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Breed and sex effects on morphometric parameters of four indigenous cattle in Nigeria

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SUMMARY

Experiments were conducted to assess the morphometric traits in four indigenous cattle breeds (n=300) namely; Keteku, Muturu, N'dama and White Fulani, so as to determine the effects of breed and sex on the body measurements in cattle and prediction of the linear body relationship among body parameters using linear, quadratic and cubic functions, results of the morphometric traits data analyses showed that breeds and breed*sex were important sources of variation and significantly (P<0.05) influenced linear traits such as Body length (BL), Heart girth (HG), Height at withers (HW) and Head circumference (HC); N'dama had higher linear body dimensions than other breeds in this study as indicated by determination coefficients (R2) of regression equation that included all body measurements which were higher in White Fulani and Muturu (97.5 and95.0 %, respectively), it was found that the best and highest R2 value for White Fulani was obtained from the equation contained heart girth, height at withers and head circumference was found as97.5 %, followed by the R2 value obtained from the equation contained heart girth and height atwithers which was found as 91.8 % while the poorest relationships were found in Keteku with highest R2 value found in withers height (69.5%) and the lowest in the head circumference (37.9%), based on the R2, body length and other linear relationships were fitted best by linear, followed by quadratic and cubic functions while cubic term was not statistically significant for withers height and heart girth (P>0.05), the coefficients correlation gave the best and highest relationship between HW and HC in N'dama with a value of 0.94, and the coefficients correlation in the Muturu were generally lower as compared with other breeds.

Raza y efectos sexuales en los parámetros morfométricos de cuatro reses autóctonas en Nigeria

Palabras clave
Ganado.
Medidas corporales.
Predicción.
Morfométrico.

RESUMEN

Se llevaron a cabo experimentos para evaluar los rasgos morfométricos en cuatro razas de ganado autóctonas (n = 300); Keteku, Muturu, N'dama y White Fulani, para determinar los efectos de la raza y el sexo en las mediciones del cuerpo en el ganado y la predicción de la relación corporal lineal entre los parámetros corporales usando funciones lineales, cuadráticas y cúbicas, resultados de los rasgos morfométricos los análisis de datos mostraron que las razas y el sexo de raza fueron fuentes importantes de variación y significativamente (P <0.05) influyeron en rasgos lineales como longitud del cuerpo (BL), circunferencia del corazón (HG), altura a la cruz (HW) y circunferencia de la cabeza (HC) ; N'dama tuvo dimensiones corporales más altas que otras razas en este estudio según lo indicado por los coeficientes de determinación (R2) de la ecuación de regresión que incluyó todas las mediciones corporales que fueron mayores en White Fulani y Muturu (97.5 y 95.0%, respectivamente). que el mejor y más alto valor de R2 para Fulani blanco se obtuvo de la ecuación contenía circunferencia del corazón, la altura a la cruz y la circunferencia de la cabeza se encontró como 97.5%, seguido por el valor R2 obtenido de la ecuación contenía circunferencia del corazón y altura a la cruz que se encontró como 91.8% mientras que las relaciones más pobres se encontraron en Keteku con el valor R2 más alto encontrado en la altura de la cruz (69.5%) y el más bajo en la circunferencia de la cabeza (37.9%), basado en el R2, la longitud corporal y otras relaciones lineales lineal, seguido de las funciones cuadrática y cúbica, mientras que el término cúbico no fue estadísticamente significativo para la altura de la cruz y la circunferencia del corazón (P> 0.05), la correlación de los coeficientes dio lo mejor y más alto La relación entre HW y HC en N'dama con un valor de 0.94 y la correlación de los coeficientes en Muturu fueron generalmente más bajas en comparación con otras razas.

