = \mu + y_k + \alpha_i + \beta_j + \alpha_i \times \beta_j + e_{ijk}$, Where y_{ijk} was the dependent variable, μ was overall mean, y_k is the random effect of k^{th} treatment (k = 1, ……, 6) and e_{ijk} was the random error, α_i (i = 1, 2; two species i.e., cattle and buffalo bull), β_j (j = 1, 2, 3; three age groups i.e., 18 months, 24 months and 30 months) and $\alpha_i \times \beta_j$ were the fixed effects of irh animal species (cattle, buffalo) j^{th} age group (18 months, 24 months and 30 months) and their interaction, respectively. Correlation of BW with BCS and all the measured phenotypic traits computed to explore their effects on BW. Linear regression of all phenotypic and morphometric traits was also computed to measure the in-between relationship of one trait to another by Microsoft Excel Program.

Ethical Approval Statement

Institutional authority was concerned before experimenting. All the involved participants were informed about the experiment, and they were also responsible for their job. All the staff associated with the operation participated voluntarily. During the evaluation process, no animals were harmed (intended or otherwise) by any means, animals were treated humanely, and as simple as possible measures followed.

Results

Different body measurements of local pabna cattle and local buffalo bulls of three different ages at pre-slaughter are presented in Table 1. Between Cattle and Buffalo, it revealed that all the body parameters except body length differed with each other at a different level of significance and in the case of each parameter buffalo showed high measurement than cattle except tail length. Heart girth (HG), barrel (Ba), horn length (HL), horn circumference (HC), thigh circumference (ThC), hind shank circumference (HsC), fore shank circumference (FsC), hook to hook distance (HHD) and pin to pin distance (PPD) of buffalo was higher ($p<0.001$) than cattle (188.9: 173.2, 206.2: 194.4, 48.6: 12.2, 32.78: 20.13, 113.2: 98.5, 23.3: 19.1, 22.7: 17.8, 54.8: 42.8, 29.6: 23.1 cm, respectively); where tail length (TL) of cattle found longer ($p<0.001$) than buffalo (98.0: 87.6 cm, respectively).

The measured value of wither height (WH) and muzzle (Mz) were found significantly higher ($P < 0.01$) with buffalo

Table 1. Species-age effects on the skin thickness of cattle and buffalo at slaughter (mm)

Species, age & their interactions		Skin Thickness at slaughter					
Species	Age	At neck	At rib	At back	At hook	At pin	At tail base
Cattle	18M	19.52	16.92	13.04	15.12	13.44	11.64
(Local pabna)	24M	21.28	18.98	13.8	16.45	14.6	11.8
	30M	22.92	19.73	16.2	17.47	14.49	12.12
	18M	27.42	28.75	16.05	25.2	27.35	14.63
Buffalo	24M	32.32	29.12	19.77	29.08	30.08	15.62
	30M	33.97	30.12	21.42	33.72	32.82	16.35
Species	BCB-1	21.24	18.54	14.35	16.35	14.18	11.85
	Buffalo	31.23	29.33	19.08	29.33	30.08	15.53
	18M	23.47^{b}	22.83	14.54^{b}	20.16^{b}	20.4	13.13
Age	24M	26.80^{bc}	24.05	16.79^{bc}	22.77^{bc}	22.34	13.71
	30M	28.45^{ac}	24.93	18.81^{ac}	25.60^{ac}	23.66	14.23
SED		0.96	1.27	0.79	1.34	0.99	0.76
	s	***	***	***	***	***	**
Sig.lev.	a	*	NS	*	*	NS	NS
	s × a	NS	NS	NS	NS	NS	NS

M= months; s = species; a = age; s × a = species × age interactions, * = P < 0.05; ** = P < 0.01; *** = P < 0.001; NS = non-significant than cattle (135.7: 129.3 and 47.0: 42.8 cm, respectively), and the value of tail circumference (TC) and hook to pin distance (HPD) found significantly higher (P < 0.01) with cattle than buffalo (25.9: 23.7 and 42.9: 41.3 cm, respectively) as well. Hook height (HH) of buffalo was higher than cattle at a 5% level of significance.

