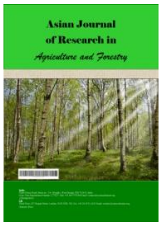

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On-station Performance Evaluation of Indigenous Breeds of Cattle for Dairy Production Systems in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author DSBU designed the study. Author UAU performed the statistical analysis. Author BIN wrote the protocol. Author OOR managed the literature searches. Author IS managed the analyses of the study. Author SIO managed the data cleaning. Author LU managed the proofreading of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This study was aimed at evaluating on-station performance of indigenous breeds of cattle for milk yield and body conformation traits. The data for the study came from four hundred and fifty (450) genotypes (Bunaji, Friesian X Bunaji and Gudali) of cattle reared on-station from 1995 through 2012. Morphometric variables measured were BW: Body weight (Kg); BL: Body Length (cm); HW:

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Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres). There variations in morphometric traits and milk yield among the genotypes of cows. Bodyweight was significant and highly correlated with total yield in milk for all the genotypes of cows. The accuracy of predicting total yield in milk using morphometric traits was best in FriesianXBunaji (76.24%) followed by Bunaji (70.43%) while Gudali had the least prediction classification (62.06%). It is concluded that performance differences among the indigenous cattle indicate genetic diversity exists among the genotypes.

Keywords: Indigenous breeds; cattle; dairy production; milk yield.

1. INTRODUCTION

African indigenous cattle breeds have unique morphological features which distinguishes them from other cattle [1,2]. Characterization of livestock breeds is the first approach to a sustainable use of its animal genetic resources [3]. The first step in the characterization of local genetic resources is based on the knowledge of variations in the morphological traits [4]. Yakubu et al. [5] have reported that generally, the linear body measurements of Sokoto Gudali were higher than those of the Bunaji cattle with the exception of body length and face length respectively. Genetic characterization of indigenous breeds and their morphological traits form one important component is a strategy to expand food production. The local indigenous breeds have received less attention due to low performance in productivity which has shifted the interest of the breeders towards temperate cattle breeds to upgrade their local genetic resources. It is generally accepted that the highest amount of genetic diversity in the populations of livestock is found in the developing world where record keeping is poor, and the risk of extinction is high and on the increase. Recently, loss of genetic diversity within indigenous livestock breeds has been a major concern [5]. The rate of improvement is constrained by the information available on each individual animal and the population at large, as well as the abilities of statistical models to correctly capture the biological and environmental processes that underlie variation in the population. If improvement of a population is to be maintained in future generations it must be improvement in the genetic make-up of that population. However, to the best our knowledge there is a dearth of information on the relationship among morphometric traits in indigenous cattle population in Nigeria. Therefore, this study is designed to analyse the variations and relationships between morphometric traits of indigenous cattle in Nigeria.

2. MATERIALS AND METHODS

2.1 Animals and Management

Animals used for this research were sourced in National Animal Production Research Institute (NAPRI). They were raised under semi intensive system of management.

2.2 Sampling Size and Sampling Structure

Record of 450 cattle comprising of equal number of Friesian X Bunaji cross (n=150), Sokoto Gudali (n=150) and White Fulani (n=150) at different parities from 1995 to 2008 were used to determine the variations and relationship between traits among the different cattle genotypes. Bio-information of birth date of all the animals used in this study was collected from NAPRI.

2.3 Quantitative Characters

Nine metric characters including body weight and ten linear measurements were taken on each sampled animal. They include: BW: Body weight (kg), BL: Body length (cm), HW: Height at withers (cm), CW: Chest width (cm), HG: Heart girth (cm), RW: Rump width (cm), TL: Teat Length (cm), RUH: Rear udder height (cm), UC: Udder circumference (cm). Weights of the animals were taken using a spring balance and walk-in weighing bridge (kg). Flexible tape rule was used to take the body measurement. During body measurement animals were made to stand upright and restrained by two assistants in such a way that their heads, necks, and chest were stretched almost in a straight line, each measurement were taken at least three times and the mean recorded to the nearest cm.

2.4 Udder Measurements

The Udder and teat measurements were done using flexible tape (cm) as follows:

Udder circumference (cm): Measured at the widest point of the Udder round it.

Udder height (cm): Measured from the rear attachment of the Udder to the front of it where it blends with the body.

