GENETIC EVALUATION OF LINEAR UDDER AND BODY CONFORMATION TRAITS IN BUNAJI COWS

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ABSTRACT

Genetic parameters for conformation traits of Bunaji cows are presented in this study. Data from 50 Bunaji cows collected between 2007 and 2008 at the Dairy Research Farm, National Animal Production Research Institute (NAPRI), Shika, Zaria was used. Analyzed conformation traits includes 7 body conformation traits: stature (ST), chest width (CW), wither height (WH), heart girth (HG), body length (BL), body depth (BD), rump width (RW) and 7 udder conformation traits: rear udder height (RUH), rear udder width (RUW), udder depth (UD), udder cleft (UC), fore teat position (FTP), rear teat placements (RTP) and teat length (TL), both of which were measured in centimeter (cm) using measuring stick and flexible tape. The measurements were taken monthly by 3 evaluators for the complete lactation length of the cows, this resulted in 1200 cumulative records, The estimated h2 of the linear conformation traits were between 0.203 (UD) and 0.621 (HG). The genetic correlations amongst the body conformation traits ranged from 0.116 to 0.992 while the phenotypic correlation ranged from 0.187 to 0.743. The genetic and phenotypic correlations amongst the udder conformation traits varied between – 0.538 to 0.352 and -0.257 to 0.325, respectively. The observed higher magnitude of genetic correlations than the phenotypic correlations for most of the conformation traits, coupled with the high heritability and repeatability estimate indicates that most of the conformation traits are influenced more by genetic factors rather than environmental factors; hence they can be improved with high degree of certainty through selection.

Keywords: Bunaji cow, Genetic traits evaluation, Body conformation, Udder conformation, Genetic factors

INTRODUCTION

Cow's evaluations are of much value for choosing outstanding dams of sires for progeny testing. Most of these evaluations involve linear measurements for both udder and body conformation traits. Conformation is the externally visible or measurable variations in shape and appearance or body proportions of the animals (Legate and Warwick, 1990). Since these conformation traits have genetic component they may be subjected to selection, a few traits relating to the conformation of the cow affect her life time production (Wattiaux, 2002). Therefore, linear conformation evaluation is very important in animal breeding; primarily, because it allows more accurate evaluation of dairy cattle. These evaluations can then be statistically translated into breeding values for both bulls and cows, and dairy breeders can utilize these breeding values much like they use PTAs (Predicted Transmitting Abilities) for production traits and these can therefore, help in breeding a more profitable herd through selecting better bulls and cows.

Although several studies had been conducted to objectively evaluate the use of linear measurements in estimating live weight of local breeds of cattle in Nigeria (Orheruata and Olutogun, 1994; Akpa *et al.,* 1998; Alade *et al.,* 1999) there is however, scanty information on the genetic values of linear udder and body conformation traits and the relationship between them. This information is necessary in the formulation of programmes for selection and improvement of dairy cattle and in predicting the direct and correlated responses due to selection. Since one trait in animal is often associated with others, it may there fore be necessary to consider more than one trait for selection and improvement at a time. The interaction between genotype and phenotype determines the productivity of an animal; hence phenotypic and genetic indices are useful in selection programmes (Chineke and Owosangba, 1999). Of equal importance too, is the need for reliable estimates of genetic parameters, such as; heritability of the traits and the correlations (particularly genetic correlation) between them. Therefore, this study was conducted with the aim of estimating the genetic and phenotypic parameters for linear udder and body conformation traits in Bunaji cows.

MATERIALS AND METHODS

Study Site: The study was conducted between 2007 and 2008 at the dairy herd of the National Animal Production Research Institute (NAPRI) Shika, Nigeria, located between latitude 110 and 120N at an altitude of 640m above sea level, and lies within the Northern Guinea Savannah zone (Oni *et al.,* 2001). The mean annual rainfall in this zone is 1,100m which commence from May and last till October, of which 90% falls during the wet rainy season (June – September). Following the wet season is a period of dry, cool weather called harmattan, which marks the onset of the dry season, this extends from mid – October to January. The dry season (February – May) is characterized by very hot weather conditions. At this period daily temperature range from 21^{o}C to 36^{o}C, the mean relative humidity is 21 and 72% during "harmattan" and the rainy season respectively (Malau-Aduli and Abubakar, 1992).

