Developing New Indicator Traits for Selection for High Milk Yield of Indigenous Dual-purpose Cows in Hot-Humid Environment, Ghana

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Abstract: Records on association of milk yield and morphological traits, particularly, parts distal to the knee/hock joints (fore/hind shank length and circumference) in dual-purpose cows are hardly available. This makes selection for milk yield potentials in favour of these traits difficult. This study was conducted to assess the relationship between average milk yield (AvMY) and morphological traits (MT) of on-farm dual-purpose cows of hot humid environment in Ghana and to determine the best MT predictor of AvMY. Three hundred and eighty-four (384) cows were purposively selected for measurement of association between AvMY and MT in 20 farms from April, 2015 to July, 2017. Analysis of data revealed that, phenotypic correlations between AvMY and MT (i.e., head length, horn length, horn tip spacing, and muzzle circumference) were low (0.14 to 0.24) whilst that of heart girth, ear length, tail length and pelvic width were medium (0.34 to 0.46). High correlations were observed among AvMY, body length, body height at withers, height at rump, hock circumference, and fore/hind-shank length and circumference (0.50 to 0.84). The best predictor of AvMY was the hind-shank circumference, followed by the fore-shank circumference, hind-shank length, fore-shank length, and hock circumference in descending order. It was concluded that, there were association between AvMY and MT. Breeders and producers should consider fore- and hind-shank circumference and length when selecting for improvement in AvMY potential.
[Coffie, I., Annor, S. Y., Kagya-Agyemang, J. K., Annan-Prah, A. and Seidu, H. **Developing New Indicator Traits for Selection for High Milk Yield of Indigenous Dual-purpose Cows in Hot-Humid Environment, Ghana.** *Life Sci J* 2018;15(8):39-44]. ISSN: 1097-8135 (Print) / ISSN: 2372-613X (Online). http://www.lifesciencesite.com. 6. doi:10.7537/marslsj150818.06.

Keywords: Relationship between traits, dual-purpose cows, fore/hind-shank circumference, milk yield, morphometric traits.

1. Introduction

Dual purpose cattle contribute to the diverse animal genetic resources in the tropical developing world. In Ghana, these breeds of cattle play a key role in economic development of the rural and peri-urban areas. Many lives in rural areas depend on the meagre milk produced by these cows which is usually shared between herdsmen and calves. Sustainable management and improvement of the dual-purpose cattle are important because of the multiple benefits offered by the breeds (Barnes *et al.,* 2012), including milk production, disease resistance and acclimatization to harsh climatic condition. Adaptation of these cattle to hot humid environment could be due to their genetic and morphological characteristics. According to FAO (2012), a good understanding of breed characteristics, especially morphological traits, is necessary to guide decision-making in livestock development and breeding programmes.

It is well documented that breed and non-genetic factors affect milk productive potentials of the dual-purpose cattle (Aboagye 2002; Coffie *et al*., 2015). However, little is known about influence of their morphological features on milk production traits of these cows. Even where assessment of body measurements and productive traits have been done (Yanar *et al*., 2000; Musa *et al.*, 2011), parts distal to the knee and hock of the limbs, shank length and circumference, have been given a little attention. Although, the usefulness of morphological traits is mostly centred on differentiation, classification and identification of species/breeds or indications for assessment of sexual differences (Lindenfors *et al.,* 2007), the traits could be associated with various productive characteristics (FAO, 2012). Morphometric traits also play a key role in evaluation of the goals of a breeding programme (Zechner *et al.,* 2001; FAO 2012). Therefore, estimation of association between average partial milk yield and morphological traits of local cows could serve as a guide for selecting an economic trait and aid in future breeding programmes. The objectives of this study were to estimate relationship between average milk yield and morphological traits, and to determine the best morphological trait predictor of average milk yield in dual-purpose cows of hot humid environment in Ashanti Region, Ghana.