Teat length (cm): measured as the distance from the upper part of the teat, where it hangs perpendicularly from the Udder to the tip of the teat.

2.5 Milk Yield Characteristics

Milk yield characteristics were measured as follows:

Average Daily Yield (ADY):- As average of all test day yields within the milking period.

Total Yield (TY):- As milk production during the lactation period up to the point where the production of the cow dropped below 100 ml.

Lactation Length (LL):- As the period from calving to the point when the milk yield of the cow falls below 100 ml.

2.6 Statistical Model

Model for the Analysis as illustrated below:

$Y_{ijk}=\mu+B_i+e_{ij}$

Where Y_{ij} is the record observed

μ= population mean
B_i = Fixed effect of the i^{th} breed of cattle
e_{ij} = random error particular to the ij^{th} observation assumed to be independently randomly distributed with mean zero and variance $б^2e$, i .e , NID (0, $б^2e$)

2.7 Statistical Analysis

The effect of breed on measured traits were determined using the PROC GLM of SAS 9.2 (2003). Significant ($p<0.05$) differences in means were separated using Duncan Multiple Range Test (DMRT). The degree of association between all pairs of metric variables was computed for all the animals within each breed using correlation procedure of the [6] package and PROC REG of SAS 9.2 to predict total milk yield.

3. RESULTS

The result of mean comparison of morphometric and selected milk Production traits of the three breeds is presented in Table 1. Bodyweight and all other measured traits differed significantly ($p<0.05$) between the breeds; the highest BW and BL was obtained with the Friesian–Bunaji and this differed from the Gudali which differed from the Bunaji with the least the BW and BL. The Gudali had the highest HW, CW, HG, Rumwi and TY (178.42 cm, 31.69 cm 127.78 cm, 50.18 cm and 1388.52 litres); the Friesian–Bunaji (174.99 cm, 25.13 cm, 124.09 cm, 43.53 cm and 1097.59 litres). TL was significantly higher in the hybrid (5.10 cm) and differed from the Bunaji (4.67 cm) which also differed from the Gudali (4.47 cm) being the least. The same trend was observed with RUH and UC with the exception that UC were similar in magnitude between the Bunaji and Gudali. TY in this study was significantly higher with the Gudali (1203.52 litres), while the Bunaji and its hybrid were statistically ($p>0.05$) similar. ADY indicated a reversed trend with the Friesian–Bunaji having the highest Production while the Bunaji and Gudali were similar. LL was higher and similar between the Bunaji and Friesian–Bunaji compared to the Gudali which had the least LL value.

Table 2 reveals the Pearson correlation coefficient among growth and milk traits pooled across the breeds. BW was significantly ($p<0.05$) and positively correlated with BL, HW, CW, RUH, UC, TY, ADY and LL. BL also was found to be positively and significantly related to HW, Rumwi, RUH, TY, ADY and LL; HW had significant and negative association with CW, HG and Rumwi while been positively correlated with TL, RUH, UC, TY, ADY and LL. CW had positive and significant correlation with HG, Rumwi, TY and LL but negatively with TL, RUH and UC. HG was only positively correlated with Rumwi and LL but negatively with TL, RUH, UC, TY and ADY. TY had high, significant and positive correlations with ADY and LL which implies that selection improve total milk yield will cause a corresponding improvement in average daily milk yield with an extended lactation.

Phenotypic correlation for growth and milk Production traits in the Bunaji breed is described in Table 3. Observed correlations in the Bunaji breed were low and mostly non-significant ($p>0.01$) among measured characteristics. BW was negatively and significantly ($p<0.05$) correlated with HG, TL, RUH and ADY. HW had high and positively correlated with Rumwi. TY had high, positive and significant correlations with ADY and LL. BL had high and positively correlated with HW, Rumwi, UC and ADY.

Table 4 shows the correlation between studied traits in the Friesian- Bunaji cross. Positive and significant ($p<0.05$) relationship existed between BW and Rumwi, HG, HW, UC, TY and ADY. Significant and negative relationship was observed between BW and TL, CW and RUH. BL had high, positive and significant correlations with HG, TL, UC, TY and LL. TY had high, positive and significant correlations with ADY.

