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Phenotypic correlation of linear type measurements and functional type traits in two Nigerian cattle breeds

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Abstract

A study was conducted to evaluate the effect of linear measurements and linear type traits in two breeds of cattle in Nigeria. Observations on linear type traits of 142 cows consisting of 89 Bunaji and 53 Sokoto Gudali breeds were scaled and scored thrice within a period of May to July, 2017. Live weight and nine body linear measurements (Height at Rump-HR, Height at Withers-HW, Body Length-BL, Length of Hip-LH, Rump Length-RL, Width of Hips-WH, Width of Pins-WP, Chest Depth-CD, and Chest Width-CW) and eight linear type traits scores (Stature-ST, Body Depth-BD, Rump Width-RW, Teat Length-TL, Udder Depth-UD, Body Condition Score-BCS, Rear Legs Set (side view), and Fore Udder Attachment) were also measured. Result showed significant (p<0.05) difference for HW (129.61±0.31), BL (107.87±0.32), LGT (85.37±0.34), RL (40.04±0.17) and CW (35.07±0.28) for Bunaji cows which were higher than HW (127.65±0.40), BL (104.02±0.51), LGT (82.22±0.40), RL (37.87±0.91) and CW (30.04±0.29 cm), respectively for Sokoto Gudali cows. The highest live weight was obtained with Sokoto Gudali (230.61 kg) which differed significantly (p<0.05) from the Bunaji cows (219.05 kg). Phenotypic correlation result showed that cumulative index had the highest correlation with body length (0.684) in Bunaji cow and highest correlation with width of pins (0.790) in Sokoto Gudali cows. Live weight had the highest correlation with height at withers (0.701) in Bunaji cows, and highest correlation with chest depth (0.823) in Sokoto Gudali cows. In conclusion, there were considerable variations observed for some body measurements, linear type and functional indices and type trait scores between Bunaji and Sokoto Gudali cows, which indicated clear genetic distinction between them.

Keywords: Cattle, Bunaji, Sokoto Gudali, cows, linear type traits

Introduction

Livestock production is a major component of the agricultural economy of developing countries that goes beyond food production to providing direct cash returns to farmers (Jabbar *et al.,* 1995). Morphological descriptions such as head measurements, height at withers, heart girth, girth circumference and rump height were used to indicate breed origins, size, weight and particularly for describing cattle in beef show classes (Alderson, 1999; Salako, 2006; Kashoma *et al*., 2011; Mazza, *et al*., 2013). Alternative body measurements and indices estimated from diverse combinations of different body traits produced a superior guide to weight and were used as an indicator of type and functional traits in domestic animals (Schwabe and Hall, 1989; Alderson, 1999; Salako, 2006). Since 1994, a group within the International Committee for Animal Recording has been established to study conformation recording, but its work was directed mainly at dairy cattle (Stoll *et al*., 1996). The use of linear type traits as indirect indicators of fertility to improving reproductive performances could be an option to reducing generation interval since it allows for early selection. Linear type traits depict measurements for a range of visual characteristics of an animal (Berry *et* *al*., 2004). Literally, it describes what 'type' or external form of an animal. It also describes the animal's physical form as measured over 20-25 distinct individual points of its conformation (Centre for Dairy Information, 2016). Functional traits are traits impacting commercial dairy production such as udder type; feet and legs (Centre for Dairy Information, 2016). Alternative body measurements and indices estimated from diverse combinations of different body traits produced a superior guide to weight and were used as an indicator of type and functional traits in domestic animals (Salako, 2006). Since 1994, a group within the International Committee for Animal Recording has been established to study conformation recording, but its work was directed mainly at dairy cattle (Stoll *et al*., 1996) however those of this study is on beef cattle. Consequently, type traits are usually obtained early during the productive life; they are cheap and easy to measure therefore assisting scientist in keeping track of the possible variations which might exist. This work therefore is aimed at determining the relationship of body linear type traits and functional indices of Bunaji and Sokoto Gudali cows.

Materials and methods

Experimental location

The research was conducted at the Beef Research Programme of National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika, Zaria, Kaduna State, Nigeria. The location is as described by Meteorological Unit, IAR/ABU (2017).

Experimental animal and management

A total of 142 cows consisting of eighty-nine (89) Bunaji and fifty-three (53) Sokoto Gudali breeds were used for the study. The animals were supplemented with concentrates made up of cotton seed cake and wheat offal before and after their normal unrestricted grazing of about 7-9 hours per day. They had access to water and salt lick *ad-libitum*.