2. Materials and Methods

The study was conducted in five districts in Ashanti Region (Mampong municipal, Sekyere south, Ejisu–Juaben, Ejura– Sekyedumase and Atwima-Nwabiagya districts) from April, 2015 to July, 2017. Ashanti region lies within the hot humid zone of Ghana and it is located between longitudes 0° 9'W and 2° 15'W, and latitudes 5° 30'N and 7° 27'N. The region has a population density of 148.1 persons per square kilometre. More than half of the region lies within the wet, semi-equatorial forest zone. Bushfires during the dry season has reduced the forest vegetation of parts of the region, to savannah, particularly the north-eastern portion. The region has an average annual rainfall of 1270 mm and two rainy seasons. The major rainy season starts from April to July. The minor rains occur in August to November. December to March is dry, hot, and dusty. The average daily temperature is about 27°C (Ghana Districts 2006). Much of the region is situated between 150 and 300 metres above sea level (Ghana Districts 2006). The common forage species grazed in the rangeland include elephant grass (*Pennisetum purpureum*), guinea grass (*Panicum maximum),* Centro (*Centrocaema pubescens),* giant star grass (*Cynodon plectostachyus*), *Andropogon gayanus*, *Panicum minimum* and Carpet grass (*Axonopus sp.*).

Cross–sectional survey was used to obtain data on morphological traits and milk yield of dual-purpose cows. Purposive sampling technique was used to sample three hundred and eighty-four (384) cows on the basis of their lactation. These cows were kept under farmers own management practices as described in Coffie *et al*. (2015). A summary of the structure of descriptive statistics of data is presented in Table 1. Milk yield was measured (once a day—partial milking) in litres using 800 ml (0.8 litre) graduated beaker. Hand milking was used. All morphological traits (MT) were measured in centimeters (cm) (Plate 1). The MT and how they were measured are described as follows:

