Nig. J. Anim. Prod. 2022, 49(3):227-242. https://doi.org/10.51791/njap.v49i3.3577 *Nigerian Journal of Animal Production*

Performance of indigenous cattle breeds and composites in the humid rainforest agro-ecological zone of Nigeria

[1]Nwachukwu, E. N., [#2]Ogbu, C. C., [3]Kalla, D. J. U., [4]Ukwu, H. O., [1]Ezea, J., [5]Udoh, U. H.. and [6]Ekumankama, O. O.

[1]Department of Animal Breeding and Physiology, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria; [2]Department of Veterinary Biochemistry and Animal Production, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria; [3]Department of Animal Production, Abubaka Tafawa Balewa University Bauchi, Bauchi State, Nigeria; [4]Department of Animal Breeding and Physiology, Federal University of Agriculture Makurdi, Benue State Nigeria; [5]Department of Animal Science, University of Uyo, Akwa Ibom State, Nigeria; [6]Department of Agricultural Extension and Rural Sociology, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria.

[#]**corresponding author:** ogbu.cosmas@mouau.edu.ng; Phone: +2348052365857

Abstract

Southeastern Nigeria has all year round forage and water availability for cattle farming however, this zone is endemic to ticks and tse tse fly; vectors of endemic diseases such as trypanosomosis that limit cattle survival and performance. Trypanotolerant breeds such as the Muturu found in this zone is characterized by poor growth rate due to poor genetics. To attract and expand investment in cattle production in Southeastern Nigeria, there is need to formulate composite cattle genotypes that could combine trypanotolerance with improved growth rate. The objective of the present study was therefore to test the performance of composite cattle genotypes created using crossbreeding schemes that involved indigenous breeds of Muturu, N'Dama, White Fulani, Sokoto Gudali, and Red Bororo in the humid agro-ecological zone of Southeastern Nigeria. Parameters measured were body weight (BW), linear body measures (LBMs), and body indices. A total of 120 animals belonging to four life stages: calf (5 – 12 moa), yearling (13 – 24 moa), heifers/bullock (25 – 36 moa), and adult (37 – 54 moa) were used for the study. Data were subjected to Variance and Spearman's correlation analyses. Results showed significant effect of genotype on BW, some LBMs and body indices. Generally, crossbred genotypes marched or surpassed some of the foundation breeds in growth variables indicating positive effects of breed combinations on growth performance. Evaluation of body indices revealed good proportionality (range: 68 – 89 %), conformation (range: 2.23 – 2.53), area index (range: 1.18 – 2.41), and thoracic development (range: 1.12 – 1.26) all of which indicate good balance, stability, compactness, robustness, respiratory efficiency, and meat yield in the composites. Correlation analysis showed mostly high and positive correlations between BW and LBMs. Therefore, composite cattle genotypes created from indigenous breeds had better growth performance and body conformation compared to native breeds in the humid rainforest agricultural zone of Nigeria. Crossbreeding of selected indigenous cattle breeds would yield composites with greater genetic merit for growth and body conformation.

Key words: Crossbreeding, growth, conformation, Muturu, N'Dama, Sokoto Gudali, White Fulani.

Performance des races bovines indigènes et composites dans la zone agro-écologique de la forêt pluviale humide du Nigeria

Résumé

Le sud-est du Nigéria dispose de fourrage et d'eau toute l'année pour l'élevage bovin, mais cette zone est endémique aux tiques et à la mouche tsé-tsé ; vecteurs de maladies endémiques telles que la trypanosomose qui limitent la survie et les performances des bovins. Les races trypanotolérantes telles que le Muturu que l'on trouve dans cette zone se caractérisent par un faible taux de croissance dû à une mauvaise génétique. Pour attirer et développer les investissements dans la production bovine dans le sud-est du Nigeria, il est nécessaire de formuler des génotypes bovins composites qui pourraient combiner la trypanotolérance avec un taux de croissance amélioré. L'objectif de la présente étude était donc de tester les performances de génotypes composites de bovins créés à l'aide de schémas de croisement impliquant des races indigènes de Muturu, N'Dama, White Fulani, Sokoto Gudali et Red Bororo dans la zone agro-écologique humide du sud-est du Nigeria. . Les paramètres mesurés étaient le poids corporel (PC), les mesures corporelles linéaires (MCL) et les indices corporels. Un total de 120 animaux appartenant à quatre stades de vie : veau (5 – 12 moa), yearling (13 – 24 moa), génisses/taureau (25 – 36 moa) et adulte (37 – 54 moa) ont été utilisés pour l'étude. Les données ont été soumises aux analyses de variance et de corrélation de Spearman. Les résultats ont montré un effet significatif du génotype sur le poids corporel, certains MCL et les indices corporels. En général, les génotypes croisés ont progressé ou dépassé certaines des races de base dans les variables de croissance indiquant des effets positifs des combinaisons de races sur les performances de croissance. L'évaluation des indices corporels a révélé une bonne proportionnalité (plage : 68 - 89 %), la conformation (plage : 2,23 - 2,53), l'indice de surface (plage : 1,18 - 2,41) et le développement thoracique (plage : 1,12 - 1,26), qui indiquent tous une bonne équilibre, stabilité, compacité, robustesse, efficacité respiratoire et rendement en viande dans les composites. L'analyse de corrélation a montré des corrélations principalement élevées et positives entre PC et MCL. Par conséquent, les génotypes composites de bovins créés à partir de races indigènes avaient de meilleures performances de croissance et une meilleure conformation corporelle par rapport aux races indigènes de la zone agricole de la forêt tropicale humide du Nigeria. Le croisement de races bovines indigènes sélectionnées donnerait des composites avec un plus grand mérite génétique pour la croissance et la conformation corporelle.

Mots clés : Croisement, croissance, conformation, Muturu, N'Dama, Sokoto Gudali, Peul blanc.

Introduction

Livestock production has been critical for survival, sustenance, livelihood, and food security of peoples globally. It represents a major asset among resource-poor small holder farmers by providing meat, milk, manure, hides and skin and traction force (Kubkomawa, 2017). Cattle production is particularly important for provision of food (milk and meat) and traction for growing crops in vulnerable communities in addition to other economic, social, traditional, cultural, and socio-cultural roles (Abdela, 2016; Kubkomawa, 2017).

Growth is an important selection criterion for genetic improvement of meat animals such as beef cattle. Growth is generally observed and measured as increase in size or weight over time. Measurement of body weight gain is used to assess meat yield and the efficiency of production especially as it relates to feed inputs, make selection and breeding decisions, determine feeding levels, determine accurate doses of medicaments for treatment and/or prevention of diseases, determine market weight, and market value, and hence make culling decisions (Lukuyu *et al.,* 2016; Hafi, 2020).