Animal Management: A total of 50 Bunaji cows were used for this study. The animals were raised during the rainy season on both natural and paddock–sown pasture, while hay or silage supplemented with concentrate of cotton seed cake, were offered during the dry season. They had access to water and salt lick *ad-libitum.* They were maintained on paddock according to sex and physiological status (i.e. open herd, pregnant herd etc). Unrestricted grazing was allowed under the supervision of the herdsmen for about 7 – 9 hour per day. Routine spraying against ticks and other ecto-parasites was observed, while vaccination was carried out against endemic diseases.

Genetic Evaluation: The cows were artificially mated using artificial insemination (AI) techniques and were checked 30 days later for non-return (conception). Following parturition, udder and body conformation traits were measured monthly for the complete lactation period of the cows, commencing 3 – 4 days post-partum. The measurements were taken by three evaluators for the complete lactation period of the cows. Each evaluator was able to take only 8 repeated measurements on each of the cows due to there relative short lactation length, (average 250 days). The data collected by the three evaluators from the 50 cows resulted in the creation of 1200 cumulative record (8 x 50 x 3 = 1200). All measurements were taken immediately before the morning milking of cows while locked in the milking parlour.

Fourteen (14) linear conformation traits were measured. This include: Seven (7) traits which described the udder conformation {rear udder height (RUH), rear udder width (RUW), udder-hock distance (UD), udder cleft (UC), fore teat position (FTP), rear teat placements (RTP) and teat length(TL)} and the other seven (7) traits {stature (ST), chest width (CW), body depth (BD), withers-height (WH), heart–girth(HG), body length(BL), rump width(RW) } that described the body conformation. The measurements were taken in centimeters (cm) using measuring stick and flexible tape (Boisot *et al.,* 2002; IHFA, 2011). The detailed measurements and definitions of the traits are presented (Table 1).

Data Analysis: The data collected were subjected to standard statistical analysis. The means and standard deviations were determined for each trait. The coefficient of variation (CV) was calculated as the standard deviation divided by the mean multiply by 100. The heritability (h^2) of the traits was estimated using sire component variance method as describe by Cameron (1997).

$$h^2 = \frac{4\delta_s^2}{\delta_s^2 + \delta_e^2}$$

Where, δ_s^2 = sire variance; δ_e^2 = error variance. The repeatability estimates were obtained using the formula as described by Cameron (1997).

$$R = \frac{\delta_b^2}{\delta_b^2 + \delta_w^2}$$

Where, δ_b^2 = between group variance; δ_w^2 = within group variance; R = Repeatability. The standard errors of the estimates were calculated as thus;

$$SE(R) = \frac{\left[(1-R)^2\right]\left[1+(K-1)R\right]^2}{K(K-1)(N-1)}$$

Where, K = number of records per animal; N = number of individuals in the population; R = estimated repeatability of a trait. The genetic correlations were estimated using the corresponding (Co) variances as described by Cameron (1997). The genetic (Co) variances were combined to estimates the genetic correlations among the traits as follow:

$$r_A(xy) = \frac{\delta_A(xy)}{\sqrt{\delta_{A(x)}^2 \delta_{A(y)}^2}}$$

Where: rA(xy) = Genetic correlations between x and y, $\delta_A^2(xy)$ = Additive genetic co variance between x and y, and $\delta_{A(x)}^2, \delta_{A(y)}^2$ = Additive genetic variance of x and y respectively.

RESULTS

Phenotypic Means and Coefficients of Variation (CV) of Udder and Body Conformation Traits: Of all the linear conformation traits analyzed, the largest genetic variation existed for the udder conformation traits, the CV for the udder conformation traits ranged from 9.71% to 25.41%. While the CV for the body conformation traits ranged from 2.31% to 7.88%. Teat placement (FTP and RTP) presented the largest genetic variability among the conformation traits (19.44 – 25.41%) (Table 2).