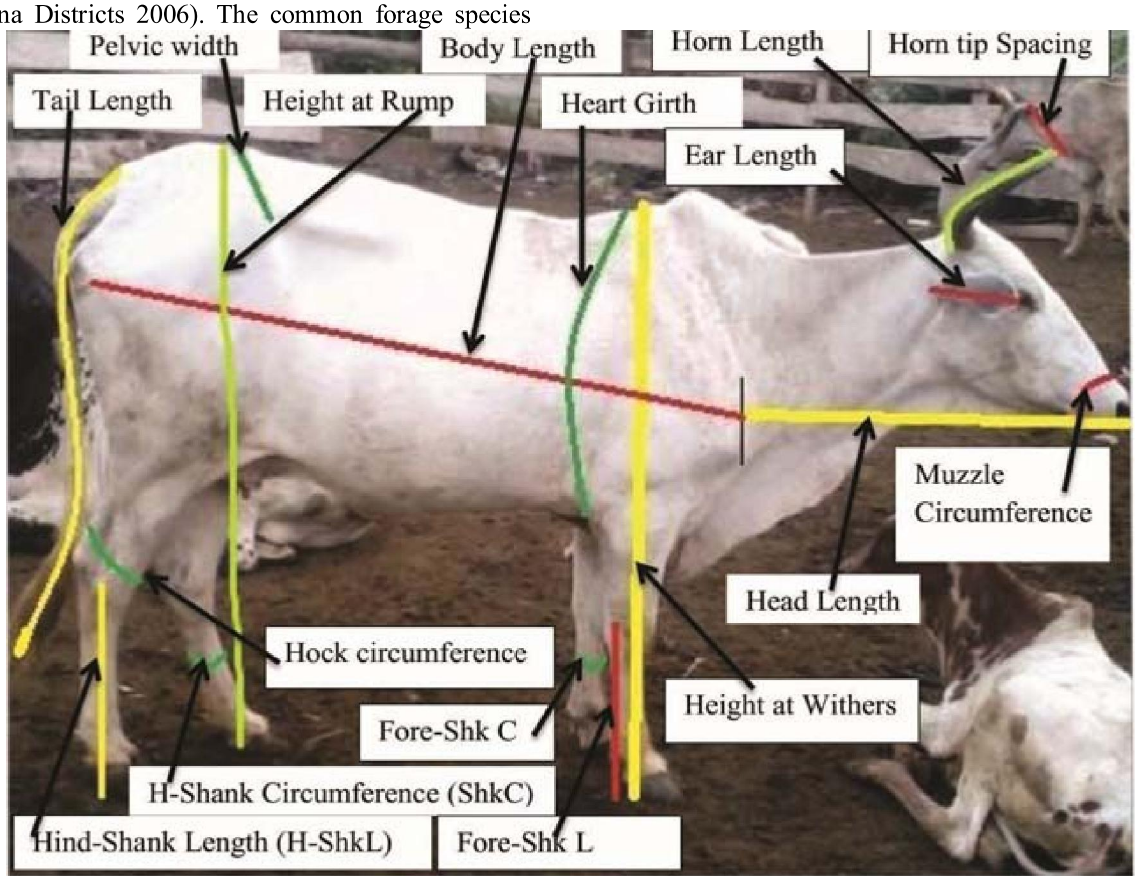

Plate 1. Morphometric measurement of Indigenous dairy/dual-purpose cow.

1. Body length (BL): Body length was measured from point of shoulder (greater tubercle corresponding to the outer central tuberosity) to pin bone (tuber ischii).

2. Heart/Chest Girth (HG): This was measured and recorded as the circumference of the chest immediately posterior to the fore limbs at right angle to the body axis.

3. Head Length (HL): It was measured as the distance from the pre-scapula or tuberosity to the naso-labial plane of muzzle.

4. Body height at withers (BHW): This was measured as the distance from the withers to the ground level.

5. Body height at rump (BHR): This was the height measured from the apex of the rump at the sacral region along the hind limb to the ground.

6. Pelvic Width (PW): It was the broadest points between right and left iliac branches of the hip–bone or the external distance between the most lateral points of the tuber coxae.

7. Horn length (HoL): It was measured from the base of the horn to its tip.

8. Horn tip spacing (HTS): it was measured as distance between the two horn tips.

9. Muzzle Circumference (MC): this was measured as the circumference, a little above the nostrils and around the point of muzzle.

10. Ear Length (EL): Ear length was taken by measuring from the base of ear to its tip.

11. Tail Length (TL): It was measured from the base (around the first caudal vertebra) of the tail to the tip of the tail switch.

12. Hock circumference (HC): This was considered as the circumference slightly above the point of hock.

13. Fore-shank length ($SHKL_F$): This was measured from the knee (carpus) to the distal to phalanx (hoof) at the ground level.

14. Fore-shank circumference ($SHKC_F$): It was also measured as circumference around the foreshank or metacarpus.

15. Hind-shank length ($SHKL_H$): This was measured as height from the hock joint to the ground level.

16. Hind-shank circumference ($SHKC_H$): This was measured as the circumference around the hind-shank or metatarsus.

Correlation between traits was estimated using SAS (2010). Correlations were classified as low (0.1 – <0.3), medium (≥0.3 – <0.5), and high (≥0.5 – 1.00) (Annor *et al*., 2012). Average milk yield was regressed on MT using regression analysis (SAS, 2010). The general simple linear regression equation used was:

$Y_i = \alpha + \beta X_i + e_i$

Where: Y_i = the dependent variable (Average milk yield—AvMY); α = the intersect or the value of Y_i when $X_i = 0$,; β = the coefficient of regression or the slope defined as the change in Y_i resulting from a unit change in X_i; X_i = the independent variable represented by BL, HL, HG, BHW, BHR, EL, HoL, HTS, MC, TL, PW, HC, $SHKL_F$, $SHKC_F$, $SHKL_B$ and $SHKC_B$; e_i = error term.

Results and Discussions

Means of milk yield and morphological traits are presented in Table 1. Average of milk yield (AvMY) value obtained in this study was comparable to 1.8, 2.0 and 2.3 litres reported on local breed by Annor (1996), Coffie *et al*. (2015) and Millogo *et al*. (2008).