Body measurements and indices calculated from different body measurements are important for description of individual cattle, herds, breeds, and types, and for designation of function (Getu and Misganaw, 2015). Proper proportion of particular body parts are assessed using body indices (Przysucha *et al.,* 2012). Body indices in combination with linear body measures and live weight, enables the objective assessment of animal body condition, health status and welfare (Lukuyu *et al.,* 2016). In production and marketing scenarios in which weighing systems are not available or affordable, body measurements and body indices enable the estimation of growth performance and live weight (Lukuyu *et al.,* 2016). Body measurements hence complement live weight determination in expressing growth and performance.

Few studies exist that compared observed and estimated live weights and body measurements in Nigerian indigenous cattle breeds and crossbred genotypes as well as for different life stages: calf, yearling, growers (heifers/bullocks), and mature animals. When body measurements and body indices are employed in live weight estimation equations, studies show that their usefulness is influenced by breed, age of animal and production environment (Lukuyu *et al.,* 2016). Thus the usefulness and applicability of live weight predictor variables and expressions could be specific for genotype, age of animal, and production environment. The present study was designed to evaluate the live weight of eight cattle genotypes made up of purebreds, crossbreds and composites as part of the effort to develop and test trypanotolerant cattle genotypes for use in cattle production in the humid rainforest and derived Savannah agro-ecological zones of Nigeria.

Materials and methods

The study was carried out at the cattle breeding unit of the Teaching and Research Farm, Michael Okpara University of Agriculture Umudike (MOUAU), Abia State. Umudike lies on latitude 05° 29' North and longitude 07° 32' East in the rainforest zone of Southeastern Nigeria with ambient temperature range of 25 to 35°C and annual rainfall range of 1677.5 to 2200mm (N.R.C.R.I. 2016).

The cattle herd comprised of purebreeds namely N'Dama (ND), Muturu, Sokoto Gudahli (GU), Red Bororo (BO), and White Fulani (WF) and crossbred genotypes namely GUxWF, ND(BOxWF), ND(GUxWF), ND(WFxMU), and ND(GUxWFxMU). The herd is managed semi-intensively with daily grazing of natural pasture and supplemental feeding, sheltering and watering in the holding area after grazing periods. Routine health management includes strategic deworming at the beginning and end of rains and treatment against bacterial infections and blood parasites following diagnosis. Ectoparasite control is by periodic administration of systemic and topical acaricides.

The animals were in four age categories according to months of age (moa) that corresponded to four life stages namely calf (5 – 12 moa), yearling (13 – 24 moa), grower (heifers/bullocks, 25 to 36 moa), and adult (37 – 54 moa). Five linear body measurements (LBMs) were obtained from a total of 120 animals (sexes combined) using measuring stick and flexible tape following standard practices. Live body weights (BW) were determined using direct weighing for calves and calibrated heart girth tape for other age categories or life stages. From LBMs, various body indices were calculated and BW estimated using the expression outline by Przysucha *et al.* (2012). For estimation of body volume (BV), the method described by Takaendengan *et al.* (2012) for horse was adapted. In summary, animal barrel was assumed to correspond to a cylinder shape with body length (BL) as cylinder height, chest girth (CG) as cylinder circumference, and radius of chest girth as radius of cylinder.

Results and discussion

The description of the LBMs, and expressions for calculated variables are summarized in Table 1 while the descriptive statistics for age of animals, observed and estimated live weights, and body volume, according to genotype is presented in Table 2. The youngest animals in the herd were N'dama (5 moa) followed by composite ND(GUxWFxMU) (11 moa), and ND(WFxMU) (18 moa) (Table 2). N'dama cattle were also the oldest breed in the herd (54 moa) followed by ND(WFxMU) (52 moa), and ND(WFxGU) (46 moa). Mean age in the mixed breeding herd varied between 11.5 mo for ND(GUxWFxMU) and 46.0 mo for ND(WFxGU). Coefficient of variation for age of genotypes was highest for N'Dama (111.3 %, 5 – 54 mo), followed by ND(WFxMU) (39.3 %, 18 – 52 mo), and WF (7.7 %, 32 – 38 mo) but least in ND(WFxGU) (0.0 %, 46 mo). Observed and calculated body weights were highest ($p < 0.001$) for Gudali (351.9 kg, and 759.6 kg, respectively) compared to WF, ND(BOxWF), ND(WFxGU), and WFxGU which did not differ significantly (351.9 and 759.6 kg vs 257.2 and 598.69, 256.0 and 635.5, 242.0 and 540.6, and 230.4 and 539.6 kg, respectively) but least ($p < 0.001$) in ND(GUxWFxMU) and ND (122.1 and 327.5, and 159.3 and 373.0 kg, respectively).

Table 1 : Methods for observed and calculated growth variables of cattle genotypes in a humid rainforest agro-ecological zone

S/N	Variable	Symbol	Method
1	Observed live weight (kg)	BW	Weighing balance
2	Calculated live weight (kg)	W-cal	(BLxCGxK)/100; K = 2.5 for beef cattle
3	Body volume (cm^3)	BV	$BLx\pi[(1/2CG)/\pi]^2$; $\pi = 3.14$
Linear body measures			
4	Body length	BL	Distance from point of shoulder to the pin bone
5	Height at withers	HW	Distance from ground to dorsal point of shoulder.
6	Chest girth	CG	Circumference of chest just behind the fore legs.
7	Head length	HL	Distance from top of head to middle of muzzle.
Body indices			
8	Body index	BI	(BL/CG)100
9	Area index	AI	BLxHW
10	Height index (Proportionality)	HI	(HW/BL)100
11	Length index	LI	BL/HW
12	Thoracic development	TD	CG/HW
13	Conformation index	CI	(CGx2)/HW
Weight indices			
14	Weight index 1	WI-1	(BWx100)/HW
15	Weight index 2	WI-2	(W-cal/HW)100

Body volume mirrored body weight values being highest in GU and least in ND(GUxWFxMU) and N'Dama ($p < 0.001$) compared to other genotypes. The age structure of the mixed breeding herd reflect variation in the stage at which the different breeds were introduced, the stage at which various crossbred and composite genotypes were generated, and the reproductive success of the various breeds and breed combinations. N'Dama is the oldest breed in the herd being the foundation breed and the reference breed for the breeding objectives namely beef production, adaptation to humid rainforest environment, tick resistance and trypano-tolerance. The Muturu was involved to exploit trypano-tolerance, and tick resistance genetics as well as adaptation to high humidity. The youngest mean age observed for the composite ND(GUxWFxMU) is because this genotype represents the target product of the breeding operation and is hence the most recent output of the breeding effort.