The body length (BL) of these two species was quite similar and no significant difference was observed. Irrespective of species, it is observed that all the parameters differed with the age groups at different levels of significance. It experienced that, with the increase of age the BL, HG and Ba increased certainly, and the values of 30 months age was mostly (P < 0.001) higher (142.4, 188.9 and 207.7 cm, respectively) followed by 24 months and 18 months of age (138.0, 188.8 and 201.1 cm; 130.9, 173.5 and 192.1 cm, respectively), in regarding these four parameters. In the case of HHD, 28 months of age showed a highly significant difference with other age groups. There was no significant difference between the age groups of 34 and 40 months (46.1, 49.5, and 50.8 cm, respectively). A significant difference (P < 0.01) was also observed in the measurements of WH, HH, HC, Mz, HsC, TC, and HPD where, in the case of WH, HC, Mz, and HsC, 40 months age group differed significantly (137.9, 29.0, 48.1 and 22.4 cm, respectively) with other age groups who showed no significant difference with each other (131.2, 25.8, 44.0 and 21.0; 128.4, 24.6, 42.6 and 20.1 cm, respectively). Likewise, HH and HPD measurements of 34 months and 40 months age groups differed (P<0.01) than that of 28 months of age group where the groups of 34 and 40 months of age didn’t differ from each other (129.5, 40.1 cm; 133.9, 42.9 cm and 137.9, 43.3 cm, respectively).

In the case of TC, a slow but gradual development was observed, where 40 months of age group differed (P < 0.01) with 28 months of age group (26.1 and 23.4 cm, respectively) but 34 months of age group (24.9 cm) not differed with any of them. Again, the measurements of HL, ThC, FsC, TL, and PPD indicated that with the increase of age all the values of these parameters increased, and 40 months age group showed the highest value in all the cases at a 5% level of significance. Regarding the interaction of species and age, it examined that, most of the body measurement parameters showed no significant interaction effects. However, BL measurement showed that there were significant (P<0.01) interaction effects of species and age. At the same time, HC and TL also showed an interaction effect of species and age at a 5% level of significance.

Data of skin thickness presented in Table 2. The skin of buffalo bulls is much thicker than local pabna cattle resulting highly significant difference found with the measured value of buffalo than cattle. Regarding only species, the skin thickness of buffalo bulls was thicker and showed a very high significant difference (P < 0.001) with cattle at five different regions of the body, i.e.: neck, rib, back and hook regions (31.23: 21.24, 29.33: 18.54, 19.08: 14.35, 29.33: 16.35 and 30.08: 14.18 mm, respectively). At the region of the tail base, buffalo bulls showed a highly significant difference (P < 0.01) with cattle (15.53: 11.85 mm, respectively) again. Irrespective of species, age effects found in the measurements of three regions and case of rest of the three regions, any variation of skin thickness between the species not found. At the neck, back, and hook regions, it saw that with the increase of age; thickness of the skin of bulls of both the species increased with gradual augmented manner (23.47, 26.80 & 28.45 mm; 14.45, 16.79 & 18.81 mm and 20.16, 22.77 & 25.60 mm, respectively) at 5% level of significance. In this aspect, it was observed that 40 months age group differed with 28 months of age group, but the 34 months age group not differed with others.

Body condition score (BCS) of buffalo possessed over cat-

Table 2. Effect of species and age on body parameters of cattle and buffalo at slaughter (cm)