Table 1. Basic statistics of average partial milk yield and Morphological Traits

Traits	N	Mean	Std Dev	Minimum	Maximum
AvMY (L)	384	2.01	0.86	0.50	4.50
BL (cm)	384	125.42	9.98	99.00	159.00
HL (cm)	384	64.15	7.45	33.00	97.00
HG (cm)	384	160.65	13.08	120.00	200.00
BHW (cm)	384	123.05	6.89	104.00	140.00
BHR (cm)	384	129.01	6.73	112.00	169.00
EL (cm)	383	20.55	2.82	12.00	26.00
HoL (cm)	381	31.02	11.25	4.00	71.00
HTS (cm)	353	43.12	16.24	13.00	120.00
MC (cm)	383	37.22	7.66	20.00	49.00
TL (cm)	384	99.69	12.90	40.00	140.00
PW (cm)	384	39.74	4.56	27.00	56.00
HC (cm)	384	33.96	2.11	26.00	44.00
$SHKL_F$ (cm)	384	36.65	4.03	28.00	46.00
$SHKC_F$ (cm)	384	16.00	1.17	14.00	19.00
$SHKL_H$ (cm)	384	42.01	3.98	29.00	49.00
$SHKC_H$ (cm)	384	17.39	1.27	15.00	20.00

AvMY=average milk yield; BL=body length; HL=head length; HG=heart girth; BHW=body height at withers; BHR=body height at rump; EL=ear length; HoL=horn length; HTS=horn tip spacing; MC=muzzle circumference; TL=tail length; PW=pelvic width; HC=hock circumference; $SHKL_F$ =fore-shank length; $SHKC_F$=fore-shank circumference; $SHKL_H$=hind-shank length; $SHKC_H$=hind-shank circumference; L=litres; cm=centimeters.

Kamal *et al*. (2009) however had 3.8 litres in local cows in India whilst Aboagye (2002) recorded 5.3 on the local cows on-station in Ghana. The differences observed in the AvMY in this study and the on-station farms reflect breed differences and management regimes. The low AvMY values on-farm are characteristics of local cows which trek long distances for their feed with little or no feed supplementation.

The means of morphological traits, especially, body height and length, obtained were lower than that of 128 and 141, respectively, reported by Rege (1999) and Aboagye *et al*. (1994). However, all means of MT fell within the ranges (minimum and maximum values) obtained in this study. The variations observed might be due to different breeds of cows used in this study. The present study used only cows, and according to Lindenfors *et al*. (2007), sexual dimorphism accounts for differences in many traits in mammals.

The relationship between AvMY and morphological traits is presented in Table 2. Among the phenotypic traits, the correlation coefficient values were all positive and ranged from low to high. Low ($p<0.01$) correlations were observed between AvMY and horn tip spacing, and muzzle circumference.

Table 2. Correlation Coefficient between average milk yield and Morphological Traits

	BL	HL	HG	BHW	BHR	EL	HOL	HTS
AvMY P-value	0.50 0.0001	0.24 <0.0001	0.37 <0.0001	0.53 <0.0001	0.61 <0.0001	0.34 =0.0000	0.20 <0.0001	0.14 =0.0069
	MC	TL	HC	PW	$SHKL_F$	$SHKC_F$	$SHKL_H$	$SHKC_H$
AvMY P-value	0.15 =0.0023	0.43 <0.0001	0.70 <0.0001	0.46 <0.0001	0.78 <0.0001	0.81 <0.0001	0.79 <0.0001	0.84 <0.0001

AvMY=average milk yield; BL=body length; HL=head length; HG=heart girth; BHW=body height at withers; BHR=body height at rump; EL=ear length; HoL=horn length; HTS=horn tip spacing; MC=muzzle circumference; TL=tail length; PW=pelvic width; HC=hock circumference; $SHKL_F$ *=fore-shank length;* $SHKC_F$*=fore-shank circumference;* $SHKL_H$*=hind-shank length;* $SHKC_H$*=hind-shank circumference; p-value=probability of mean effects.*