The magnitude of the coefficient of variation for age in the different breeds and genotypes reflect the degree of age variation among individuals of each genetic group. As expected, the studied herd varied in observed and calculated BW, BV, LBMs and body indices according to breed and genotype. Even though within and between genotype age differences could be a confounding factor, the generally higher observed and calculated BW and BV, LBMs, and body indices in GU compared to other breeds and genotypes confirms this breed as the biggest in size among the cattle breeds and genotypes studied. This breed was included in the breeding operation to maintain acceptable growth rate in resulting composites and hence minimize the negative effects on growth rate of including in the mating arrangements smaller breeds like the trypanotolerant Muturu, characterized by slow growth rate. In cattle improvement programmes, large framed breeds are generally selected to establish elite flocks in the field (Dossa *et al.*, 2007; Yakubu *et al.*, 2021). Bene et al. (2007) and Hafi (2020) reported similar variations in biometric measurements in cattle populations composed of different breeds of varied within and between breed age structures as well as environmental variables. Closely following GU in observed BW was WF (the 2[nd] large sized breed in the herd), and the crossbred genotypes: ND(BOxWF), WFxGU, and ND(WFxGU) which were all heavier than N'Dama indicating superiority of the crossbreds over the N'Dama pure breed. In a study that evaluated mature ($\geq$13 years of age) indigenous breeds of cattle in Nigeria for dairy production system, Umar et al. (2020) reported BW, BL, HW, and CG for Bunaji (WF) vs Sokoto Gudali as 379.95 vs 388.42 kg; 175.48 vs 178.35; 170.02 vs 178.42; and 124.94 vs 127.78 cm, respectively. Compared to the values reported in the present study, these values are higher with respect to BW and HW, lower with regards to CG, and slightly in agreement with respect to BL. In cattles of three to three and a halve years, Oladepo *et al.* (2018) reported BL, HW, and CG values for WF vs GU as 116.45, 130.39, and 83.20 cm, respectively vs 116.03, 47.51, and 129.21 cm, respectively which were generally lower than the values reported in the present study. These disparities are attributable to differences in age structure of the studied populations, different ecological and management environments, and the level of gender mix. Oduguwa *et al.* (2013) evaluated indigenous cattle breeds $\leq$12 to 36 moa and reported higher body weight in WF compared to N'Dama and Muturu (114.78 vs 96.55 and 91.21 kg, respectively). White Fulani and the crossbred genotypes in the present study were also next to GU in estimated BW (W-cal) and BV. The inferior BW of ND(WFxMU) (mean age: 32.6 mo) could result from inferior growth rate due to the Muturu breed in the cross while youngest age (11.5mo) was likely the reason for the inferior BW of the ND(GUxWFxMU) composite.

The comparison between breeds and genotypes for linear body variables showed similar trends as was observed for body weight values (Table 3).

Table 2: Age, body weight, and body volume of cattle genotypes reared in a humid rainforest agro-ecological zone

Variable /Genotype	Number	Mean	SD	CV (%)	MIN	MAX
Age (month)						
ND	19	20.8	23.15	111.3	5	54
ND(BOxWF)	6	32.7	1.21	3.7	31	34
ND(WFxMU)	31	32.6	12.82	39.3	18	52
WF	39	34.8	2.69	7.7	32	38
GU	4	31.3	0.6	3.1	30	32
WFxGU	4	32.0	0.82	2.6	31	33
ND(WFxGU)	6	46.0	0.00	0.0	46	46
ND(GUxWFxMU)	11	11.5	0.52	4.5	11	12
Overall	120	30.1	13.89	46.2	5	54
Observed body weight (kg)						
ND	19	159.3^{cd}	80.39	50.5	92.5	305.5
ND(BOxWF)	6	256.0^{bc}	39.55	15.5	184.5	290.0
ND(WFxMU)	31	213.0^{c}	69.88	32.8	85.0	286.0
WF	39	257.2^{b}	39.55	15.4	196.0	344.0
GU	4	351.9^{a}	14.20	4.0	332.0	365.0
WFxGU	4	230.4^{bc}	6.13	2.7	223.0	238.0
ND(WFxGU)	6	242.0^{bc}	5.17	2.1	236.5	250.0
ND(GUxWFxMU)	11	122.1^{d}	21.62	17.7	98.5	152.0
Overall	120	217.3	74.03	34.1	85.0	365.0
Calculated body weight						
ND	19	373.0^{d}	140.90	37.8	243.0	638.4
ND(BOxWF)	6	635.5^{b}	87.66	13.8	535.0	729.6
ND(WFxMU)	31	494.3^{c}	124.59	25.2	206.8	616.2
WF	39	598.7^{bc}	44.94	7.5	501.1	706.0
GU	4	759.6^{a}	31.64	4.2	718.5	795.5
WFxGU	4	539.6^{bc}	15.05	2.8	519.4	553.8
ND(WFxGU)	6	540.6^{bc}	27.76	5.1	511.9	572.8
ND(GUxWFxMU)	11	327.5^{d}	56.30	17.2	232.3	384.3
Overall	120	509.0	142.92	28.1	206.8	765.5
Estimated body volume (L)						
ND	19	149.7^{d}	83.12	55.5	76.32	309.0
ND(BOxWF)	6	296.3^{b}	56.89	19.2	22.24	360.4
ND(WFxMU)	31	224.3^{c}	75.89	33.8	58.0	310.1
WF	39	282.1^{bc}	32.40	11.5	209.1	364.9
GU	4	404.3^{a}	27.70	6.9	368.4	435.8
WFxGU	4	245.2^{bc}	12.36	5.0	229.1	258.1
ND(WFxGU)	6	241.8^{bc}	18.00	7.4	222.5	264.5
ND(GUxWFxMU)	11	120.3^{d}	30.58	25.4	71.6	154.2
Overall	120	232.9	85.86	36.9	58.0	435.8

$^{a-d}$: different superscripts down column indicate significantly different means; $P \leq 0.01$; ND: NDama, MU: Muturu, WF: White Fulani, GU: Sokoto Gudali, BO: Red Bororo.

Table 3: Linear body measures of cattle genotypes reared in a humid rainforest agro-ecological zone