Heritability (h^2) and Repeatability Estimates: Regarding the linear conformation traits measured, the h^2 was between 0.203 (UD) and 0.621 (HG). However, the most heritable body measurement was HG (0.621) while udder cleft (UC) was the most heritable udder trait (0.482). The least heritable body conformation trait was BD (0.271), while the least heritable udder conformation trait was UD (0.203). Generally, the h^2 estimates of the body related traits were higher than those of the udder related traits (Table 3). The repeatability of the measurements of linear conformation traits varied between 0.778 (CW) to 0.961 (HG) for linear body conformation traits and 0.456 (TL) to 0.905 (RTP) for linear udder measurements. The most repeatable udder and body conformation traits were RTP (0.905) and HG (0.961), respectively.

Genetic and Phenotypic Correlations: The linear conformation traits measured were divided into two groups reflecting traits measured on a similar part of the body, that is, traits measured from the udder and traits measured from the body of the animals. First, correlation was described within these groups of traits, subsequently; the correlation between traits in different groups was described.

Genetic and Phenotypic Correlations amongst the Body Conformation Traits: The genetic and phenotypic correlations were positive, with the genetic correlations being generally higher in magnitude than the phenotypic correlations, but had similar direction of relationship. However, the higher genetic and phenotypic correlations were observed between stature and all the other body related traits, although the single strongest genetic correlation was between ST and HW (0.992). Also, the highest phenotypic correlation was between ST and HG (0.743) (Table 4).

Table 1: Detailed measurements for genetic evaluation of udder and body conformation traits in Bunaji cows (Fisher, 1976; IHFA, 2011)

No	Measurements	Abbreviation	Description	Equipments
1	**Stature**	ST	Measured from top of the spine in between hips to ground	Measuring stick
2	**Height-at-withers**	HW	Highest point over the scapulae vertically to the ground or measured from the highest point on the dorsum of the animal to the ground surface at the level of front legs.	Measuring stick
3	**Heart Girth**	HG	Measured as a circumference of the body at a point immediately behind the fore legs, perpendicular to the body axis	Flexible tape
4	**Chest width**	CW	Measured from the inside surface between the top of the front legs.	Flexible tape
5	**Body depth**	BD	Distance between the top of spine and bottom of barrel at last rib, the deepest point independent of stature.	Flexible tape
6	**Body length**	BL	Measured from the point of shoulder to the ischium.	Flexible
7.	**Rump width**	RW	The distance between the most posterior point of pin bones	Flexible tape
8	**Rear udder height**	RUH	The distance between the bottom of the vulva and the milk secreting tissue, in relation to the height of the animals.	Flexible tape
9	**Rear udder width**	RUW	Determined by the width of the udder from the maximum dimension	Flexible tape
10.	**Udder depth (udder-hocks distance)**	UD	The distance from the lowest part of the udder floor to the hock or distance between rear attachment	Flexible tape
11	**Udder cleft (central ligament)**	UC	The depth of cleft, measured at the base of the rear udder	Flexible tape
12	**Rear Teat Position**	RTP	The position of the rear teat from centre of quarter	Flexible tape
13	**For teat placement**	FTP	The position of the front teat from central of quarters	Flexible tape
14	**Teat length**	TL	The length of the front teat	Flexible tape

Genetic and Phenotypic Correlations amongst Udder Conformation Traits: Generally, correlations amongst the udder conformation traits were negatively weak. Although there were some few exceptions, the most noticeable ones were the high genetic correlations observed between RTP and UC (0.911). Apart from these exceptions and a few others; most genetic correlations amongst the udder conformation traits were weak, indicating some high level of independence amongst the traits. The genetic and phenotypic correlations varied between – 0.538 to 0.352 and -0.257 to 0.325, respectively, hence the magnitude of the genetic relationship was stronger than that of the phenotypic. The highest genetic correlation amongst the udder conformation traits was between RUW and UC (-0.538) (Table 5).