Table 3. Linear regression of average milk yield on morphological traits

TRAITS	EQUATION	R^2	PROBABILITY		
		(%)	Model	α	β
BL	-3.52 + 0.04X	24.5	<0.0001	<0.0001	<0.0001
HL	0.11 + 0.03X	5.6	<0.0001	0.7698	<0.0001
HG	-2.12 + 0.07X	14.1	<0.0001	<0.0001	<0.0001
BHW	-6.25 + 0.07X	27.7	<0.0001	<0.0001	<0.0001
BHR	-8.26 + 0.08X	37.5	<0.0010	<0.0010	<0.0010
EL	-0.28 + 0.10X	11.2	<0.0010	0.3690	<0.0010
HOL	1.38 + 0.02X	4.0	<0.0001	<0.0001	0.0001
HTS	1.53 + 0.01X	2.1	0.0069	<0.0001	0.0069
MC	1.22 + 0.02X	2.2	0.0030	<0.0010	0.0030
TL	-0.98 + 0.03X	18.2	<0.0001	0.0017	<0.0001
PW	-1.61 + 0.09X	21.3	<0.0001	<0.0001	<0.0001
HC	-7.87 + 0.29X	49.1	<0.0001	<0.0001	<0.0001
$SHKL_F$	-4.23 + 0.17X	60.2	<0.0001	<0.0001	0.0001
$SHKC_F$	-7.80 + 0.60X	65.4	<0.0001	<0.0001	<0.0001
$SHKL_H$	-5.32 + 0.17X	62.1	<0.0010	<0.0010	<0.0001
$SHKC_H$	-8.08 + 0.57X	71.0	<0.0001	<0.0001	<0.0001

BL=body length; HL=head length; HG=heart girth; BHW=body height at withers; BHR=body height at rump; EL=ear length; HoL=horn length; HTS=horn tip spacing; MC=muzzle circumference; TL=tail length; PW=pelvic width; HC=hock circumference; $SHKL_F$ *=fore-shank length;* $SHKC_F$*=fore-shank circumference;* $SHKL_H$*=hind-shank length;* $SHKC_H$*=hind-shank circumference.*

The low phenotypic correlations between the traits indicate little phenotypic association. In other words one trait could be less economically used as a selection criterion for the other trait (Annor *et al*., 2012). The association between AvMY and head length, and that of horn length were also low. Medium to high phenotypic association ($p<0.01$) obtained between AvMY and ear length, heart girth, tail length, pelvic width, body length, body height at withers, height at rump, hock circumference, fore-shank length, hind-shank length, fore-shank circumference and hind-shank circumference, in ascending order, denotes that any one of these traits could be used as a selection criteria or a measure for AvMY. Musa *et al.* (2011) also had similar positive correlations among milk yield, heart girth, body height and length in Kenana cows in Sudan.

The high positive correlation between morphological traits (hock circumference, fore-shank length, hind-shank length, fore-shank circumference and hind-shank circumference) and AvMY also indicates that any of them could be used to estimate AvMY. According to Annor *et al*. (2012) medium to high positive correlation could be used to predict other economic traits in farm animals. The current study also confirms the assertion that body measurements are proxy indicators of productive traits in farm animals (FAO, 2012).

Average milk yield could be predicted by considering the percentage variation accounted for (R^2 values) by morphological traits in expressing AvMY (Table 3). This study shows that, hind-shank circumference is the best predictor of average milk yield, followed by the fore-shank circumference. The shank circumference determines the size, the thickness and the firmness of shank. Therefore bigger shank circumference provides firm and strong shank for supporting cows during feeding, and in good posture for the general well-being of cows.

The $SHKL_H$ and $SHKL_F$ are also good predictors, followed by HC, BHR and BHW. Shank length contributes to the body height in farm animals. Bardakcioglu *et al*. (2015) observed that Holstein cows with higher body height had more milk yield than those with lower height. According to Holstein Foundation (2012), hock shape and the entire feet conformation play a crucial role in judging a good dairy cow.