Variable /Genotype	Number	Mean	SD	CV (%)	MIN	MAX
Body length (BL, cm)						
ND	19	121.6[e]	24.69	20.3	98.6	168.0
ND(BOxWF)	6	174.2[ab]	15.50	8.9	152.0	192.0
ND(WFxMU)	31	140.9[d]	20.54	14.6	92.0	162.0
WF	39	163.6[bc]	6.12	3.7	150.0	176.0
GU	4	181.9[a]	2.66	1.5	178.5	185.0
WFxGU	4	151.4[cd]	3.40	2.3	148.0	156.0
ND(WFxGU)	6	154.0[cd]	4.56	3.0	150.0	160.0
ND(GUxWFxMU)	11	114.4[e]	9.92	8.7	96.0	126.0
Overall	120	146.8	24.76	16.9	92.0	192.0
Height at withers (HW, cm)						
ND	19	95.6[d]	12.41	13.0	80.5	116.0
ND(BOxWF)	6	117.8[b]	3.94	3.3	112.7	124.0
ND(WFxMU)	31	108.9[bc]	14.40	13.2	76.0	122.0
WF	39	120.0[b]	4.37	3.6	110.0	129.5
GU	4	132.4[a]	2.30	1.7	129.2	134.4
WFxGU	4	114.5[b]	1.63	1.4	112.5	116.5
ND(WFxGU)	6	115.5[b]	3.53	3.1	112.2	120.0
ND(GUxWFxMU)	11	101.9[cd]	7.03	6.9	90.4	115.0
Overall	120	111.5	13.38	12.0	76.0	134.4
Chest girth (CG, cm)						
ND	19	119.1[c]	19.40	16.3	98.6	152.0
ND(BOxWF)	6	145.5[b]	8.98	6.2	130.5	156.0
ND(WFxMU)	31	137.7[b]	19.78	14.4	88.0	160.0
WF	39	146.9[b]	6.92	4.7	131.0	162.3
GU	4	167.0[a]	4.55	2.7	161.0	172.0
WFxGU	4	142.6[b]	3.94	2.8	138.5	148.0
ND(WFxGU)	6	140.3[b]	3.37	2.4	136.5	145.0
ND(GUxWFxMU)	11	113.7[c]	10.82	9.5	96.8	127.0
Overall						
Head length (HL, cm)						
ND	19	35.4[c]	5.29	14.9	28.0	45.5
ND(BOxWF)	6	53.3[a]	5.49	10.3	47.5	62.0
ND(WFxMU)	31	42.8[b]	7.04	16.5	25.0	52.0
WF	39	46.6[b]	2.83	6.1	42.0	52.0
GU	4	57.7[a]	0.47	8.2	57.0	58.0
WFxGU	4	44.7[bc]	0.48	1.1	44.0	45.0
ND(WFxGU)	6	46.2[bc]	1.30	2.8	45.0	48.5
ND(GUxWFxMU)	11	35.6[d]	5.15	14.5	28.0	44.0
Overall	120	43.5	7.38	17.0	25.0	62.0

[a-e]: different superscripts down column indicate significantly different means; $P \leq 0.01$.

Values for BL, HW, and CG were highest in GU, and least in the composite ND(GUxWFxMU) and ND compared to other genotypes. Values for HL were highest in GU and the crossbred ND(BOxWF) (57.7 and 53.3 cm, respectively) followed by WF, ND(WFxGU), and WFxGU (46.6, 46.2, and 44.7 cm, respectively) but least in ND and ND(GUxWFxMU) genotypes (35.4, and 35.6 cm, respectively). The observed higher BL, HW, CG, and HL in GU followed from the larger body size of this breed. Oni *et al.* (2011) reported BL, HW, and CG in GU of ≤18 moa as 95.32, 96.44, and 114.84 cm, respectively compared to 92.88, 93.76, and 109.88 cm, respectively for WF. Except for ND(GUxWFxMU), other crossbred genotypes were statistically similar to or higher than WF and ND in linear body values indicating improvement in growth traits following crossbreeding. This result however contradicts that of Nosike *et al.* (2020) in which BL and CG decreased in the WFxND crossbred compared to either parents across the age groups studied.

Linear body indices differed significantly among genotypes with height index (HI) having highest value ($P < 0.01$) in ND(GUxWFxMU) (89.2) followed by ND, ND(WFxMU), WFxGU, and ND(WFxGU) (80.0, 77.6, 75.5, and 75.0, respectively) while length index (LI) was highest ($P < 0.01$) in ND(BOxWF) (1.48) followed by WF and GU (1.37, respectively) and least in ND(GUxWFxMU) (1.12) compared to other genotypes (Table 4). Conformation index (CI) did not differ significantly between genotypes except for ND(GUxWFxMU) which had the least values compared to other genotypes while area index (AI) was highest in GU (2.41) followed by ND(BOxWF) (2.06) and least in ND, and ND(GUxWFxMU) (1.18, and 1.17, respectively) compared to other genotypes. The higher height index of the four breed composite ND(GUxWFxMU), shows that this genotype has better proportionality compared to other genotypes having slightly lower HW compared to BL. This notwithstanding, the values observed in this study indicate good balance for all the breeds and crossbreds. Balance in height and length indicate balance in gravity center (Chacon *et al.*, 2011) required for stability, strength and adaptation in varied environments.

Similar close BL and HW values had been reported by Oni *et al.* (2011) in GU (95.32 vs 96.44 cm), and WF (92.88 vs 93.76 cm) as well as by Umar *et al.* (2020) (178.35 vs 178.42 cm for GU, and 175.48 vs 170.02 cm for WF) while Yakubu *et al.* (2021) reported wide values for the two variables (157.03 vs 115.94 cm, and 163.02 vs 120.49 cm for BL vs HW for WF and GU, respectively). Umar *et al.* (2020) concluded that the GU is generally more balanced, more compactly built, deeper and wider bodied than the WF characterized by a 'leggy' appearance and shallowness of body. Length index was lowest in ND(GUxWFxMU) because of the very close BL and HW values in this genotype but highest in ND(BOxWF) due to the slightly higher BL value. Conformation index (CI) is a measure of robustness. Thus, the higher the value, the more robust the animal, and vice versa (Chacon *et al.*, 2011). The high and predominantly similar CI among the breeds and genotypes indicate good and similar robustness and compactness among the breeds and genotypes. The significantly lower value observed for ND(GUxWFxMU) could be the result of younger age (mean: 11.5 moa) compared to between 20.8 and 46.0 moa for other genotypes such that the necessary body parts were still evolving and developing. The observed higher area index (AI) in GU agrees with the large body size of this breed being the largest breed in the herd. Umar *et al.* (2020) identified the GU as a wider bodied breed compared to WF or Bunaji.

Table 5 shows that body index (BI) was highest in ND(BOxWF) (119.7) compared to other genotypes followed by WF (111.5) and least in ND, and ND(GUxWFxMU) genotypes (101.6, and 100.8, respectively). The study also shows that thoracic development (TD) was statistically similar across genotypes except for ND(GUxWFxMU) genotype which had significantly lower value (1.12) for this trait. Weight index-1 (WI-1) was significantly higher in GU (265.6) compared to other genotypes followed by ND(BOxWF), WF, and ND(WFxGU) (216.7, 214.7, and 209.6, respectively) but least in ND(GUxWFxMU) (119.6) compared to other genotypes. A similar result was observed for WI-2 with GU, ND(BOxWF) having highest values followed by WF, and WFxGU.