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INTRODUCTION

Indigenous cattle breeds are an important component of livestock agriculture, especially in some rural locations of Nigeria. They are kept as a source of investment and to some extent as a source of food (Alphonosus et al. 2010, p. 134). Management and conservation of animal genetic resources require assessment

of genetic diversity (Kugonza et al. 2011, p. 141). This is because it is difficult to design appropriate breeding programs for breeds that have not been adequately characterized either phenotypically and/or genetically (Yunusa et al. 2013, p. 662). Phenotypic characteristics are important in breed identification and classification in ways that farming communities can relate to (Gouveia et al. 2014, p. 334). An accurate description of Nigerian cattle kept under extensive management conditions would enable an accurate comparison of these breeds with in themselves and other cattle breeds, so that conservation and improvement programmes can then be developed using such information (FAO, 2011b, p. 2). Over the years, it has been known that body measurements can be used to interpret growth and production factors, to describe size inheritance and types of breeds or strains, and to estimate weight in beef cattle (Ndumu et al. 2008, p. 482). Morphological descriptions have also been used to evaluate breeding goals, to assess type and function and to estimate the animals' value as potential breeding stock (Mwacharo et al. 2006, p. 66). Linear body measurements (LBM) can be used in assessing growth rate, feed utilization and carcass characteristics in farm animals (Yunusa et al. 2013, p. 662). Linear body measurements are divided into skeletal and tissue measurements (Hamito 2009, p. 3).

Nigerian cattle have been described as belonging to four breeds: White Fulani, Ndama, Muturu and Keteku (Roger 1999, p. 15). The objective of this study was to phenotypically characterize four indigenous breed of cattle in Nigeria, using Generalized Linear Model (GLM) to examine the effects of breed, sex and their interaction on linear measurement and to determine the relationship among body measurement using linear, quadratic and cubic functions.

MATERIALS AND METHODS

The field work of the research was carried out by animals sampling and data collection from three different States in Nigeria namely: Ondo, Oyo and Kogi States. The climatic condition of these areas fall within Rain Forest Region of Nigeria where the average rainfall in a year is about

1524 mm and the atmospheric temperature ranges between 28 0C and 31 0C while mean annual relative humidity is about 80 % . Data from 300 animals of the four breeds under study; White Fulani, N'dama, Muturu and Keteku, were used for this experiment. Typically, these animals were raised under similar conditions of extensive and semi-intensive production systems in which animals are free grazing. Morphometric measurements taken from each animal at about three to four years of age included body length, heart girth, height at withers and head circumference. Because farmers often did not have birth records, age was estimated by examining each animal's teeth as suggested by Hamito (2009, p. 8). Only animals with an eruption of the fourth pair of teeth, indicating maturity, were included in the study. Body measurements were taken according to the procedure described by Hamito (2009, p. 3); Salako & Ngere (2002, p. 165). Graduate tape rule was used to measure the body measurements. All measurements were repeated three times with the animal being moved to a "normal" position for each measurement.

EXPERIMENTAL DESIGN AND METHODOLOGY

The design of the experiment was a randomized complete block design with 2 factors in 2x4 factorial analysis (with Breed and Sex as the main effects). Data were obtained from 2 indigenous Bos indicus (Zebu) breeds (White Fulani, n = 84; Keteku, n = 78) and Bos taurus breeds (Muturu, n = 62 and N'Dama, n = 76). The individuals were sampled from distant locations and unrelated. Morphometric measurements were taken from each animal which included the body length, heart girth, height at withers and head circumference as described by Salako & Ngere (2002, p.165). Data obtained were analyzed with the General Linear Model (GLM) procedure of SAS (SAS, 2010). In the analyses, the effect of breed and sex were fixed while body length, heart girth, height at withers and head circumference were used as continuous variables.

ANALYTICAL PROCEDURES AND STATISTICAL ANALYSIS

Data were analyzed with the General Linear Model (GLM) procedure of SAS (SAS, 2010). In the analyses, breed and sex were included as fixed variables while body length, heart girth, height at wither and head circumference were used as continuous variables. The significance of means of all variables were separated via protected Least Significant Difference (LSD) of SAS analytical package.