Species	Age	Body parameter (cm)															
		BL	HG	Ba	WH	HH	HL	HC	Mz	ThC	HsC	FsC	TL	TC	HPD	HHD	PPD
Cattle	18M	126.5	164.7	183.2	124	126.8	11.1	19.4	41	93.8	17.8	17.3	97.6	24.3	39.8	39.7	21
(Local pabna)	24M	139.2	175.4	198.4	130.2	133.2	12.6	20.4	42.6	98.6	19.6	17.6	98.6	26	44.4	44	23.4
	30M	143.6	179.6	201.6	133.6	135.8	13	20.6	44.8	103	19.9	18.6	97.8	27.4	44.6	44.8	24.8
Buffalo	18M	135.4	182.4	201	132.8	132.2	37.3	29.7	44.2	106.2	22.5	21.7	84	22.4	40.4	52.6	29.2
	24M	137.4	186.2	203.8	132.2	134.6	53.4	31.2	45.4	114	22.4	22.4	84	23.8	41.4	55	29.6
	30M	141.2	198.2	213.8	142.2	140	55	37.4	51.4	119.4	25	24	95	24.8	42	56.8	30
Species	BCB-1	136.4	173.2	194.4	129.3	131.9	12.2	20.13	42.8	98.5	19.1	17.8	98	25.9	42.9	42.8	23.1
	Buffalo	138	188.9	206.2	135.7	135.6	48.6	32.78	47	113.2	23.3	22.7	87.6	23.7	41.3	54.8	29.6
Age	18M	130.9^{c}	173.5^{c}	192.1^{c}	128.4^{b}	129.5^{b}	24.2^{b}	24.6^{b}	42.6^{b}	100.0^{bc}	20.1^{b}	19.5^{bc}	90.8^{ac}	23.4^{b}	40.1^{b}	46.1^{b}	25.1^{b}
	24M	138^{b}	180.8^{b}	201.1^{b}	131.2^{b}	133.9^{a}	33.0^{a}	25.8^{b}	44.0^{b}	106.3^{ac}	21.0^{b}	20.0^{ac}	91.30^{a}	24.9^{bc}	42.9^{a}	49.5^{a}	26.5^{bc}
	30M	142.4^{a}	188.9^{a}	207.7^{a}	137.9^{a}	137.9^{a}	34.0^{a}	29.0^{a}	48.1^{a}	111.2^{a}	22.4^{a}	21.3^{a}	96.4^{bc}	26.1^{ac}	43.3^{a}	50.8^{a}	27.4^{ac}
SED		0.98	1.11	1.61	1.34	1.23	1.96	0.68	0.74	2.1	0.37	0.41	1.35	0.41	1.29	0.57	0.56
Sig.lev.	S	NS	***	***	**	*	***	***	**	***	***	***	***	**	**	***	***
	A	***	***	***	**	**	*	**	**	*	**	*	*	**	**	***	*
	s × a	**	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	*	NS	NS	NS	NS

M= months; s = species; a = age; s × a = species × age interactions, * = P < 0.05; ** = P < 0.01; *** = P < 0.001; NS = Non - significant, BL = body length, HG = heart girth, Ba = barrel, WH = wither height, HH = hip height, HL = horn length, HC = horn circumference, Mz = muzzle, ThC = thigh circumference, HsC = hind shank circumference, FsC = fore shank circumference, TL = tail length, TC = tail circumference, HPD = hook to pin distance, HHD = hook to hook distance, PPD = pin to pin distance tle (P < 0.01) and it also revealed that BCS of both the species showed significantly higher (P < 0.01) value with elder group of ages than the younger groups. On a scale of 6 for measuring BCS, buffalo as a species scored 5.36 and local pabna cattle got 5.13. Irrespective of species, 5.08, 5.25, and 5.41 overall score for 28, 34, and 40 months of age groups marked, respectively. Among the age groups, the elder two groups differed with the younger group but not differed with each other (Figure1).

Whatever the BCS was, buffalo showed a highly significant (P < 0.001) live weight than local pabna cattle at the time of slaughter. Irrespective of species, a very high significant difference (P < 0.001) was observed among the groups. Regarding only species, with the significant difference in live weight at slaughter buffalo (464.2 kg) gained 75.7 kg more weight than that of cattle (388.5 kg). It is observed that, live weight of both the species increased (P < 0.001) and consecutively at the rate of around 44 kg from 28 months (382.9 kg) to 34 months (425.7 kg) age groups of animal and then to 40 months (470.5 kg). There were also interaction effects observed between species and age at a 1% level of significance. Live weight and body condition score showed an uphill trend between species along with different groups of ages of both species (Figure1).