Table 4: Linear body indices of cattle genotypes reared in a humid rainforest agro-ecological zone

Variable /Genotype	Number	Mean	SD	CV (%)	MIN	MAX
Height index (Proportionality)						
ND	19	80.0^{b}	9.88	12.4	65.2	98.3
ND(BOxWF)	6	68.0^{d}	4.82	7.1	62.5	76.3
ND(WFxMU)	31	77.6^{bc}	4.24	5.5	70.5	88.2
WF	39	73.4^{cd}	3.39	4.6	64.0	77.8
GU	4	72.8^{cd}	0.72	1.0	72.3	73.8
WFxGU	4	75.7^{bc}	1.20	1.6	74.7	77.4
ND(WFxGU)	6	75.0^{bc}	0.35	4.7	74.7	75.6
ND(GUxWFxMU)	11	89.2^{a}	3.75	4.2	83.6	94.2
Overall	120	76.9	7.05	9.2	62.5	98.3
Length index						
ND	19	1.27^{c}	0.15	11.8	1.02	1.53
ND(BOxWF)	6	1.48^{a}	0.10	6.8	1.31	1.60
ND(WFxMU)	31	1.29^{bc}	0.07	5.4	1.13	1.42
WF	39	1.37^{b}	0.07	5.1	1.28	1.56
GU	4	1.37^{b}	0.01	0.7	1.35	1.38
WFxGU	4	1.32^{bc}	0.02	1.5	1.29	1.34
ND(WFxGU)	6	1.33^{bc}	0.01	0.8	1.32	1.34
ND(GUxWFxMU)	11	1.12^{d}	0.05	4.5	1.06	1.20
Overall	120	1.31	0.11	8.4	1.02	1.60
Conformation index						
ND	19	2.49^{a}	0.25	10.0	1.93	2.90
ND(BOxWF)	6	2.47^{a}	0.08	3.2	2.32	2.53
ND(WFxMU)	31	2.53^{a}	0.14	5.5	2.20	2.79
WF	39	2.45^{a}	0.08	3.3	2.28	2.63
GU	4	2.52^{a}	0.04	1.6	2.49	2.57
WFxGU	4	2.49^{a}	0.06	2.4	2.44	2.59
ND(WFxGU)	6	2.43^{a}	0.04	1.7	2.37	2.48
ND(GUxWFxMU)	11	2.23^{b}	0.16	7.2	2.07	2.48
Overall	120	2.46	0.16	6.5	1.93	2.90
Area index						
ND	19	1.18^{e}	0.38	32.2	0.82	1.90
ND(BOxWF)	6	2.06^{b}	0.24	11.7	1.76	2.31
ND(WFxMU)	31	1.56^{d}	0.38	14.4	0.72	1.98
WF	39	1.96^{bc}	0.11	5.6	1.75	2.25
GU	4	2.41^{a}	0.73	30.3	2.31	2.47
WFxGU	4	1.73^{cd}	0.06	3.5	1.69	1.82
ND(WFxGU)	6	1.78^{bcd}	0.11	6.2	1.68	1.92
ND(GUxWFxMU)	11	1.17^{e}	0.18	15.4	0.87	1.45
Overall	120	1.67	0.43	25.8	0.72	2.47

$^{a-e}$: different superscripts down column indicate significantly different means; $P \leq 0.01$.

Table 5: Body and weight indices of cattle genotypes reared in a humid rainforest agro-ecological zone

Variable /Genotype	Number	Mean	SD	CV (%)	MIN	MAX
Body index (BI)						
ND	19	101.6^{d}	5.59	5.5	88.9	110.5
ND(BOxWF)	6	119.7^{a}	8.03	6.7	104.8	126.3
ND(WFxMU)	31	102.3^{d}	4.95	4.8	93.5	111.0
WF	39	111.5^{b}	5.32	4.8	103.8	126.9
GU	4	108.9^{bc}	1.41	1.3	107.6	110.9
WFxGU	4	106.2^{cd}	4.34	4.1	100.0	109.9
ND(WFxGU)	6	109.7^{bc}	1.79	1.6	107.1	112.7
ND(GUxWFxMU)	11	100.8^{d}	3.77	3.7	94.5	106.8
Overall	120	106.6	7.33	6.9	88.9	126.9
Thoracic development (TD)						
ND	19	1.25^{a}	0.13	10.4	0.97	1.45
ND(BOxWF)	6	1.23^{a}	0.04	3.25	1.16	1.27
ND(WFxMU)	31	1.26^{a}	0.07	5.56	1.10	1.40
WF	39	1.22^{a}	0.04	3.25	1.14	1.31
GU	4	1.26^{a}	0.02	1.59	1.25	1.29
WFxGU	4	1.25^{a}	0.03	2.3	1.22	1.29
ND(WFxGU)	6	1.22^{a}	0.02	1.6	1.18	1.24
ND(GUxWFxMU)	11	1.12^{b}	0.08	7.1	1.04	1.24
Overall	120	1.23	0.08	6.5	0.97	1.45
*Weight index 1(WI-1)						
ND	19	161.3^{c}	65.10	40.4	108.8	270.4
ND(BOxWF)	6	216.7^{b}	28.30	13.1	163.7	241.7
ND(WFxMU)	31	190.4^{bc}	48.20	25.3	92.2	242.4
WF	39	214.7^{b}	21.50	10.0	170.4	265.6
GU	4	265.6^{a}	6.20	2.3	257.0	271.6
WFxGU	4	201.2^{bc}	2.48	1.2	198.2	204.3
ND(WFxGU)	6	209.6^{b}	4.60	2.2	205.1	217.4
ND(GUxWFxMU)	11	119.6^{d}	17.83	14.9	100.8	143.1
Overall	120	192.4	49.72	25.8	92.2	271.6
**Weight index 2 (WI-2)						
ND	19	382.9^{de}	106.03	27.7	275.09	564.96
ND(BOxWF)	6	538.1^{ab}	58.80	10.9	474.76	608.00
ND(WFxMU)	31	446.1^{cd}	73.29	16.4	258.50	522.03
WF	39	500.9^{bc}	31.23	6.2	435.72	573.91
GU	4	573.4^{a}	16.20	2.8	556.09	594.99
WFxGU	4	471.2^{bc}	7.33	1.6	461.67	478.25
ND(WFxGU)	6	467.7^{c}	11.08	2.4	456.22	485.38
ND(GUxWFxMU)	11	320.1^{e}	42.17	13.2	256.99	376.76
Overall	120	450.6	89.22	19.8	256.99	608.00

$^{a-e}$: different superscripts down column indicate significantly different means; $P \leq 0.01$; *: based on observed body weight, **: based on calculated body weight.

The values observed for body index (BI) indicate that the genotypes studied are longiline with values greater than 0.9 or 90% for all genotypes (Chacon *et al.*, 2011). Considered alongside the good HI, there is indication that the genotypes will mature into large frame animals (Oladepo *et al.*, 2018) with good beef yield potentials. Our study also revealed good thoracic development (TD) in all the genotypes with values greater than 1.2 across genotypes except the very young composite ND(GUxWFxMU) genotype. Good TD is important for efficient respiration, fitness, and meat yield (Chacon *et al.*, 2011).

The comparison between genotypes within age categories for BW, linear body measures (LBMs), and various body indices is presented in Tables 6 to 8.