The model and the factors used were:

$$Y_{ijk} = \mu + B_i + S_j + (B_i + S_j) + E^{ijk}$$

Where

Y_{ijk} = the vector of N observations on an animal of a given breed and sex for a given variable (body length, heart girth, withers height and head circumference);

μ = the average from a specific population and sex;

B_i = ith breed (i = N'dama, Muturu, Keteku and White Fulani);

$S_j = j^{th}$ Sex;

$(B_i + S_j)$ = two-way interaction effect between breed and Sex; and

E_{ijk} = residual effect, which is independently and identically distributed with mean = 0 and variance = $\sigma 2$

Analysis of variance of SAS was used to determine the significance of all factors. The correlation coefficients among the variables were computed on a within sex and within breed basis using proc corr procedure of SAS (SAS, 2010).

Further, data were subjected to more analyses using multiple regression models of SAS. Rela-

Table I. Mean Square of analyses of variance of morphometric measurements (cm) in Nigerian indigenous cattle breeds (Media de los análisis de varianza de mediciones morfométricas (cm) en razas bovinas autóctonas nigerianas).

Source of Variation	Degree of freedom	Body length	Heart girth	Height at wither	Head circumference
Breed	3	428.5	582.1*	127.5	102.2*
Sex	1	257.4	181.6	128.7	90.5
Breed*Sex	3	138.0*	23.1	147.1*	100.3
Residual	292	31.9	34.4	38.3	23.5

* Statistically significant ($p < 0.05$). Body length (BL), Heart girth (HG), Height at withers (HW) and Head circumference (HC).

tionships between body length and other linear traits (heart girth, withers height and head circumference) within the Nigerian indigenous cattle were determined. The best prediction equations for body length from other traits (heart girth, withers height and head circumference) as independent variables were also determined. Linear, quadratic and cubic effects of independent variables on body length were included in the following model:

$$Y_i = b_o + b_{1xi} + b_{2xi2} + b_{3xi3} + e_i$$

where Y_i is the body length observation of an *i-th* animal, b_0 the intercept, b1, b2, b3 the corresponding linear, quadratic and cubic regression coefficients, x_i the body measurement (heart girth, withers height and head circumference) and ei the residual error term.

RESULTS

The mean squares estimated through the analysis of variance (ANOVA) for linear measurements viz: Body length (BL), Heart girth (HG), Height at withers (HW) and Head circumference (HC) by breed and sex is presented in **Table I**. Breed had significant ($p < 0.05$) effects on heart girth (582.1) and head circumference (102.2). Also breed and sex interaction had significant ($p < 0.05$) effects on body length and height at withers with mean square values of 138.0 and 147.1 respectively.

Furthermore, the estimated least squares mean and standard errors for linear measurements (Body length (BL), Heart girth (HG), Height at withers (HW) and Head circumference (HC)) by breed and sex are presented in **Table II**. There was no significant difference ($p > 0.05$) between male and female in heart girth across all breeds while the male animals were significantly higher than the female in body length and head circumference for all breeds in this study. N'dama male had a significantly ($p < 0.05$) higher means for BL (138.4±0.6cm) and HW (146.3±7.4cm) than other breeds while Muturu had the highest value for HG (184.39±5.9cm) and Keteku recorded the highest mean for the HC (112.61±1.7cm). The White Fulani females were significantly smaller in BL (125.82±7.1cm), HW (128±3.2cm) and HC (96.42±1.6cm) than the other breeds. The correlation coefficients of the linear body measurements among Nigerian indigenous cattle for Body length (BL), Heart girth (HG), Height at withers (HW) and Head circumference (HC) are presented in **Table III** and **Table IV**. In general, the correlation coefficients among linear variables in this study ranged from moderate to high. White Fulani had the least relationship between the BL and WH with a value of 0.62 while the highest relationship existed in N'dama with a value of 0.94. Also, the relationship between HG and HC was lowest in Keteku with a value of 0.66. The best and highest relationship was observed between WH and HC in N'dama with a value of 0.94.

The regression equation of the body length on other measurements are shown in **TableV**. On the basis of R2, the best and highest value for White Fulani was obtained from the equation contained heart girth, height at withers, and head circumference, was found as 97.5 % followed by the R2 value obtained from the equation contained heart girth and height at withers which was found as

Table II. Least Squares Means and standard errors of morphometric measurements (cm) in Nigerian indigenous cattle (Medios mínimos cuadrados y errores estándar de mediciones morfométricas (cm) en el ganado autóctono nigeriano).