Conclusion

It was concluded that, hind-shank circumference, fore-shank circumference, hind-shank length, fore-shank length, hock circumference, height at rump, body height at withers, body length, pelvic width, tail length, heart girth and ear length, in order of importance, could be used as a selection criteria for milk yield in dual-purpose cows. The best predictor of average milk yield was the hind-shank circumference, followed by the fore-shank circumference, hind-shank length, fore-shank length, and hock circumference in descending order. Therefore, breeders should consider fore- and hind-shank circumference and length when selecting for improvement of average (Mean) milk yield potential in the dual-purpose cows.

Acknowledgement:

The authors are very grateful to Dr. Zachariah Coffie and the entire Coffie family for providing fund for this study. Authors highly acknowledged Edulink II Project for support in Summer Schools and conferences in Kenya.

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References

1. Aboagye, G. S. (2002). Phenotypic and Genetic Parameters in Cattle Populations in Ghana. *International Livestock and Research Institute*. Retrieved 11/03/2013, from: http://agtr.ilri.cgiar.org/index.php?option=com_content & task=view & id=153 & Itemid=179.
2. Annor, S.Y., Ahunu, B.K., Aboagye, G.S., Boa-Amponsem K. and Cassady, J.P. (2012). Phenotypic and genetic parameter estimates for grasscutter production traits. 1. (Co) variance components and heritability *Global Advanced Research Journal of Agricultural Science,* 1(6): 148-155.
3. Bardakcioglu, H.E., Sekkin, S. and Toplu, H.D. (2011). Relationship between some teat and body measurement of Holstein Cows and subclinical mastitis and milk yield. *J. Anim. and Vet. Adv.* 10 (13): 1735-1737.
4. Barnes, K., Dion, S., Collins, T., Reynolds, H., Riess, S., Stanzyk, A., Wolfe, A., Lonergan, S., Boettcher, P., Charrondiere, U. R. and Stadlmayr, B. (2012). Importance of cattle biodiversity and its influence on the nutrient compostionof beef. *Animal Frontiers,* 2 (4):54–60.
5. Coffie, I., Annor, S. Y., Kagya-Agyemang J. K. and Bonsu, F. R. K. (2015). Effect of breed and non-genetic factors on milk yield of dual-purpose cattle in Ashanti Region, Ghana. *Livestock Research for Rural Development* 27 (07) 2015
6. Food and Agriculture Organisation (FAO), (2012). *Phenotypic characterization of animal genetic resources.* FAO Animal Production and Health Guidelines No. 11. Rome.
7. Holstein Foundation, (2012) *Dairy Judging workbook, Vol.2. Developing Dairy Leaders for Tommorrow*, USA. Retrieved May 4, 2016 from *www.holsteinfoundation.org*

8. Lindenfors, P., Gittleman, J. L. and Jones, K. E. (2007). Sex, size and gender roles: evolutionary studies of sexual dimorphism. In: Sexual dimorphism in mammals. D. J. Fairbairn, W. U. Blanckenhorn and T. Szekely (Eds.), Oxford University Press, Oxford, pp 19-26.
9. Musa, A.M., S.A. Mohammed, H.O. Abdalla and K.M., Elamin. (2011). Linear body measurements as an indicator of Kenana cattle milk production. *Online J. Anim. Feed Res.* 1(6): 259-262.
10. SAS (2010) User's Guide. SAS/STAT® 9.2, Cary, NC: SAS Institute Inc.
11. Yanar, M., Aydin, R., and Ugur, F. (2000). Relationships of body measurements with milk production traits in Brown Swiss cattle. *Ind. J. Dairy Sci*., 53: 444-447.
12. Zechner, P., Zohman, F., Solkner, J., Bodo, I., Habe, F. and Marti, E. (2001). Morphological description of the zipizzan horse population. *Livestock production science,* 69(2): 163-177.

8/17/2018