Table 6: Body weight and linear body measures (mean ± sd) of cattle genotypes of different age categories

		Linear body variables			
Age group/genotype	BW (kg)	BL (cm)	HW (cm)	CG (cm)	HL (cm)
5 – 12 moa (Calf)					
ND	107.8 ± 18.92	105.8 ± 5.23	91.6 ± 13.00	106.9 ± 6.05	32.3 ± 2.17
ND(GUxWFxMU)	122.1 ± 21.62	114.4 ± 9.92	101.9 ± 7.03	113.7 ± 10.82	35.6 ± 5.12
13 – 24 moa (Yearling)					
ND(WFxMU)	163.4 ± 84.23	126.9 ± 25.68	98.4 ± 16.91	123.0 ± 22.55	37.6 ± 8.05
ND(GUxWFxMU)	132.8 ± 6.60	123.5 ± 3.00	113.5 ± 6.40	122.1 ± 3.38	39.4 ± 3.00
25 – 36 moa (Grower: heifers/bullocks)					
ND(BOxWF)	256.0 ± 39.55^{b}	174.2 ± 15.50^{ab}	117.8 ± 3.94^{b}	145.5 ± 8.98^{b}	53.3 ± 5.49^{ab}
ND(WFxMU)	253.4 ± 11.65^{b}	154.0 ± 2.97^{b}	114.7 ± 4.46^{b}	150.8 ± 7.10^{b}	47.5 ± 3.21^{bc}
WF	247.3 ± 24.88^{b}	163.8 ± 6.03^{b}	118.6 ± 3.67^{b}	145.2 ± 6.13^{b}	45.9 ± 2.56^{bc}
GU	351.9 ± 14.20^{a}	181.9 ± 2.66^{a}	132.4 ± 2.30^{a}	167.0 ± 4.55^{a}	57.7 ± 0.47^{a}
WFxGU	230.4 ± 6.13^{b}	151.4 ± 3.40^{b}	114.5 ± 1.63^{b}	142.6 ± 3.94^{b}	44.7 ± 0.48^{c}
37 – 54 moa (Adult)					
ND	271.1 ± 22.47	155.8 ± 8.85^{ab}	106.9 ± 6.86^{b}	145.6 ± 6.31	42.1 ± 3.38
ND(WFxMU)	246.5 ± 22.22	149.4 ± 5.01^{b}	117.5 ± 3.90^{ab}	147.1 ± 6.60	46.1 ± 2.10
WF	289.8 ± 34.12	162.8 ± 6.63^{a}	123.7 ± 4.17^{a}	152.0 ± 6.83	48.8 ± 2.47
ND(WFxGU)	242.0 ± 5.17	154.0 ± 4.56^{ab}	115.5 ± 3.53^{ab}	140.3 ± 3.37	46.2 ± 1.30

a-c: Different superscripts down column indicate significantly different means; $P \leq 0.01$; BL: body length, HW: whither height, CG: chest girth, HL: head length.

For BW and LBMs (Table 6), ND and ND(GUxWFxMU) calves (5 – 12 moa) as well as ND(WFxMU) and ND(GUxWFxMU) yearlings (13 – 24 moa) did not differ significantly in any of the parameters while GU heifer/bullock (25 – 36 moa) surpassed other genotypes in BW, HW, and CG but had comparable BL and HL with their ND(BOxWF) counterparts. Other genotypes did not differ significantly in all the parameters measured. Among mature cattle (37 – 54 moa), no significant differences were observed in BW, CG and HL but WF had significantly higher values for BL compared to ND(GUxWFxMU) and higher HW compared to ND. The comparable BW and LBMs amongst calves (ND vs ND(GUxWFxMU)) and yearlings (ND(WFxMU) vs ND(GUxWFxMU)) indicate equivalent and/or enhanced growth rate in the composite genotypes and that growth rate was maintained at acceptable levels in the crossbred genotypes. Similar BW and linear body values in heifer/bullock of ND(BOxWF), and ND(WFxMU), with those of WF, GU (for BL, and HL), and WFxGU also indicate good growth potentials in addition to other desirable traits such as tick resistance, trypanptolerance and tolerance of high humidity derivable from the inclusion of N'dama and Muturu genetics in the crossbred genotypes. The same result was observed among genotypes in the 37 – 54 moa category where ND(WFxMU), and ND(WFxGU) genotypes marched the traditional breeds (ND, and WF) in most of the traits indicating good beef yield potentials.

For body indices (Table 7), ND and ND(GUxWFxMU) calves (5 – 12 MoA) as well as ND(WFxMU) and ND(GUxWFxMU) yearlings had comparable values while WFxGU heifer/bullock (25 – 36 moa) had significantly higher HI compared to ND(BOxWF). These two genotypes did not differ significantly from other genotypes in this trait. ND(BOxWF) had significantly higher BI and LI compared to ND(WFxMU) and WFxGU, respectively but did not differ significantly from other genotypes while TD and CI did not differ significantly between genotypes. For mature cattle, LI was significantly higher while HI was significantly lower in ND compared to other genotypes. This genotype had comparable TD and CI with ND(WFxMU) but higher values compared to other genotypes. No significant differences were observed in BI. Calves of ND(GUxWFxMU) genotype had equivalent body indices as those of ND indicating good body conformation in the composite similar to that of the ND breed.

As expected, yearling ND(GUxWFxMU) showed improved conformation and balance over the three breed counterpart (ND(WFxMU)) with higher HI, equivalent BI, and CI, and acceptable levels of LI and TD. The equivalent values of body indices between heifer/bullock of ND(BOxWF), and ND(WFxMU) with those of the traditional breeds (WF and GU) and their cross (WFxGU) also indicate improved beef conformation, balance and compactness similar to the observation among mature cattle genotypes (ND(WFxMU) and ND(WFxGU) vs ND and WF).

Area index (AI), BV, W-cal, WI-1, and WI-2 did not differ significantly among calves (ND vs ND(GUxWFxMU)) and yearlings (ND(WFxMU) vs ND(GUxWFxMU)) but heifer/bullock of GU had higher BV, and WI-2 compared to other genotypes (Table 8).