Breed	Body Length(cm)		Heart girth(cm)		Height at wither(cm)		Head circumference(cm)	
	Male	Female	Male	Female	Male	Female	Male	Female
White Fulani	132.1±4.8^{ab,1}	125.82±7.1^{c,2}	178.63±3.2^{b,1}	173.09±13.5^{c,1}	132.9±2.8^{b,1}	128±3.2^{c,2}	110.42±0.1^{a,1}	96.42±1.6^{a,2}
N'dama	138.4±0.6^{a,1}	130.25±3.6^{b,2}	180.12±1.6^{ab,1}	185.16±4.0^{b,1}	146.3±7.4^{a,1}	141.4±3.5^{a,1}	105.12±3.9^{a,1}	92.21±2.4^{b,2}
Muturu	127.2±2.4^{ab,1}	122.63±2.9^{a,1}	184.39±5.9^{a,1}	170.35±1.5^{a,1}	137.5±3.2^{b,1}	130.62±7.0^{b,1}	101.03±0.6^{a,1}	97.50±5.8^{a,2}
Keteku	123.9±3.8^{b,1}	120.40±0.6^{c,2}	163.51±0.2^{c,1}	165.4±7.1^{b,1}	135.6±2.5^{b,1}	132.95±1.4^{b,1}	112.61±1.7^{a,1}	98.32±0.9^{a,2}

$^{a-c}$ Means within each column with differing alphabetic superscripts are significantly different ($P < 0.05$). ^{1,2} Means within each row for each measurement with differing numeric superscripts are significantly different ($P < 0.05$).

Table III. Correlation coefficients among the morphometric measurements (cm) in White Fulani and N'dama cattle (Coeficientes de correlación entre las mediciones morfométricas (cm) en el ganado Fulani blanco y N'dama).

Body Measurement	Body length	Withers height	Heart girth	Head circumference
Body length	-	0.94*	0.89*	0.88*
Wither height	0.62*		0.86*	0.94*
Heart girth	0.88*	0.78*		0.92*
Head circumference	0.92*	0.89*	0.76*	-

* Statistically significant ($p < 0.05$) The coefficients for each trait represent White Fulani on the lower diagonal and N'dama on the upper diagonal

Table IV. Correlation coefficients among the morphometric measurements (cm) in Muturu and Keteku cattle (Coeficientes de correlación entre las mediciones morfométricas (cm) en el ganado bovino de Muturu y Keteku).

Body Measurement	Body length	Withers height	Heart girth	Head circumference
Body length	-	0.92*	0.89*	0.91*
Wither height	0.91*		0.86*	0.81*
Heart girth	0.86*	0.89*		0.66*
Head circumference	0.68*	0.78*	0.85*	-

* Statistically significant ($p < 0.05$). The coefficients for each trait represent Muturu on the lower diagonal and Keteku on the upper diagonal.

91.8 %. Also among the three measurements, the highest R2 value was obtained from the equation contained only heart girth (R2=91.1 %) while the lowest was obtained from the equation contained only head circumference (R2=50.8%). Similar trend was observed for Muturu where the best and highest R2 value was obtained for the combination of heart girth, height at withers, and head circumference with a value of 95.0% and the equation contained only heart girth had a R2 value of 88.8 % while the lowest value was from the equation contained only head circumference (R2=51.7%). Moreover, the best fitted equation for N'dama contained the heart girth and height at withers with a R2 value of 90.3 % while 79.1% and 79.2% were obtained for equations containing only heart girth and height at withers respectively. Overall, Keteku had the lowest R2 values obtained from different equations as compared to others. The highest R2 value was obtained from the equation contained heart girth, height at withers, and head circumference was found 68.2 % followed by the R2 value obtained from the equation contained height at withers and head circumference was found 66.1 %. The lowest and poorest R2 value was obtained from the equation contained only head circumference (R2=50.8%).