However, a correlation matrix of 16 different phenotypic traits of cattle and buffalo altogether established to explore the correlation coefficient. From there, it evident that in 11 cases a strong uphill relationship was found with various phenotypic traits and in 28 cases it revealed that there was a moderate positive relationship between different phenotypic traits. In the case of all other cases, in most of the places, a weak relationship was observed but a negative relationship wasn't found anywhere. BW showed a strong relationship with HG and Ba (0.79 and 0.74, respectively), where HG expressed a strong correlation coefficient with Ba, HC, HsC, and HHD (0.84, 0.72, 0.73, and 0.78, respectively. WH only correlated strongly with HH (0.84), likewise HsC only correlated with FsC (0.78) strongly. HL and HC, each expressed a strong linear positive relationship with three different traits; HL had a strong relation with HC, FsC, and HHD (0.88, 0.71, and 0.79, respectively), whereas HC had a strong relation with HsC, FsC, and HHD (0.76, 0.80 and 0.78, respectively). Phenotypic traits surely affect the BW and one trait is stimulated through the change of other traits affecting each other positively at 4E - 07 to + 0.88 ranges of the correlation coefficient. BCS, the morphometric measurements of cattle and buffalo did not show any correlation (Table 3).

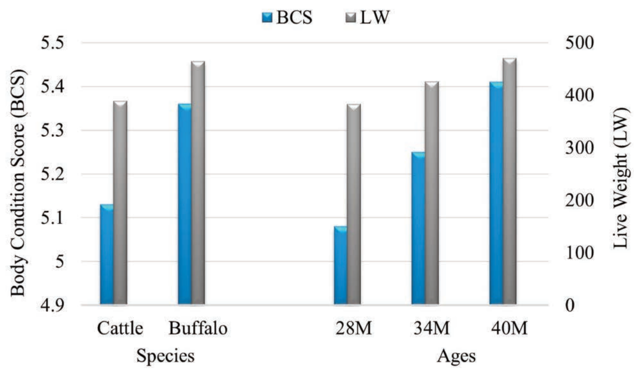

Fig. 1. BCS and LW of cattle and buffalo at three stages of age

Discussion

Buffalo revealed superior body measurements than that of cattle in most of the cases and these findings were somewhat similar with the findings of Tiawo *et al*. (2010), where compared body measurements of beef cattle and claimed that breed and environmental factors affected body measurements. Celikeloglu *et al*. (2019) also observed significant environmental impacts on body measurements at different ages. But Bene *et al*. (2007) observed that the body measure index had no significant effects on production after the completion of the fattening program. In the case of skin thickness, the current study found again a significant difference between the species, and Bertoni *et al*. (2020) gave a quite supportive statement with this finding. They stated that, though those species belong to the Bovidae family, they occupy distinct phylogenetic positions and show anatomical, physiological, and behavioral differences due to their different karyotypes.

With the increase of the age of animals, different body measurement increased affecting body weight or other traits. This statement has resembled the findings of Mwacharo *et al*. (2006), where they found age group effects on body meas-

Table 3. Correlation matrix for body measurements of cattle and buffalo altogether

Correlation	BW	HG	Ba	BL	WH	HH	HL	HC	Mz	TC	HsC	FsC	TL	TC	HPD	HHD	PPD
HG	0.79																
Ba	0.74	0.84															
BL	0.49	0.38	0.54														
WH	0.67	0.63	0.57	0.38													
HH	0.59	0.51	0.53	0.48	0.84												
HL	0.44	0.63	0.42	0.1	0.33	0.27											
HC	0.55	0.72	0.48	0.1	0.47	0.36	0.88										
Mz	0.41	0.55	0.46	0.18	0.42	0.17	0.39	0.52									
TC	0.44	0.49	0.3	0.18	0.22	0.35	0.65	0.55	0.16								
HsC	0.58	0.73	0.59	0.2	0.45	0.38	0.67	0.76	0.56	0.39							
FsC	0.41	0.64	0.39	0.08	0.41	0.26	0.71	0.8	0.47	0.41	0.78						
TL	0.04	0.08	0.04	0.001	4.00E-07	0.001	0.17	0.14	5.00E-05	0.08	0.08	0.16					
TC	0.002	1.00E-05	0.02	0.15	0.01	0.65	0.12	0.09	0.0002	0.01	0.01	0.07	0.15				
HPD	0.09	0.06	0.17	0.48	0.14	0.29	0.01	0.007	0.01	0.001	0.003	0.008	0.07	0.49			
HHD	0.67	0.78	0.61	0.22	0.48	0.39	0.79	0.78	0.41	0.52	0.68	0.63	0.26	0.05	0.0005		
PPD	0.59	0.6	0.46	0.24	0.32	0.26	0.62	0.59	0.21	0.49	0.52	0.52	0.21	0.04	0.0001	0.73	
BCS	0.002	4.00E-05	0.001	0.01	0.001	0.0003	0.09	0.05	0.01	0.003	0.02	0.04	0.19	0.16	0.23	0.12	0.08