Table 7: Linear body indices (mean ± sd) of cattle genotypes of different age categories

	Linear body indices				
Age group/genotype	HI	TD	BI	LI	CI
5 – 12 moa (Calf)					
ND	86.4 ± 8.89	1.18 ± 0.13	99.1 ± 4.94	1.17 ± 0.11	2.36 ± 0.26
ND(GUxWFxMU)	89.2 ± 3.75	1.12 ± 0.09	100.8 ± 3.77	1.12 ± 0.05	2.23 ± 0.16
13 – 24 moa (Yearling)					
ND(WFxMU)	78.1 ± 5.51	1.25 ± 0.04^{a}	102.9 ± 4.34	1.29 ± 0.01^{a}	2.50 ± 0.16
ND(GUxWFxMU)	92.0 ± 7.42	1.08 ± 0.09^{b}	101.1 ± 1.27	1.09 ± 0.09^{b}	2.16 ± 0.18
25 – 36 moa (Grower: heifers/bullocks)					
ND(BOxWF)	68.0 ± 4.82^{b}	1.23 ± 0.04	119.7 ± 8.03^{a}	1.48 ± 0.10^{a}	2.47 ± 0.09
ND(WFxMU)	74.5 ± 2.58^{ab}	1.32 ± 0.05	102.3 ± 5.72^{b}	1.34 ± 0.05^{ab}	2.63 ± 0.09
WF	72.5 ± 3.42^{ab}	1.22 ± 0.05	113.0 ± 5.37^{ab}	1.38 ± 0.07^{ab}	2.45 ± 0.09
GU	72.8 ± 0.72^{ab}	1.26 ± 0.02	108.9 ± 1.41^{ab}	1.38 ± 0.01^{ab}	2.52 ± 0.04
WFxGU	75.7 ± 1.20^{a}	1.25 ± 0.03	106.2 ± 4.34^{ab}	1.32 ± 0.02^{b}	2.49 ± 0.06
37 – 56 moa (Adult)					
ND	68.6 ± 2.17^{b}	1.36 ± 0.04^{a}	106.9 ± 1.89	1.46 ± 0.05^{a}	2.73 ± 0.09^{a}
ND(WFxMU)	78.7 ± 2.46^{a}	1.25 ± 0.06^{ab}	101.7 ± 5.52	1.27 ± 0.04^{b}	2.51 ± 0.12^{ab}
WF	76.0 ± 1.39^{a}	1.23 ± 0.02^{b}	107.1 ± 1.21	1.32 ± 0.02^{b}	2.46 ± 0.04^{b}
ND(WFxGU)	75.0 ± 0.35^{a}	1.22 ± 0.02^{b}	109.7 ± 1.79	1.33 ± 0.01^{b}	2.43 ± 0.04^{b}

$^{a-b}$: Different superscripts down column indicate significantly different means; P ≤0.01; HI: height index, TD: thoracic development, BI: body index, CI: conformation index.

Table 8: Body volume, area, and weight indices (mean ± sd) of cattle genotypes of different age categories

	Area, volume and body weight indices				
Age group/genotype	AI	BV	W-cal.	*WI-1	**WI-2
5 – 12 moa (Calf)					
ND	0.97 ± 0.18	96.8 ± 14.09	283.1 ± 26.44	311.5 ± 27.50	117.3 ± 7.16
ND(GUxWFxMU)	1.17 ± 0.18	120.3 ± 30.58	327.5 ± 56.30	320.1 ± 42.17	119.6 ± 17.8
13 – 24 moa (Yearling)					
ND(WFxMU)	1.29 ± 0.46	167.8 ± 86.35	403.5 ± 148.17	398.2 ± 90.41	158.2 ± 58.98
ND(GUxWFxMU)	1.40 ± 0.05	146.9 ± 11.4	377.2 ± 19.08	333.9 ± 35.56	117.5 ± 12.05
25 – 36 moa (Growers: heifers/bullocks)					
ND(BOxWF)	2.06 ± 0.24^{ab}	296.3 ± 56.89^{b}	635.5 ± 87.66^{ab}	538.1 ± 58.80^{ab}	216.7 ± 28.34^{bc}
ND(WFxMU)	1.77 ± 0.09^{b}	279.3 ± 25.31^{b}	580.6 ± 26.19^{b}	506.3 ± 9.55^{bb}	221.1 ± 8.18^{b}
WF	1.94 ± 0.09^{b}	275.6 ± 27.48^{b}	594.8 ± 37.57^{b}	501.5 ± 30.82^{b}	208.2 ± 17.84^{bc}
GU	2.41 ± 0.07^{a}	404.3 ± 27.70^{a}	759.6 ± 31.64^{a}	573.4 ± 16.20^{a}	265.6 ± 6.20^{a}
WF x GU	1.73 ± 0.06^{b}	245.1 ± 12.36^{b}	539.6 ± 15.05^{b}	471.2 ± 7.33^{b}	201.2 ± 2.48^{c}
37 – 54 moa (Adult)					
ND	1.67 ± 0.19	264.3 ± 36.89^{ab}	568.0 ± 55.99	530.6 ± 26.66^{a}	253.5 ± 9.67^{a}
ND(WFxMU)	1.76 ± 0.10	257.9 ± 25.14^{ab}	549.4 ± 31.02	467.8 ± 22.12^{b}	209.9 ± 18.76^{b}
WF	2.02 ± 0.15	300.9 ± 39.25^{a}	619.5 ± 52.92	500.0 ± 27.63^{ab}	233.7 ± 20.60^{ab}
ND(WFxGU)	1.78 ± 0.11	241.8 ± 18.00^{b}	540.6 ± 27.76	467.7 ± 11.08^{b}	209.6 ± 4.60^{b}

[a-c]: Different superscripts down column indicate significantly different means; $P \leq 0.01$; AI: area index, BV: body volume, W-cal: calculated weight, *WI-1: weight index based on observed weight, **WI-2: weight index based on W-cal.

This genotype had comparable AI, W-cal, and WI-1 with ND(BOxWF) but differed significantly from other genotypes which in turn were comparable to the values for ND(BOxWF). For mature cattle, genotypes did not differ significantly in AI, and W-cal but significant differences were observed in BV, WI-I and WI-2 with ND and WF having similar values for BV, WI-1 and WI-2 with ND and ND(WFxMU) but higher values compared to ND(WFxGU) while the least values for BV were observed in ND(WFxGU) but in ND(WFxGU) and ND(WFxMU for WI-1 and WI-2.

The comparable values for AI, BV, W-cal, WI-1, and WI-2 among calves of ND and ND(GUxWFxMU), yearlings belonging to ND(GUxWFxMU) and ND(WFxMU)), heifers/bullocks of ND(BOxWF), ND(WFxMU), WF, GU, and WFxGU, and adults of ND, ND(WFxMU), WF, and ND(WFxGU) genotypes were expected given the comparable biometric values observed in these genotypes. These results indicate good body conformation in the crossbred genotypes comparable to those of the parent breeds. There is dearth of information on morphometric indices in Nigerian indigenous cattle breeds and comparisons of morphometric indices of breeds with crossbreds and composites from *inter se* matings is virtually none existent. The present study could well be the first of this kind of study hence further studies are required in this direction.

The correlation between BW and linear body measures for the different genotypes and age categories is presented in Table 9.