Data collection

Nine separate measurements and live weight were taken from each breed of the cows. These include: Height at rump, height at withers, body length, hip length, rump length, hips width, width of pins, width of chest and depth of chest. All the traits were measured using flexible tape (cm) with the exception of height at withers and height at rump which were measured using a measuring stick calibrated in centimeter. The measurements taken were used in calculating the appropriate indices for each breed of cows in the study. The calculated indices were: Height Slope (HS), Length Index (LI), Rump Length Index (RLI), Balance (Bal.), Width Slope (WS), Depth Index (DI), Foreleg Length Index (FLI) and Cumulative Index (CUI). Live weight was taking using Avery weighing bridge scale (Tronix ModelE1010) calibrated in kilogram. The calculations followed the procedures on White Park cattle in the United Kingdom in 1994-1995.

Data analysis

Data were analyzed using the General Linear Model procedure of Analysis of Variance. Means with significant differences were separated using the two-tailed, two-sample t-test of R.3.0.3 (2016) statistical package. The correlations between variables were computed for all the animals within each breed of beef cattle using biserial CORR procedure of the R.3.0.3 (2016) statistical package.

Results and discussion

Effect of breeds of cows on linear type measurements

The description of the sampled population is presented in Table 1. Results were expressed as mean, standard deviation and coefficient of variation for each linear type measurements of Bunaji and Sokoto Gudali cows. Significant ($p<0.05$) difference was observed between the genotypes with Bunaji cows having higher values for HW, BL, LGT, RL and CW (129.61 ± 0.31, 107.87 ± 0.32, 85.37 ± 0.34, 40.04 ± 0.17, 34.91 ± 0.22, respectively) than in Sokoto Gudali cows (127.65 ± 0.40, 104.02 ±0.51, 82.22 ± 0.40, 37.87 ± 0.91 and 30.04 ± 0.29, respectively). On the other hand, Sokoto Gudali had higher value for CD (76.09 ± 0.34) than in Bunaji (74.16 ± 0.32).

However, there was no significant difference ($p>0.05$) observed between the genotypes for HR, WP and WH (126.13 ± 0.29, 20.37 ± 0.12, and 44.88 ± 0.25) in Bunaji (125.99 ± 0.39, 20.26 ± 0.15 and 44.47 ± 0.39) and in Sokoto Gudali. The coefficient of variation varied between 3.79-13.11 for Bunaji cows and 3.92-12.30 for Sokoto Gudali cows, respectively. The most variable trait was CW (CV= 10.41 and 12.30) in Bunaji and Sokoto Gudali, respectively while the least variable trait was HR (CV= 3.79 and 3.92) in Bunaji and Sokoto Gudali, respectively. Result from this study was similar to the findings of Raji *et al*. (2007) who reported an average of 120.18 cm for HW in White Fulani cattle. This was also similar to 109.732, 115.572, 119.158, 31.674, 11.589 and 55.892 cm reported for BL, HW, HR, RL, RW and CD, respectively by Adinata *et al*. (2016) on Jabres cattle of Indonesia. Observations were also in close range with 124.9 cm and 111.1 cm reported for HW and BL respectively by Dim *et al*. (2012) for Bunaji breed. However, they are lower than values of 131.13, 131.91, 147.57, 55.41, 59.66, 51.37 and 75.36 (cm) for (HW, HR, BL, RL, WH, WP and CD) respectively, reported by Alderson (1999) for White Park cattle. Most body measurements showed significant ($p<0.05$) difference between the two genotypes. The result revealed that Bunaji is genetically taller, have longer body with a wider chest than Sokoto Gudali cow considering HW, BL, LGT, RL and CW (129.61 ± 0.31, 107.87 ± 0.32, 85.37 ± 0.32, 40.04 ± 0.17, 34.91± 0.22) for Bunaji and (127.65 ± 0.40, 104.02 ± 0.51, 82.22 ± 0.40, 37.87 ± 0.91 and 30.04 ± 0.29 cm) for Sokoto Gudali respectively.

This contradicted the report of Yakubu *et al.* (2010) that HW, HR, BL, RL and RW (49.53, 179.02, 42.17 and 50.43 cm, respectively) of Sokoto Gudali were significantly higher than those of Bunaji (111.84, 120.34, 175.29, 39.06 and 33.32). Similarly, it was contrary to Okeh and Ugwu (2014) who found that BL, HW and HR (123.14, 133.54 cm and 138.00 cm) of Sokoto Gudali were higher than (117.04 cm, 127.15 cm and 127.24 cm) of Bunaji respectively.