HG = heart girth, Ba = barrel, BL = body length, WH = wither height, HH = hip height, HL = horn length, HC = horn circumference, Mz = muzzle, TC = tail circumference, HsC = hind shank circumference, FsC = fore shank circumference, TL = tail length, HPD = hook to pin distance, HHD = hook to hook distance, PPD = pin to pin distance urements of two breeds of zebu cattle. Other findings stated that BW and body measurements are shown a correlation in most of the experiments along with influenced through breed and age groups (Heinrichs *et al*., 2007; Ozkaya and Bozkurt, 2009). Tiawo *et al*. (2010) also reported that body measurements increased maximum between 1 - 3 years and it happened gradually with the increase of age, which affected significantly (P < 0.01) the body parameters. The current study in line with this agreement as the animals used in this study was 28 - 40 months ranges of age. In other words, body measurements could be recognized as an important management tool for selection of the beef cattle or for serving breeding purposes (Dingwell *et al*., 2006). Sometimes spending an extended time for breeding intention could create the increment of BW of mature bulls along with WH (Tozser *et al*., 2001). This finding resembled the present study as WH showed a moderate relationship with BW. Therefore, from the current study, it confirmed that mature animal shown variations in body parameters and this statement is an agreement of the study of Lukuyu *et al*. (2016) where they saw variations in body parameters of mature animals while exotic genotypes compared through adding different classes of animals.

BCS is a vital indicator that can use for subjective measures like reserve fat content or nutritional status of animals (Roche *et al*., 2009). Though between the species, BCS differed significantly (P < 0.001) along with age and interaction effects (P < 0.001) but regressing with different body measurements there was no significant correlation observed. In the study of Tiawo *et al*. (2010), it was observed that body condition scores affected significantly the body parameters like heart girth, wither height, body length, hook height, etc.

Body measurements like HG, BL, WH, etc. recognized as useful assessment tools for predicting animal's live weight. Bene *et al*. (2007) advised that such types of body measurements or other phenotypic traits could be used in the study of skeletal development. In this study, BW, HG, WH along with some other phenotypic traits of cattle and buffalo were strongly and somewhere moderately correlated with each other. This statement is in line with the report of Lukuyu *et al*. (2016), where they stated that live weight showed a strong correlation with HG and moderate correlation with BL and WH. In the case of BW, the correlation between BW and HG carried the highest value and between BW and BCS carried the lowest value. At the same time, HG itself was strongly or moderately correlated with nine other traits. These findings were somewhat similar to the study of Goe *et al*., 2001. In the case of BL, no strong or moderate correlation was observed with any measurements but correlation with BL was found and reported in other studies (Gunawan and Jakaria, 2010; Kashoma *et al*., 2011). However, there was a lot of correlation observed among different phenotypic traits, whether the levels of relationship that could be used. Even though positive relationships among the traits suggest that an increase in one could lead to a corresponding increase in the other trait resulting influenced the animal selection program (Assan, 2013).

Conclusion

The live weight of buffalo increased with a significant difference than buffalo even at age prolongation. Different body measurements showed a correlation among them and, it is responsible for the change of one trait for others.

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Conflict of interest

The authros declared that no conflict of interest exist.

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