Phenotypic correlation for growth and milk Production traits in the Gudali breed is described in Table 5. Significantly ($p<0.05$) positive relationship in these breed among measured characteristics existed between BW and BL, CW, TL, TY and ADY; HG and RUH; TL and RUH; RUH, UC and TY; and UC with ADY. Significant and negative relationship existed between BW and HG; CW with HG and TL.

3.1 Stepwise Linear Regression Predictor for Total Milk Yield

Table 6 presents the stepwise linear regression for Total milk yield equation pooled for all breeds and within breeds. Prediction equation of TY showed R^2 values ranging from 62.06% in Gudali to high 87.16% in the pooled data. BW, BL, CW, HG, Rumwi, RUH, ADY and LL were traits that featured in the overall prediction equation. In the Bunaji with R^2 value of 70.43% consisted of BL, HG and Rumwi as predictors for TY while HW and ADY were observed in the Friesian X Bunaji cross with R^2 value of 76.24%. The Gudali only had one predictor component for predicting TY and this was RUH and it showed a R^2 value of 62.06%.

4. DISCUSSION

Comparative measurements of morphometric traits can provide evidence of breed relationships and size. The considerable variation in body dimensions of the two cattle breeds might not be unconnected with individual breed's potential and peculiarities. The Bunaji cattle is noted for milk production, their Sokoto Gudali counterparts which is often ranked second in milk production produce more meat and appear to have more draught power (Yakubu et al., 2010). The superiority of cross bred animals to local breeds in this study needs not be emphasised as it is a generally accepted trend in animal improvement studies. The estimates for BL (175.48 – 180.63) were comparable to 175.29 – 179.02 cm reported by Tawah and Rege [7]. HW estimates of 170.02 -178.42 cm were higher than 110-148.40 cm reported by various authors for different cattle breed [8]. Observed measures of HG range of 124.09-127.78 cm obtained were lower than the values 141-151 cm reported for Bunaji [8]. Average daily yield of 3.37 to 4.43 litres observed were comparable to 4.8l reported for Bunaji and Friesian X Bunaji [9]. Lactation length (days) of 245.33 days were within the range of 173 – 249.5 days reported by Kallweit [9]. The LL of 218.99 days obtained for the Gudali were comparable to the values of 216 – 225 days for Yola Gudali in Kafare station [10]. The significant superiority of the Gudali in milk production compared to the Bunaji was contrary

Table 1. Performance of breeds in morphometric and selected milk production traits

Breed	Bunaji	Friesian X Bunaji	Gudali	SEM
BW	379.95^c	395.40^a	388.42^b	3.35
BL	175.48^c	180.63^a	178.35^b	1.01
HW	170.02^c	174.99^b	178.42^a	0.78
CW	22.22^c	25.13^b	31.69^a	1.13
HG	124.94^b	124.09^b	127.78^a	1.20
Rumwi	44.00^b	43.53^b	50.18^a	3.08
TL	4.67^b	5.10^a	4.47^c	0.36
RUH	19.69^b	24.43^a	17.45^c	1.95
UC	41.35^b	44.08^a	40.08^b	1.56
TY	1042.87^b	1097.59^b	1203.52^a	47.71
ADY	4.37^b	7.40^a	5.43^b	0.76
LL	245.33^a	255.68^a	218.99^b	9.61

^{abc}Means with different superscript across rows differ significantly ($p<0.05$)

Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days); SEM-Standard error of mean

Table 2. Correlation of growth and milk traits for all breeds

	BW	BL	HW	CW	HG	Rumwi	TL	RUH	UC	TY	ADY	LL
BW												
BL	0.48*											
HW	0.56*	0.21*										
CW	0.36*	0.09	-0.67*									
HG	0.14	0.03	-0.81*	0.62								
Rumwi	-0.19	0.22*	-0.47*	0.37*	0.46*							
TL	-0.05	0.14	0.21*	0.12	-0.17*	-0.10						
RUH	0.28*	0.31*	0.49*	0.32*	-0.45*	-0.25*	0.18					
UC	0.76*	0.11	0.14*	-0.09	-0.10	-0.04	0.02	0.11				
TY	0.42*	0.26*	0.23*	0.10	-0.12	-0.11	0.14	0.47*	0.11			
ADY	0.49*	0.39*	0.26*	0.03	-0.16	-0.15	0.12	0.40*	0.13	0.72*		
LL	0.24*	0.22*	0.14*	0.28*	0.12	0.08	0.11	0.20*	0.05	0.58*	0.46*	