Genetic and phenotypic correlations between udder and Body Conformation traits: The genetic and phenotypic correlations between the udder and body conformation traits ranged from negative to positive; -0.572 to 0.680 and -0.234 to 0.498, respectively. Generally, the genetic correlations were higher than the phenotypic correlations. Rear udder height and rear teat placement were positively

Table 2: Means and coefficients of variation (CV) of udder and body conformation traits of Bunaji cows

Traits (cm)	Mean	CV	Min	Max
Body conformation traits				
Stature (ST)	127.40 ± 0.37	4.18	118.00	140.00
Chest Width (CW)	22.12 ± 0.12	7.88	18.00	26.00
Body Depth (BD)	100.65 ± 0.31	4.53	93.00	112.00
Height at withers (HW)	124.20 ± 0.65	7.56	112.00	137.00
Heart Girth (HG)	172.34 ± 0.75	6.28	154.00	199.00
Body Length (BL)	120.13 ± 0.19	2.31	114.00	126.00
Rump Width (RW)	17.61 ± 0.84	6.89	14.00	21.00
Udder conformation traits				
Rear Udder Height (RUH)	18.48 ± 0.17	13.41	13.00	26.00
Rear Udder Width (RUW)	18.83 ± 0.13	9.71	14.00	25.00
Udder Depth (UD)	15.09 ± 0.15	14.69	8.00	19.00
Udder Cleft (UC)	2.22 ± 0.02	14.55	2.00	3.00
Rear Teat Placement (RTP)	5.18 ± 0.09	25.41	3.00	9.00
Fore Teat Position (FTP)	8.64 ± 0.12	19.44	5.00	15.00
Teat Length (TL)	4.62 ± 0.61	19.26	3.00	8.00

Table 3: Mean heritability (h^2) and repeatability (γ) estimates for udder and body conformation traits of Bunaji cows

Traits	h^2	γ
Body conformation traits		
Stature (ST)	0.368 ± 0.03	0.910 ± 0.08
Chest Width (CW)	0.551 ± 0.05	0.778 ± 0.18
Body Depth (BD)	0.271 ± 0.03	0.854 ± 0.13
Height at withers (HW)	0.388 ± 0.04	0.787 ± 0.18
Heart Girth (HG)	0.621 ± 0.05	0.961 ± 0.04
Body Length (BL)	0.365 ± 0.03	0.957 ± 0.18
Rump Width(RW)	0.617 ± 0.05	0.930 ± 0.07
Udder conformation traits		
Rear Udder Height (RUH)	0.355 ± 0.03	0.841 ± 0.16
Rear Udder Width (RUW)	0.406 ± 0.04	0.675 ± 0.22
Udder Depth (UD)	0.203 ± 0.04	0.835 ± 0.14
Udder Cleft (UC)	0.482 ± 0.02	0.535 ± 0.26
Rear Teat Placement (RTP)	0.509 ± 0.03	0.905 ± 0.09
Fore Teat Position (FTP)	0.213 ± 0.03	0.484 ± 0.26
Teat Length (TL)	0.213 ± 0.03	0.456 ± 0.16

Table 4: Genetic (above diagonal) and Phenotypic (below diagonal) correlations in body conformation traits in Bunaji Cows

Traits	ST	CW	BD	HW	HG	BL	RW
Stature (ST)		0.873	0.972	0.992	0.91	0.989	0.297
Chest Width (CW)	0.277		0.724	0.803	0.347	0.938	0.490
Body Depth (BD)	0.635	0.196		0.860	0.79	0.777	0.175
Height at withers (HW)	0.603	0.181	0.377		0.857	0.788	0.259
Heart Girth (HG)	0.743	0.266	0.493	0.498		0.746	0.289
Body Length (BL)	0.443	0.487	0.187	0.287	0.459		0.116
Rump Width(RW)	0.517	0.22	0.416	0.349	0.65	0.284	