Table VI shows that the linear, quadratic and cubic coefficients for body length on other linear measurements in this study were either positive or negative. The R2 so obtained by using linear, quadratic and cubic functions ranged from 39.2% – 94.4%, 37.9% – 93.1% and 41.6% - 85.8% respectively. The regression coefficients for body length on linear measurements were either positive or negative. The highest R2 value was found in withers height and heart girth for White Fulani (R2=94.4% and 93.1 %, respectively) while the poorest relationships were found in Keteku with highest R2 value found in withers height (69.5%) and the lowest in the head circumference (37.9%). Based on the R2, body length and other linear relationships were fitted best by linear, followed by quadratic and cubic functions. The cubic term was not statistically significant for withers height and heart girth ($P>0.05$).

DISCUSSION

Generally, the linear body dimensions for the N'dama breed were higher than other breeds in this study. According to Alphonsus et al. (2010, p. 177), skeletal measurements such as ulna length, body height and length, and chest depth were less affected by nutrition and thus may indicate inherent size better than measures related to muscle and fat deposition, such as body girth. The marked differences between male and female cattle suggested the presence of sexual dimorphism among the Nigerian indigenous cattle breeds. The sex-related differences could be as a result of the usual between-sex differential hormonal effects on growth. This is similar to the reports of previous workers on goats (Yakubu et al. 2010, p. 385), sheep (Yakubu & Ibrahim 2011, p. 85), cattle (Alphonus et al. 2010, p. 178) and buffalo (Johari et al. 2009, p. 290-291) respectively. Also, body measurements and indices estimated from various combinations of conventional and non- conventional body parameters have been used as markers for weight and as indicators of type and function in domestic animals (Chineke et al. 2003, p. 3). The least squares mean of adult measurements for the Muturu females are relatively higher than those of the small East African Zebu and Friesian-Bunaji cows (Mwacharo et al. 2006, p. 68; Alphonus et al. 2010, p. 178).

In a similar study, the mean measurements in the Masaai female adults for body length, heart girth and withers height were reported to be 116.7cm, 145.9cm and 111.3cm respectively (Mwacharo et al. 2006, p. 68), which are lower than those of the animals considered in this study.

The correlation coefficients in the Muturu were generally low as compared with other breeds in this study. The significantly high and positive correlation coefficients obtained in this study could be attributed to a pleiotropic effect of gene or genetic linkage for genes controlling these traits.

The implication of this is that an improvement in one parameter will give positive response to the other parameter. This could be used for selection and breeding programme for improvement in Nigerian cattle. Similar observations were made by Mwacharo et al. (2006, p. 69) in cattle body measurements and Chineke (2005, p. 782) in rabbit body measurements. This also agreed with the reports of Olutogun et al. (2003, p. 31) who observed highly significant correlations between

Table V. Prediction equations of body length on other body measurements (Ecuaciones predictivas de la longitud corporal en otras mediciones corporales).

Breeds	Regression Equations	S. E	R^2%
White Fulani	Y=108+0.69 HG*+2.81 HW*–0.62 HC	4.65	97.5
	Y=−102+2.91 HG*+1.10 HW*	4.03	91.8
	Y=-67+2.11 HW+3.59 HC	1.69	91.3
	Y=103+5.21 HG*	4.70	91.1
	Y=107+8.39 HW*	6.58	79.2
	Y=96+1.5 HC*	0.98	50.8
N'dama	Y=86+2.28 HG*–0.10 HW–0.94 HC	3.98	82.2
	Y=83+2.53 HG*−0.69 HW	1.81	90.3
	Y=66-1.36 HW+1.91 HC*	1.37	71.3
	Y=−69+7.27 HG*	9.31	79.1
	Y=56+11.7 HW*	7.84	79.2
	Y=−86+15.4 HC	4.98	60.4
Muturu	Y=−105+4.78HG*–1.27 HW+0.81 HC*	10.98	95.0
	Y=−118+5.80 HG*+5.02 HW*	8.40	93.9
	Y=−68+2.80 HW*+1.76 HC	3.45	73.0
	Y=−15+7.69 HG*	4.47	88.8
	Y=−32+9.80 HW*	2.89	82.2
	Y=36+10.1 HC	0.40	51.7
Keteku	Y=−159+2.28 HG*–0.10HW+6.87 HC	1.05	68.2
	Y=−83+ 7.81 HG*−0.69 HW	8.89	56.1
	Y=41–1.00 HW+4.59HC	4.31	66.1
	Y=−89+4.19 HG*	9.54	60.7
	Y=−96+9.25 HW*	7.62	47.7
	Y=−146+5.94 HC*	4.28	43.2