Nevertheless, the result indicated that Sokoto Gudali had higher values for chest depth (76.09 ± 0.34) which was higher than (74.16 ± 0.32) in Bunaji cows, and agrees with the report of Rege and Tawah (1999) who reported that Sokoto Gudali has deeper body than the white Funali (Bunaji) breed and resemble East African Boran and Sudanese's Kenana breeds.

The moderate coefficient of variation observed for chest width (CV=10.41 and 12.30) in both genotypes and those observed for width of hips (CV=11.05) and the width of pins (CV=9.31) in Sokoto Gudali and Bunaji cows respectively were in close range with 6.39 and 11.57 for WH and CW respectively reported by Alderson (1999) in White park cattle.

Alderson (1999) suggested that high coefficient of variation for chest width could be due to reflection of the sensitivity of chest width to changes in the fitness (condition) of the animal and owed this occurrence to the influence of the environment and peculiarities of the breeds. The moderate coefficient of variation observed for chest width and width of pins also suggest that they could respond faster to selection than those traits with lower coefficient of variation in these genotypes.

Table 1: Least squares means ± S.E. of effect of linear type measurements on Bunaji and Sokoto Gudali cows

Traits	N	Mean±SE	SD	Min.	Max.	CV
				Bunaji		
HW	267	129.61±0.31[a]	5.09	117	143	3.93
HR	267	126.13±0.29	4.78	112	138	3.79
BL	267	107.87±0.32[a]	5.15	89	121	4.77
LGT	267	85.37±0.34[a]	5.62	68	102	6.59
RL	267	40.04±0.17[a]	2.70	30	49	6.74
WP	267	20.37±0.12	1.90	15	29	9.31
WH	267	44.88±0.25	4.14	29	53	9.22
CD	267	74.16±0.32[b]	5.21	36	84	7.03
CW	267	34.91±0.22[a]	3.63	29	44	10.41
				Sokoto Gudali		
HW	159	127.65±0.40[b]	5.71	114	139	4.47
HR	159	125.99±0.39	4.94	108	137	3.92
BL	159	104.02±0.51[b]	6.45	79	115	6.15
LGT	159	82.22±0.40[b]	5.06	67	93	6.15
RL	159	37.87±0.91[b]	2.33	32	44	6.15
WP	159	20.26±0.15	1.85	15	28	9.11
WH	159	44.47±0.39	4.91	31	53	11.05
CD	159	76.09±0.34[a]	4.27	64	86	5.61
CW	159	30.04±0.29[b]	3.70	24	41	12.30

HW= Height at withers; HR= Height at rump; BL= Body length; LGT= Length; RL= Rump length; WP=Width of pins; WH= Width of hips; CD= Chest depth and CW= chest width; C.V. = Coefficient of variation; Min, = Minimum; Max, Maximum; N= Number of observation; ab= Means with uncommon superscripts for each trait in a column differ significantly, $P<0.05$.

The impact of linear type and functional indices on Bunaji and Sokoto Gudali cows

Table 2 revealed the effect of genotype on type and functional indices. It was observed in this study that Bunaji had higher values for all the indices than the Sokoto Gudali with the exception of live weight, balance, width slope and depth index (230.61 ± 3.352 kg, 0.75 ± 0.10, 14.42 ± 0.488 and 0.60 ± 0.002) for Sokoto Gudali and 219.05 ± 1.907 kg, 0.70 ± 0.007, 9.80 ± 0.403, and 0.60 ± 0.002, respectively for Bunaji. This indicates that the Bunaji cow is genetically bigger than the Sokoto Gudali cow. Both cows stood higher at withers than rump, sloping backwards from posterior. However, the difference between the heights (wither and rump) was not the same in both breeds being 3.48 cm in Bunaji and 1.67 cm in Sokoto Gudali. This suggests that the height slope of Bunaji is higher than that of Sokoto Gudali.

The indices calculated from measurements of both breeds showed the structure and proportions of each animal and established standard for breed type. Both genotypes have the proportion of beef animals with respect to their cumulative index (2.54 ± 0.011 and 2.56 ± 0.019) for Bunaji and Sokoto Gudali, respectively. This is close to the cumulative index (3.88 ± 0.17) of White Park cows in the United Kingdom reported by Alderson (1999). The author suggested that cumulative index is the most superior measure to weight because it incorporates measures of desirable conformation, namely length and balance. Since the value of weight is limited without some qualification of associated type and conformation, cumulative index is a useful indicator of overall morphological merit, as it combines values of weight and structure, and provides an accurate portrait of typical breed type as reported by Alderson (1999). This probably suggests why Bunaji and Sokoto Gudali cows are used for both milk and beef purposes as reported by Rege and Tawah (1999). Consequently, this study revealed that Sokoto Gudali cow is genetically shorter and wider than Bunaji cow because of their short height at withers and chest width. Hence, the reason they are called "Gudali" meaning short-legged animal (ILRI, 2017).

