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Productivity and morphology of Ankole cattle in three livestock production systems in Uganda

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Summary

Phenotypic characterization is critical in breed improvement and conservation. To determine the performance and morphological features of Ankole cattle in three livestock production systems (LPS) of Uganda, 248 farms were studied. Height at withers (HW), heart girth (HG), body length (BL), ear length, horn length (HL), distance between horn tips (HS) and body weight (BW) were then measured on 120 bulls and 180 cows. Data were analysed using LPS (crop livestock, agropastoral, pastoral), county (Gomba, Kazo, Kiboga, Mawoggola, Nyabushozi) and sex (females, males) as main factors. In the results, age at sexual maturity was 23.6 ± 0.5 months for bulls and 22.7 ± 0.5 months for cows. Age at first calving was 33.2 ± 0.5 months, whereas calving interval was 12.9 ± 0.8 months. Lactation length differed between LPS (5.5 ± 0.4, 6.3 ± 0.3 and 7.4 ± 0.2 months in agropastoral, crop livestock and pastoral, respectively). Mean daily milk off take was 2.2 ± 0.1 kg/cow whereas preweaning calf survivability was 90.0 ± 6.5%. Sex and LPS significantly influenced HW, HL and HS. Positive correlations were observed between BW and HG, BL and HL. Correlation coefficients were much lower in females than in males, except for BW vs HG and BW vs HW. Results show wide variations both in performance and morphology suggesting that within breed selection scheme and/or management improvement may lead to productivity improvements.

Keywords: *morphometric, characterization, reproductive performance, Ankole cattle*

Résumé

La caractérisation phénotypique est fondamentale dans l'amélioration et la conservation de la race. Afin de déterminer la performance et les caractéristiques morphologiques des bovins Ankolé dans trois systèmes de production animale de l'Ouganda, on a entrepris des études dans 248 fermes. La hauteur au garrot, le périmètre thoracique, la longueur du corps, des oreilles et des cornes, la distance entre les pointes des cornes et le poids corporel de 120 taureaux et de 180 vaches ont été alors mesurés. On a ensuite analysé les données en utilisant comme facteurs principaux le système de production animale (mixte, agropastoral, pastoral), le district (Gomba, Kazo, Kiboga, Mawoggola, Nyabushozi) et le sexe (femelle, mâle). Les résultats ont été les suivants: l'âge à la maturité sexuelle était pour les taureaux de 23,6 ± 0,5 mois et pour les vaches de 22,7 ± 0,5 mois, l'âge à la première mise bas était de 33,2 ± 0,5 mois, tandis que l'intervalle entre les mises bas était de 12,9 ± 0,8 mois. La période de lactation variait selon le type de système de production (5,5 ± 0,4, 6,3 ± 0,3 et 7,4 ± 0,2 mois respectivement dans les systèmes agropastoral, mixte et pastoral). Le rendement moyen journalier de lait était de 2,2 ± 0,1 kg par vache tandis que la survie des veaux avant le sevrage était de 90,0 ± 6,5 pour cent. Le sexe et le système de production influençaient de façon significative la hauteur au garrot, la longueur des cornes et la distance entre les pointes des cornes. On a observé des corrélations positives entre le poids corporel et le périmètre thoracique, la longueur du corps et la longueur des cornes. Les coefficients de corrélation étaient nettement inférieurs pour les femelles que pour les mâles, à l'exception des rapports poids corporel/périmètre thoracique et poids corporel/hauteur au garrot. Les résultats montrent des écarts considérables tant dans la performance que dans la morphologie, suggérant ainsi qu'un programme de sélection et/ou l'amélioration de la gestion pourraient développer la productivité de la race.