Body length (BL), Heart girth (HG), Height at withers (HW) and Head circumference (HC). Standard Error (S.E). * statistically significant ($p<0.05$). Y=body length

Body length (BL) and Height at withers (HW). The high correlation between Heart girth (HG) and Height at withers (HW) and between Body length (BL), and Height at withers (HW) in all breeds could imply that frame size and absolute height were complementary and that the total size of the animal is a function of length, height and circumference measurements as also observed by Johari et al. (2009, p.290).

The regression coefficient of the equation relating the body length and height at withers was higher for the N'dama cattle compared to other breeds. This indicated that, as body length increases for the N'dama cattle, wither height increases at a faster rate than it does for the other three breeds. This trend was also observed in White Fulani cattle as it had a closer regression coefficient. Nutritional stress may be strong in the N'dama and White Fulani cattle with genetic potential for body length not being expressed while that of wither height, which is observed to be less subject to nutritional stress according to Akpa et al. (2012, p. 3607), is much more expressed. This indicates that both N'dama and White Fulani cattle are taller than longer, relative to their proportionate size. According to Alphonsus (2010, p. 176), this type of body confirmation is an adaptation to dissipating heat than a short, squat body. The tall and leggy confirmation of the N'dama and White Fulani cattle can be considered an adaptation to free and wide-ranging mode of grazing in search of pastures and water.

There was either good or poor fit obtained for any of the three models among the various breeds. Based on the R2, body length and other linear relationships were fitted best by linear, followed by quadratic and cubic functions suggesting that multiple linear relationship will best capture the body conformation at any given time. The regression coefficient associated with independent variables x and partially representing the amount of change in Y for each unit change in x had a positive value in the relationship between the body length and some other linear measurements. This showed that these parameters were directly influenced by changes in body length. Therefore, the observation of positive values for regression coefficient could indicate that any increase in body length resulted in an increase in other linear measurements in this study (Height at withers, Heart girth and Head circumference). Similar positive relationships between body dimensions had been reported in sheep (Yunusa et al. 2013, p. 663), cattle (Omeje et al. 2001, p. 75), poultry (Oni et al.2001a, p. 86) and rabbit (Chineke 2000, p. 238). The higher R2 values obtained from this study for White Fulani was in line with the findings of Tuzemen et al. (1995, p. 250) and Bozkurt (2006, p.31) who obtained R^2 of 90.7 % and 93.6 % respectively for withers height in Brown Swiss cattle. But the R2 values for heart girth in this study was higher than those authors' findings.

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CONCLUSION

The morphometric measurements examined in this study were influenced differently by factors considered. The breed and sex were the main sources of variation in almost all the linear traits studied. The performance of cattle in this study compared favourably with reports under tropical conditions but as usual was below temperate values. This could be due to differential climatic conditions in the two regions. The correlation coefficients among the body parameters were high, positive and highly significant suggesting that increment in any of the morphometric parameters would give rise to increase in the value of the other. Also, the regression equation that combines the heart girth, height at withers and head circumference could be used to predict the body conformation in

Table VI. Estimate of parameters in Linear, Quadratic and Cubic functions for body length and other linear measurements (Estimación de parámetros de las funciones lineal, cuadrada y cúbica para la longitud del cuerpo y otras mediciones lineales).