Furthermore, the indices suggested that when live weight, balance, width slope and depth index are considered, Sokoto Gudali is heavier, well balanced with a wider and deeper body than Bunaji cow. Consequently, the study also revealed that Bunaji cow has a sloppier body from withers to rump and is taller than Sokoto Gudali cow. Pointing that when selection for shorter age at first calving and calving interval is considered, Sokoto Gudali might likely respond faster than Bunaji since small-framed cows with large body capacity were reported to have shorter calving interval and earlier age at first calving than taller cows (Zindove *et al*., 2015).

The observed difference for live weight and other body measurements of this study with the reports of other researchers might likely be due to difference in the genetic make-up of breeds, tools used in analyzing the data, environmental differences, management and the physiological state of the animals during the study. Bewely and Schutz (2008) also revealed that breed difference had been found with regard to conformational traits.

Phenotypic correlation matrix among primary measurements, live weight and cumulative index for Bunaji and Sokoto Gudali cows

Table 3 shows the phenotypic correlations among primary measurements, live weight and cumulative index results for Bunaji cows. The correlation between primary measurements and live weight were all positive and significant ($p<0.05$), ranging from 0.283 (LW and CW) to 0.701 (LW and HW). Correlation between cumulative index and primary measurements ranged from -0.063 (CUI and CW) to 0.684 (CUI and BL), while the correlation among primary measurements ranged from -0.211 (CD and CW) to 0.823 (HR and HW). The correlation between live weight and cumulative index (0.770) was positive and significant ($p<0.01$). Results for Bunaji cows shows that body length, length of back, rump length and hip width have the highest correlation with cumulative index (0.684, 0.610,0.621 and 0.626) respectively. Thus, they could be used to predict cumulative index in Bunaji cows.

Table 4 shows the phenotypic correlations among primary measurements, live weight and cumulative index results for Sokoto Gudali cows. The correlation between primary measurements and live weight were all positive and ranged from 0.341 (LW and CW) to 0.823 (LW and CD). The correlations between cumulative index and primary measurements ranged from -0.123 (CUI and CW) to 0.790 (CUI and WH). Correlations among primary measurements ranged from -0.001 (CW and WP) to 0.879 (LGT and BL), while the correlation between live weight and cumulative index (0.801) was positive and significant ($p<0.01$).

The same trend was observed for Sokoto Gudali cows where body length, back length, hip width and chest depth had the highest correlation with cumulative index (0.656, 0.696, 0.790 and 0.602) respectively. This is in agreement with the study of Alderson (1999) who reported that

Table 2: Least squares means (±S.E) of effect of linear type and functional indices in Bunaji and Sokoto Gudali cows

Traits	N	Means ± SE	SD	Min.	Max.	CV
			Bunaji			
LW	267	219.05±1.907[b]	31.16	135.0	295.0	14.23
HS	267	3.48±0.181[a]	2.95	-4.00	13.00	84.89
LI	267	0.83±0.002[a]	0.04	0.66	0.93	4.52
RLI	267	0.47±0.002[a]	0.04	0.36	0.59	7.69
Bal.	267	0.70±0.007[b]	0.11	0.39	0.99	15.66
WS	267	9.80±0.403[b]	6.58	-44.0	21.0	67.12
DI	267	0.57±0.002[b]	0.04	0.27	0.64	6.77
FLI	267	55.45±0.370[a]	5.90	43.0	96.0	10.76
CUI	267	2.54±0.011	0.18	1.88	2.97	7.21
			Sokoto Gudali			
LW	159	230.61±3.352[a]	42.28	130.0	320.0	18.33
HS	159	1.67±0.306[b]	3.86	-9.00	12.00	86.38
LI	159	0.82±0.004[b]	0.05	0.63	0.92	6.45
RLI	159	0.46±0.003[b]	0.04	0.37	0.57	7.68
Bal.	159	0.75±0.010[a]	0.13	0.46	1.17	16.97
WS	159	14.42±0.488[a]	6.15	-4.00	28.00	42.65
DI	159	0.60±0.002[a]	0.03	0.53	0.66	4.17
FLI	159	51.56±0.334[b]	4.21	41.00	62.00	8.16
CUI	159	2.56±0.019	0.24	1.95	3.41	9.43

HS= Height slope; LI= Length index; RLI= Rump length index; Bal. = Balance; WS= Width slope; DI= Depth index; FLI= Foreleg le ngth index; CUI= Cumulative index; C.V. = Coefficient of variation; Min, = Minimum; Max, Maximum; N= Number of observation; [ab]= Means with uncommon superscripts for each trait in the same column is significantly, $P<0.05$

body length, rump length and hip width have the highest correlation with cumulative index. Alderson (1999) also reported that a limited study of bulls showed different pattern of results and that body length was significantly the best indicator of cumulative index, followed by rump length.