Table 9: Correlation coefficient for body weight and linear body measures of cattle genotypes of different age categories

Genotype (age)		Linear body variables			
		BL	HW	CG	HL
ND (5-12 mo)	BW	0.870**	0.949**	0.601*	0.355
(37-54 mo)	BW	0.972**	0.884**	0.909**	0.936**
ND(BOxWF) (25-36 mo.)	BW	0.622*	0.855**	0.973**	0.785**
ND(WFxMU) (13-24 mo.)	BW	0.924**	0.913**	0.907**	0.887**
(37-54 mo.)	BW	0.185	0.207	0.858**	0.772**
WF (25-36 mo.)	BW	0.445*	0.612*	0.700**	0.607*
(37-54 mo.)	BW	0.978**	0.889**	0.953**	0.769**
GU (25-36 mo.)	BW	0.777**	0.996**	0.841**	-0.662*
WFxGU (25-36 mo.)	BW	0.747**	0.999**	0.326	0.839**
ND(WFxGU) (37-54 mo.)	BW	0.679*	0.700**	0.626*	0.421*
ND(GUxWFxMU) (5-12 mo.)	BW	0.730**	0.564*	0.735**	0.947**
(13-24 mo.)	BW	0.799**	-0.871**	0.959**	0.918**

**: $p < 0.001$; *: $p < 0.01$.

Correlation coefficients (r) were generally high, positive, and significant between BW and LBMs except for HL in ND calves (r: 0.355, NS); BL, and HW in ND(WFxMU) adults (r: 0.185, and 0.207, respectively, NS); and for CG in WFxGU growers (r: 0.326, NS). A significant negative correlation was observed between BW and HW in ND(GUxWFxMU) yearlings (r: -0.871**) and for HL in GU growers (r: -0.662*). The mostly high and positive correlation coefficients observed between BW and LBMs at the various age groups indicate that LBMs could serve as reliable predictors of BW in the cow herd. Umar *et al.* (2020) reported the correlation between BW and BL, HW, and CG as 0.69, 0.50, and –0.29, respectively for WF; and 0.49, -0.01, and – 0.13, respectively for Sokoto Gudali; most of which were quite lower than the values observed in the present study. The authors attributed the wide variation in correlation coefficients to non-uniformity in age of animals and differences in animal source. Overall, our results indicate that BW was most consistently, positively, and significantly correlated with CG followed by BL, and HW across genotypes, and age groups.

Conclusion

Composite cattle genotypes created from Nigerian indigenous cattle breeds had better growth performance and body conformation compared to native breeds in the humid rainforest agricultural zone of Nigeria. Crossbreeding of selected indigenous cattle breeds would yield composites with greater genetic merit for growth and body conformation.

Acknowledgement

Authors are grateful for funding provided by the Federal Government of Nigeria through the Tertiary Education Trust Fund (TETFund) under the National Research Fund (NRF, 2019), number: TETF/DR&D/CE/NRF/78/STI/VOL.1.

References

Abdela, N. 2016. Important cattle ticks and tick-borne haemoparasitic diseases in Ethiopia: A review. *Acta Parasitologica Globalis* 7 (1): 12-20. Doi. 10.5829/idosi.apg.2016.7.1.102140.

Bene, S., Nagy, B., Nagy, L., Kiss, B., Polgar, J. P. and Szabo, F. 2007. Comparison of body measurements of beef cows of different breeds. *Arch.Tierz. Dummerstorf* 50 (4): 363-373.

Chacon, E., Macedo, F., Velazquez, F., Paiva, S. R., Pineda, E. and McManus, C. 2011. Morphological measurements and body indices for Cuban Creole goats and their crossbreds. *Revista Brasileira de Zootecnia* 40 (8): 1671-1679.

Dossa, L. H., Wollny, C. and Gauly, M. 2007. Spatial variation in goat populations from Benin as revealed by multivariate analysis of morphological traits. *Small Rum. Res.* 73:150–159.

Getu, A. and Misganaw, G. 2015. The role of conformational traits on dairy cattle production and their longevities. *Open Access Library Journal* 2 e1342. http://dx.doi.org/10.4236/oalib.1101342.

Hafi, H. 2020. Performance body dimension of Bali cattle on slaughter house in Southeast Sulawesi. *Indonesian Journal of Agricultural Research* 3 (2): 136-144.

Kubkomawa, H. I. 2017. Indigenous breeds of cattle, their productivity, economic and cultural values in sub-Saharan Africa: A review. *International Journal of Research Studies in Agricultural Sciences* 3 (1): 27-43.

Lukuyu, M. N., Gibson, J. P., Savage, D. B., Duncan, A. J., Mujibi, F. D. N. and Okeyo, A. M. 2016. Use of body linear measurements to estimate live weight of crossbred dairy cattle in small-holder farms in Kenya. *Springer Plus* 5: 63. Doi.10.1186/s40064-016-1698-3.

N. R. C. I. 2016. Weather data: National Root Crops Research Institute (N.R.C.I.), Umudike, Abia State, Nigeria.

Nosike, R. J., Nwakpu, O. F., Isaac, U. C., Akinsola, K. L., Nwose, R. N. and Onunkwo, D. N. 2020. Characterization of indigenous cattle genotypes based on linear body traits in the humid tropics. *Nigerian Journal of Animal Production* 47 (1): 41-46.

Oduguwa, B. O., Adedeji, A. A., Sowande, S. O., Isah, O. A. and Amole, T. A. 2013. Estimation of live weight from linear body measurements of three breeds of cattle under extensive management system in Nigeria. *Nigerian Journal of Animal Science* 15: 1-9.

Oladepo, A. D., Ogunsipe, M. H., Ayoola, M. A. and Balogun, K. B. 2018. Morphometric attributes and differentiation of selected indigenous cattle breeds in Nigeria. *Nigerian Journal of Animal Science* 20 (1): 11-16.

Oni, O. O., Afolayan, R. A., Adeyinka, L. A., Lamidi, O. S. and Alawa, C. B. I. 2011. Estimation of live weight of calves from body measurements within different genetic groups. *Nigerian Journal of Animal Science* 13: 133-142.

Przysucha, T., Grodzki, H., Golebiewski, M., Slosarz, J. and Piotrowski, T. 2012. Analysis of body measurements and pelvis area index of Limousine cows. *Annals of Warsaw University of*

Life Sciences-SGGW Animal Science 51: 107-112.

Takaendengan, B. J., Paputungan, U., Noor, R. R. and Adiani, S. 2012. Live weight estimation by chest girth, body length and body volume formula in Minahasa local horse. *Media Peternakan* 35: 80-84. Doi: 10.5398/medpet.2012.35.2.80.

Umar, D. S. B., Nwagu, B. I., Umar, U. A., Rufina, O. O., Saleh, I., Onotu, S. I. and Ugwu, L. 2020. On-station performance evaluation of indigenous breeds of cattle for dairy production systems in Nigeria. *Asian Journal of Research in Agriculture and Forestry* 5 (1): 30-28.

Yakubu, A., Abdullah, A-R., Raji, A. O. and Oseni, S. O. 2021. Multivariate princioal component analysis of the morphometric traits of some cattle breeds in Nigeria. *The Journal of Animal and Plant Sciences* 31 (3): 681-689.

Received 27th Feb., 2022
Accepted 6t March, 2022