Mots-clés: *morphométrique, caractérisation, performance de reproduction, bovins Ankolé*

Resumen

La caracterización fenotípica tiene una importancia fundamental en la mejora y conservación de razas. Se han estudiado 248 explotaciones en Uganda para determinar el rendimiento y las características morfológicas del ganado Ankole en tres sistemas de producción (LPS, por sus siglas en inglés) de Uganda. Se han medido en 120 toros y 180 vacas la alzada a la cruz (HW, por sus siglas en inglés), perímetro torácico (HW, por sus siglas en inglés), diámetro longitudinal (BL, por sus siglas en inglés), longitud de la oreja (EL, por sus siglas en inglés), longitud del cuerno (HL, por sus siglas en inglés), distancia entre las puntas de los cuernos (HS, por sus siglas en inglés) y el peso corporal (BW, por sus siglas en inglés). Los datos han sido analizados utilizando LPS (pastos para el ganado, agropastoral, pastoral), el condado (Gomba, Kazo, Kiboga, Mawoggola, Nyabushozi) y el sexo (hembras y machos) como factores principales. En los resultados, la edad de madurez sexual (ASM, por sus siglas en inglés) fue de 23.6 ± 0.5 meses para los toros y

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de 22.7 ± 0.5 para las vacas. La edad para el primer parto (AFC, por sus siglas en inglés) fue de 33.2 ± 0.5 meses, mientras que el intervalo entre partos (CI, por sus siglas en inglés) fue de 12.9 ± 0.8 meses. La duración de la lactación (LL, por sus siglas en inglés) difirió entre LPS (5.5 ± 0.4, 6.3 ± 0.3 y 7.4 ± 0.2 meses en agropastoral, pastos para el ganado y pastoral, respectivamente). La producción media de leche fue de 2.2 ± 0.1 kg/vaca mientras que la supervivencia antes del destete fue de 90.0 ± 6.5%. El sexo y LPS influyó significativamente en HW, HL y HS. Se observaron correlaciones positivas entre BW y HG, BL y HL. Los coeficientes de correlación fueron mucho más bajos en las hembras que en los machos, excepto en BW vs HG y BW vs HW. Los resultados muestran grandes variaciones entre rendimiento y morfología, sugiriendo que dentro del plan de selección racial y/o de gestión puede conllevar mejora sustancial en el campo de la productividad.

Palabras clave: *morfometría, caracterización, rendimiento reproductivo, ganado Ankole*

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Introduction

Approximately 70 percent of the world's rural poor depend on livestock as an important component of their livelihoods (Hoffmann, 2010). The African continent, where many of the poor live, is home to over 230 million cattle (FAO, 2008) constituted in about 150 breeds, most of them indigenous to the continent (Rege and Bester, 1998). These breeds have unique genetic attributes such as adaptation and tolerance to drought, heat, diseases and ability to utilize low-quality indigenous forages. Ankole are one such cattle and are kept under pastoralism and crop-livestock systems (Lamwaka, 2006; Wurzinger *et al.*, 2007). Ankole cattle also exist in other countries of the African great lakes region such as Burundi, Rwanda, Tanzania (Ndumu *et al.*, 2008) and Democratic Republic of Congo. Both male and female Ankole cattle have similar features, with the exception of a hump, which exists only in the adult males. The predominant colour is brown with several shades and patterns. The occurrence of white and black Ankole cattle is low as many farmers select against these colours. The predominant morphological feature of these cattle is the pair of white, large and long horns (Plates 1–7 and 9), although other horn conditions are also present (Plate 8).

Generally, indigenous livestock breeds of developing countries are scantily documented and under exploited (Philipsson *et al.*, 2006). There is limited information on the performance of Ankole cattle in East Africa (e.g. FAO, 2009). Although the role of livestock in providing products and services is generally known (Perry *et al.*, 2002), performance data under different agro-ecological systems in which these cattle are reared within Uganda are almost non-existent. The growing demand for livestock products in Uganda justifies the need to improve livestock productivity. This part of a wider study was aimed at characterizing the performance and morphological features of the Ankole cattle in Uganda, with a goal of contributing to the improvement of this unique breed.

Materials and methods

Study area and sampling procedure

The study used a descriptive, purposive and stratified survey design and was carried out in Ankole cattle keeping households of Uganda, in the districts of Kiboga (n = 60), Mbarara (n = 137), Mpigi (n = 30) and Sembabule (n = 21) (Figure 1, Table 1). These districts have the highest Ankole cattle density in Uganda. Each district is divided into counties. The counties selected for this study were Gomba in Mpigi district, Kazo and Nyabushozi in Mbarara district, Kiboga in Kiboga district