Table 3 showed that height at withers (0.701) and body length (0.654) had the highest correlation with live weight in Bunaji cows. Nevertheless, in Sokoto Gudali cows (Table 4), chest depth and height at withers (0.823 and 0.663) respectively, had the highest correlation with live weight. This is similar with the report of Alderson who found phenotypic correlations of 0.92, 0.92, 0.69 and 0.86 between live weight with chest depth, width of pins, height at withers and body length respectively. Alderson reported that hip width and chest depth are the best and preferred measures, but that chest depth was the best indicator of weight. Hence, height at wither, body length and chest depth could be used to predict live weight in these genotype. Salako (2006) reported that various body measurements and calculated indices from body measurements are important indicators of breed characteristics and production type of animals. The implication is that cumulative index, which is preferred to live weight in predicting mature rating (Alderson, 1999), could be applied in Bunaji and Sokoto Gudali breeds in predicting their function. It could also be used in predicting these values.

The significant correlations between cumulative index and live weight in this study, (0.77 and 0.80) for Bunaji and Sokoto Gudali respectively were similar to 0.818 reported by Alderson (1999). Indicating that they could be used as selection index to rank cattle based on the comparative assessment of their growth rate or performance for morphological traits, especially for beef quality.

Table 3: Correlations matrix for primary measurements, live weight and cumulative index results for Bunaji cows

	LW	HW	HR	BL	LGT	RL	WP	WH	CD	CW	CUI
LW		0.701**	0.567**	0.654**	0.610**	0.535**	0.355*	0.298*	0.472**	0.283*	0.770**
HW			0.823**	0.468**	0.448**	0.481**	0.420**	0.276*	0.329*	0.196	0.512**
HR				0.454**	0.438**	0.413**	0.348*	0.275*	0.269*	0.154	0.450**
BL					0.744**	0.467**	0.253*	0.284*	0.189	0.274*	0.684**
LGT						0.346*	0.267*	0.289*	0.222*	0.193	0.610**
RL							0.200*	0.265*	0.096	0.275*	0.621**
WP								0.126	-0.019	0.108	0.312*
WH									0.239*	-0.131	0.626**
CD										-0.211	0.206*
CW											-0.063
CUI											

LW= Live weight; HW= Height at withers; HR= Height at rump; BL= Body length; LGT= Length; RL= Rump length; WP=Width of pins; WH= Width of hips; CD= Chest depth and CW= chest width; CUI= Cumulative index, *= significant (p<0.05), **= significant (p<0.01).

Table 4: Correlations matrix for primary measurements, live weight and cumulative index results for Sokoto Gudali cows

	LW	HW	HR	BL	LGT	RL	WP	WH	CD	CW	CUI
LW		0.663**	0.498**	0.608**	0.635**	0.491**	0.576**	0.546**	0.823**	0.341*	0.801**
HW			0.746**	0.328*	0.349*	0.508**	0.350*	0.314*	0.680**	0.467**	0.337*
HR				0.271*	0.398*	0.294*	0.222*	0.241*	0.587**	0.224*	0.281*
BL					0.879**	0.187	0.419**	0.343*	0.465**	0.109	0.656**
LGT						0.239*	0.459**	0.434**	0.508**	0.064**	0.696**
RL							0.348*	0.510**	0.462**	0.366*	0.487**
WP								0.408**	0.438**	0.204*	0.529**
WH									0.465**	-0.001	0.790**
CD										0.254*	0.602**
CW											-0.123
CUI											

LW= Live weight; HW= Height at withers; HR= Height at rump; BL= Body length; LGT= Length; RL= Rump length; WP=Width of pins; WH= Width of hips; CD= Chest depth and CW= chest width; CUI= Cumulative index, *= significant (p<0.05), **= significant (p<0.01)

Conclusion

There were considerable variations in some body measurement, linear type and functional indices and type traits scores among the genotypes which indicated clear genetic distinctions between Bunaji and Sokoto Gudali cows.

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