Table 5: Genetic (above diagonal) and phenotypic (below diagonal) correlations in udder conformation traits in Bunaji cows

Traits	RUH	RUW	UD	UC	RTP	FTP	TL
Rear Udder Height (RUH)		0.168	-0.404	0.352	0.069	0.014	0.246
Rear Udder Width (RUW)	0.031		-0.184	-0.538	-0.196	-0.296	0.267
Udder Depth (UD)	-0.036	-0.017		-0.210	0.027	-0.030	0.105
Udder Cleft (UC)	0.151	0.004	-0.173		0.221	-0.080	-0.347
Rear Teat Placement (RTP)	0.089	0.004	-0.257	0.229		0.333	-0.106
Fore Teat Position (FTP)	0.007	0.144	-0.04	-0.038	0.325		-0.168
Teat Length (TL)	0.130	-0.146	-0.007	0.114	-0.184	0.006	

Table 6: Genetic and phenotypic (in parentheses) correlations between udder and body conformation traits in Bunaji cows

Traits	ST	CW	BD	HW	HG	BL	RW
Rear Udder Height (RUH)	0.680	0.293	0.625	0.662	0.544	0.636	0.023
	(0.498)	(0.271)	(0.462)	(0.322)	(0.502)	(0.197)	(0.496)
Rear Udder Width (RUW)	0.302	0.367	-0.464	0.303	0.283	0.031	0.304
	(0.054)	(-0.021)	(0.182)	(0.125)	(0.089)	(0.230)	(0.167)
Udder Depth (UD)	0.144	0.007	0.110	-0.177	-0.422	0.332	0.304
	(0.159)	(0.159)	(0.070)	(0.121)	(0.231)	(0.163)	(0.141)
Udder Cleft (UC)	0.568	-0.035	0.416	0.498	0.419	0.453	0.076
	(0.222)	(0.077)	(0.210)	(0.176)	(0.226)	(0.215)	(-0.082)
Rear Teat Placement (RTP)	0.457	0.117	0.281	0.415	0.509	0.533	0.141
	(0.35)	(0.017)	(0.155)	(0.238)	(0.544)	(0.403)	(0.408)
Fore Teat Position (FTP)	-0.182	-0.572	-0.262	-0.234	0.268	0.117	0.247
	(-0.109)	(-0.215)	(0.187)	(-0.016)	(-0.097)	(-0.047)	(0.186)
Teat Length (TL)	-0.136	0.528	0.220	-0.174	-0.239	-0.026	-0.001
	(-0.234)	(0.269)	(0.347)	(-0.206)	(-0.268)	(-0.052)	(-0.159)

ST = Stature, CW = Chest Width, BD = Body depth, HW = Height at Withers, HG = Heart Girth, BL = Body Length, RW = Rump Width

correlated with all the body conformation traits. Some few traits like RUH (0.023), UC (0.076) and TL (-0.001) were hardly correlated with RW, also CW was hardly correlated with UD (0.007) and UC (-0.035). Apart from these exceptions, most of the genetic correlations were moderately strong (Table 6).

DISCUSSION

The high coefficient of variation observed for the udder conformation traits may be due to the high individual variability in the udder morphological traits of the animals used and was reflected in the measurements of the udder traits. However, teat placement (FTP and RTP) was the trait that presented the largest variability amongst the udder conformation traits considered. This was important because teat placement must be adapted to machine milking (Serrano *et al.,* 2002). The high variability of the udder conformation traits, indicated the possibility of improving these traits through selection (Chu and Shi, 2002).