Breeds	Variables	Functions	S.E	R^2%	Sig.
White Fulani	Withers height	$Y = -124.13 + 9.81x$	5.31	94.4	*
		$Y_1 = -620.37 + 20.09x - 0.03x^2$	123.40	84.7	*
		$Y_2 = -2810.10 + 163.28x - 3.12x^2 + 0.004x^3$	1.57	72.3	ns
	Heart girth	$Y = -107.12 + 21.30x$	14.91	79.5	*
		$Y_1 = -1052.01 + 35.12x - 0.18x^2$	160.34	93.1	*
		$Y_2 = 2189.34 - 117.36x + 1.25x^2 - 0.012x^3$	13.48	79.2	ns
	Head circumference	$Y = -139.10 + 12.90x$	10.97	75.8	*
		$Y_1 = -651.94 + 79.62x - 0.53x^2$	125.79	70.9	*
		$Y_2 = -1793.00 + 351.20x - 7.62x^2 + 0.009x^3$	9.84	78.2	ns
N'dama	Withers height	$Y = 102.68 + 10.15x$	16.71	57.9	*
		$Y_1 = -702.18 + 52.09x - 0.52x^2$	186.74	67.3	*
		$Y_2 = -1403.36 + 207.45x - 3.43x^2 + 0.015x^3$	24.96	55.0	ns
	Heart girth	$Y = -69.72 + 6.30x$	48.48	61.3	*
		$Y_1 = 576.25 - 21.54x + 0.49x^2$	558.21	59.7	ns
		$Y_2 = 2491.93 - 162.17x + 2.83x^2 - 0.018x^3$	147.13	62.0	ns
	Head circumference	$Y = -174.22 + 3.18x$	9.05	41.7	*
		$Y_1 = 840.36 - 4.65x + 0.06x^2$	96.75	50.3	*
		$Y_2 = -1701.95 + 19.21x - 0.05x^2 - 0.009x^3$	8.96	42.8	ns
Muturu	Withers height	$Y = -115.30 + 11.23x$	23.47	76.1	*
		$Y_1 = -463.51 + 10.09x + 0.09x^2$	22.09	82.0	*
		$Y_2 = 1948.42 - 135.04x + 2.16x^2 + 0.023x^3$	49.02	80.2	ns
	Heart girth	$Y = -145.95 + 13.17x$	12.84	70.9	*
		$Y_1 = -1083.22 + 75.20x + 0.79x^2$	148.87	87.5	*
		$Y_2 = 2734.20 + 103.11x - 4.38x^2 - 0.025x^3$	6.72	85.8	ns
	Head circumference	$Y = -138.31 + 58.12x$	9.36	75.2	*
		$Y_1 = -565.69 + 58.12x - 0.21x^2$	109.13	78.5	ns
		$Y_2 = -1785.02 + 307.20x - 17.09x^2 + 0.05x^3$	8.36	74.7	ns
Keteku	Withers height	$Y = -125.63 + 12.37x$	15.49	69.5	*
		$Y_1 = -463.51 + 9.13x + 0.18x^2$	168.90	47.2	*
		$Y_2 = 10048.17 - 358.35x - 2.15x^2 + 0.035x^3$	23.99	41.5	ns
	Heart girth	$Y = -138.10 + 10.58x$	57.16	45.3	*
		$Y_1 = -5661.64 + 89.12x - 0.17x^2$	65.75	43.6	*
		$Y_2 = -1852.93 + 853.10x - 2.16x^2 + 0.019x^3$	164.56	43.6	ns
	Head circumference	$Y = 112.56 + 7.25x$	11.67	39.2	*
		$Y_1 = -506.51 + 82.13x - 0.78x^2$	152.70	37.9	ns
		$Y_2 = -2475.37 + 102.41x - 4.93x^2 + 0.026x^3$	238.14	41.6	ns

ns= statistically not-significant ($p > 0.05$); * statistically significant ($p < 0.05$). Sig. Significant. S.E Standard Error. Y= Linear function, Y_1= Quadratic function, Y_2= Cubic function

cattle. Furthermore, linear function could be recommended as the best fit model for the prediction of body parameters. All these could be combined as a useful tool for genetic improvement of Nigerian indigenous cattle through breeding and selection programme.

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