*: $p<0.05$

Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days)

Table 3. Correlation of growth and milk production traits in the Bunaji

	BW	BL	HW	CW	HG	Rumwi	TL	RUH	UC	TY	ADY	LL
BW												
BL	0.69*											
HW	0.50*	0.29*										
CW	0.43*	-0.62*	-0.04									
HG	-0.29*	0.13	0.19	0.03								
Rumwi	-0.17	0.28*	0.26*	0.06	0.14							
TL	0.24*	-0.09	0.19	-0.04	0.04	-0.01						
RUH	-0.81*	0.13	0.01	-0.13	0.07	0.02	-0.05					
UC	-0.12	0.48*	-0.03	-0.02	0.17	0.16	-0.18	0.07				
TY	0.39*	-0.47*	0.07	0.04	-0.12	-0.19	0.11	-0.09	0.01			
ADY	-0.39*	0.22*	-0.02	0.03	0.01	-0.12	0.15	0.08	0.15	0.67*		
LL	-0.04	-0.21*	-0.01	0.02	-0.04	0.06	0.01	-0.12	0.14	0.22*	0.17	

**: $p<0.05$; Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).*

Table 4. Correlation of growth and milk production traits in the friesian X Bunaji

	BW	BL	HW	CW	HG	Rumwi	TL	RUH	UC	TY	ADY	LL
BW												
BL	-0.21*											
HW	0.40*	-0.11										
CW	-0.33*	-0.03	0.21*									
HG	0.71*	0.22*	0.01	-0.07								
Rumwi	0.42*	-0.17	0.14	-0.05	-0.02							
TL	-0.12	0.24*	0.03	0.03	0.11	0.03						
RUH	-0.22*	0.14	-0.06	-0.12	-0.02	0.07	0.34*					
UC	0.77*	0.31*	0.59*	0.30*	0.01	-0.12	-0.02	0.228				
TY	0.63*	0.66*	0.09	0.02	-0.18	0.03	-0.08	-0.09	0.06			
ADY	0.33*	-0.13	-0.06	-0.15	0.01	0.08	0.11	-0.13	0.13	0.68*		
LL	-0.66*	0.21*	-0.07	-0.01	0.03	-0.02	0.56*	0.12	-0.04	-0.19	-0.15	

**: p<0.05; Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days)*

Table 5. Correlation of growth and milk production traits in the Gudali

	BW	BL	HW	CW	HG	Rumwi	TL	RUH	UC	TY	ADY	LL
BW												
BL	0.49*											
HW	-0.01	0.44*										
CW	0.33*	-0.33*	0.02									
HG	-0.13	-0.11	0.55*	0.60*								
Rumwi	-0.45*	0.20*	0.03	0.02	-0.17							
TL	0.22*	-0.04	-0.22	-0.33*	0.12	-0.03						
RUH	0.01	0.07	-0.15	0.32*	0.39*	0.16	0.12					
UC	-0.18	-0.02	-0.11	-0.07	-0.06	0.04	0.02	0.68*				
TY	0.66*	0.09	-0.49*	0.17	-0.22*	0.11	0.11	0.42*	0.06			
ADY	0.22*	0.02	0.02	0.43*	0.11	0.25*	0.04	0.08	0.58*	-0.11		
LL	-0.44*	-0.40*	-0.79*	0.13	-0.02	0.13	0.25*	0.13	0.04	0.08	-0.29*	

**: p<0.05; Keys: BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days).*

Table 6. Stepwise linear regression of morphometric and milk traits pooled for all breeds and within breeds

Breed	Dependent variable	Prediction equations	R^2 %
Overall	TY	-1054.67+22.70BW+62.22BL+10.44CW-8.11HG-21.20Rumwi+27.21TL+19.70RUH+156.04ADY+42.22LL	87.16
Bunaji	TY	3701.88-83.82BL-10.70HG-24.30Rumwi	70.43
Friesian X Bunaji	TY	2981.87+30.88HW+10.88ADY	76.24
Gudali	TY	703.22+44.57RUH	62.06