Heritability and Repeatability of Conformation traits: The estimated heritability and conformation traits varied from 0.213 to 0.582 and are within the estimates of some previous studies (Ducrocq, 1993; Wiggans *et al.,* 1995; Veerkamp and Brotherstone, 1997; Gengler *et al.,* 1999; Pryce *et al.,* 2001; Veerkamp *et al.,* 2001; Yazdi *et al.,* 2002; Kadarmideen and Wegmann, 2003; Berry *et al.,* 2005; De Haas, 2007). Although there were some few exceptions and the most noticeable ones are HG (0.621) and RW (0.617) which were much higher than the estimated heritability and conformation traits in literatures (Ducrocq, 1993; Wiggans *et al.,* 1995; Veerkamp and Brotherstone, 1997; Gengler *et al.,* 1999; Pryce *et al.,* 2001; Veerkamp *et al.,* 2001; Yazdi *et al.,* 2002; Kadermideen and Wegmann, 2003; Berry *et al.,* 2005; De Haas, 2007). This may be due to differences in the methods of measurements and estimation procedures. In this study, traits were measured objectively, using measuring instruments as opposed to the usual subjective assessment by visual appraisals. Our findings in this study that udder and body conformation traits had moderate to high heritability was in agreement with earlier studies (Yazdi *et al.,* 2002; Kadarmideen and Wegmann, 2003; Berry *et al.,* 2005; De Haas, 2007). The estimated moderate to high h^2 for the conformation traits implied that, these traits were heritably enough to yield significant progress from selection, and can therefore be included in the selection indices as direct or correlated traits. The corresponding heritability and repeatability estimates obtained for conformation traits in this study, conformed to the genetic principals that repeatability sets an upper limit for heritability estimate (Odubote, 1996). In this study repeatability estimates were used to evaluate precision and accuracy for alternative objective measurements of linear udder and body conformation traits by the three evaluators. The advantage of this method was that unbiased data for conformation traits can be provided to dairy producers, and measurements were taken at a relatively lower cost with high relative accuracy and consistency. Although the high variability in the udder conformation traits might be partly attributed to the physiological changes that may have occurred in the milk secreting organs (udder) within the lactation length, probably as a reflection of milk production levels of the cows across the seasons (Alphonsus *et al.,* 2009). However, difficulty in taking accurate measurements on the soft tissue may have contributed to the high variability in the udder conformation traits. The body conformation traits had low variability (high repeatability) within the lactation length, probably due to the fact that, all the measurements taken on the body conformation traits were closely related to bone structure of the cows and since most of the cows used in this study were matured, it is reasonable to assume that the bone structure of an adult cow may not change significantly within one lactation length (Alphonsus *et al.,* 2009). This was in line with the reports of Brown *et al.* (1956) and Orheruata (1994) that 40 – 50% of skeletal structure of cows matures at birth and skeletal growth ceases at 30 – 40 month of age.

Relationships Amongst and Between Udder and Body Conformation Traits: The favourable relationship that existed amongst the body conformation traits agreed with the previous reports by Ducrocq (1993), Gengler *et al.* (1999) and De Haas *et al.* (2007). The strong genetic correlations indicated a high level of dependency amongst the body conformation traits. This implied that at any increase in one of these traits a corresponding increase is expressed in the others, therefore, selection for one of these traits will result in a correlated response in the other traits (Thiruvenkadan, 2005; Hamalayun *et al.,* 2006), hence it may not be necessary to incorporate all these traits in a selection index aim at improving the body conformation of cows. However the values of the correlation coefficient varied with different measurements, indicating a variation in the strength of the relationships amongst the various body measurements of the animals. The observed higher magnitude of the genetic correlations than the phenotypic correlations in most of the body conformation traits is an indication that these traits are influenced more by genetic factors rather than environmental factors.

The genetic and phenotypic correlations amongst the udder conformation traits were generally weak and negative and were similar to the reports of Ducrocq (1993), De Lafuente *et al.* (1996) and Gengler *et al.* (1999). The weak relationship amongst the udder conformation traits indicated the existence of some degree of independence among the traits, thus making it necessary to include some of these traits in the selection index aimed at improving the udder conformation of the cows.

Conclusion: The observed higher magnitude of genetic correlations than the phenotypic correlations for most of the conformation traits, coupled with the high heritability and repeatability estimate indicated that most of the conformation traits are influenced more by genetic factors rather than environmental factors; hence they can be improved with high degree of certainty through selection.

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