BW: Body weight (Kg); BL: Body Length (Cm); HW: Height at withers (cm); CW: Chest width (cm); HG: Heart Girth (cm); Rumwi: Rump width (cm); TL: Teat Length (cm); RUH: Rear Udder Height (cm); UC: Udder Circumference (cm); TY: Total Yield (Litres); ADY: Average Daily Yield (Litres/day) and LL: Lactation Length (days)

to the claim by Okpeku et al. [10] that generally the Gudali is a relatively poor milker compared to the White Fulani and the other important Zebu breeds in this region. This could be explained by the claim that the range in milk yield and lactation length of the Gudali indicates substantial variation in these traits unlike the Bunaji and their crosses for whose selection efforts have been intensified. These figures point to the opportunity for genetic improvement of milk traits through stringent selection.

In this study, BW and BL were only significantly and positively correlated with BL when pooled for all breeds and in the Gudali, the estimate was low, this observation may not be unconnected with the report that the Bunaji is generally taller and narrower-bodied than most European cattle breeds [10]. They are fairly medium to large size, with a well-balanced body of good depth and width, this general shallowness of the body and lack of width give the animal a "leggy" appearance. This characteristic of the breed has been described as an adaptation to long distance trekking [11]. The Gudali is generally long with well-balanced and relatively compactly built animal possessing deeper and wider body than the Bunaji, so that every increase in length will lead to increase in body weight in the Gudali. The pooled correlation revealed a strong positive and negative correlation between body morphometrics and milk productivity traits, however this trend was not observed to be so within breeds and this may have been due to the relatively low sample size employed per breed. The varying positive estimates of inter-correlatedness among traits for pooled data could be attributed to the fact that postnatal growth does not take place proportionally in all tissue categories and body regions. Instead, it gives preference in the different growth phases to particular tissue types or body regions within those tissue categories [12] since variations in age of sampled animal was not taken into cognizance to ensure uniformity of sample. Observed negative correlation between certain morphometric traits both in the pooled and individual breed correlations were at variance with the observations of [12] in goat breeds, [13] in the white Fulani cattle. This trend indicates that selection on the basis of any of these traits will lead to a decrease in its associated trait. The non-uniformity of animals used with respect to age, differences in source of animal amongst others may give plausible explanation for this trend. Oke and Ogbonnaya [14] and Alsiddig et al. [15] showed that as age advanced coefficients of determination decreased while residual mean square increased. Also, Baffour-Awuah et al. [16] reported this trend in Kanni Adu kids under farmers management in Southern part of India. These observations may however be connected with the body condition score of the animals employed in this study which was not studied as animals could be tall or long but weigh less than stockier animals. Relationship of linear conformation traits with body weight body, condition score and milk yield in Friesian X Bunaji cows were positive indicating that taller, wider, deeper and fatter cows tended to be heavier [17] and it has been stated that the magnitude of the coefficient reflects active or passive growth at different age group in the species [18].

Observed constancy of BL, HG, Rumwi, HW, ADY and RUH as major predictors in the regression equations pooled for all breed and within individual breed partly agrees with the report of Rege [19] that body lengths, width at shoulder and heart girth were significant predictors. However, the superiority of heart girth over other linear body measurements has been reported by other workers for growth targets [20].

This is not unexpected considering the high environmental sensitivity of heart girth. In this study however, BL appear to be superior to HG in influencing total milk yield. It should be noted that clear breed distinctions observed for major predictors across the breeds for total milk yield indicates differences in breed based on growth and development of body parts, so that programmes designed for selection and cross breeding must take this into recognition. The rump at udder height was the only predictor noted for influencing total yield in the Gudali, this may be a pointer to the fact that the udder of the Gudali is seemingly poorly attached unlike the Bunaji's that is fairly well-developed, is of good shape and is strongly attached with teats that are well positioned and are of medium to reasonably large size [21].

5. CONCLUSIONS

It is concluded that body and milk production traits of the three studied population indicating clear breed distinction. It was noted that the Gudali was superior to the Bunaji in most of these traits. High genetic variations observed through growth and milk production indicates the need of devising an appropriate breeding strategy and selection towards milk improvement for indigenous cattle.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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