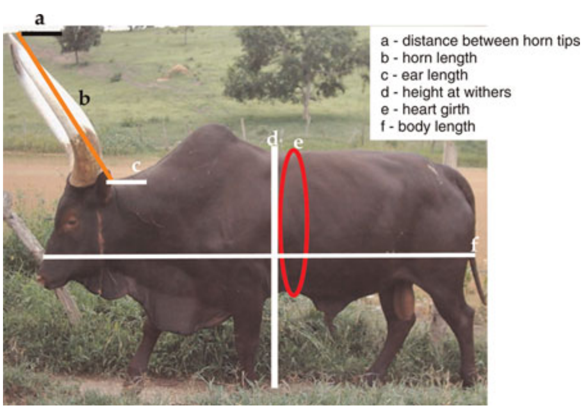

Plate 1. Measurements performed on Ankole cows and bulls.

Plate 2. An Ankole cattle herd of mostly the one preferred colour, dark brown (*Bihogo*).

Plate 3. A herd of Ankole cattle being driven to graze.

Plate 5. Ankole cattle at the water trough.

and Mawoggola in Sembabule district (Table 2). Each county (*Ssaza*) is further divided into subcounties (*Gombolola*) that are decentralized governments. The subcounties are made up of several parishes (*muluka*), each of which is subdivided into villages whose residents form the local council one, the smallest administrative unit.

Two perpendicular transects were drawn across each subcounty, and all parishes along each transect were selected. The number of farmer respondents per subcounty ranged between 10 and 20 depending on the geographical size and population density (Table 2). Three livestock production systems (LPS), namely agropastoral, crop livestock and pastoral were identified in the study area. Most respondents were from the pastoral system (Table 2).

Ankole cattle production systems

Agropastoralists are sedentary farmers who cultivate food crops both for subsistence and sale while also keeping livestock. Their animals use communal grazing land, fallow land and crop land after harvest (Twinamasiko, 2001). Livestock is used for draught, savings and milk production. The agropastoralists have little control over the feed resources. Milk production fluctuates with the seasonal availability of feed; hence, feed supply could be improved by saving grazing areas in the form of standing hay or establishment of fodder banks for dry season feeding (Mwebaze, 2002).

The crop-livestock system is characterized by the use of crop by-products as animal feed, whereas livestock provide their waste, used as a fertilizer (Ghotge and Ramdas, 2003). Milk and meat from the livestock provide income. Farm size is normally small (0–1.5 ha), with a moderate-to-high cropping intensity (Twinamasiko, 2001). In this system, dairy production is attractive because it offers opportunity for diversification, spreading risks and provides a continuous income (Mwebaze, 2002).

Pastoral systems are characterized by the use of range grasslands, migratory herding and livestock breeds that are tolerant to migration stress, droughts and periodic food and nutritional shortages (Groombridge, 1992). Livestock owners exploit natural grasslands mainly in the relatively dry areas of Uganda (Twinamasiko, 2001). Pastoralists are more sedentary today than in the past, and mainly move to find pasture and water in times of drought. The main source of food for pastoralists is milk; however, production per unit area is low (Petersen *et al.*, 2003). Producers generally have minimal control over

Plate 4. A herd of Ankole cattle grazing, note the tree cover on the range.

Plate 6. Ankole cattle approaching home, note the long and graceful horns.

Plate 7. Ankole cattle in a confinement crush during spraying against ecto-parasites.

the feed resources and therefore limited opportunity for their improvement. The pastoral system uses few commercial inputs and the cost of production is usually very low (Mwebaze, 2002).

Survey instrument, animals and tools

A questionnaire was administered to the 248 households to generate data on reproductive parameters in cows and bulls. Milk production data were provided by farmers who relied on their memorized records. One mature breeding bull and one cow were then randomly selected from each surveyed household. Live body weight (BW) and six body measurements were then taken on the selected 120 bulls and 180 cows. The studied animals were mature active breeders. Maturity was ascertained from possession of either three or four pairs of permanent teeth. A descriptor list of phenotypic characteristics to assist with the qualitative description of the animals, a colour chart to describe the coat colour of the animals, and calibrated tapes and callipers to measure the quantitative physical characteristics such as heart girth (HG) and body length (BL) were also used. The set of measurements taken for the six traits considered in this study were as described by Brown, Brown and Johnson (1983) and Adeyinka and Mohammed (2006), except for BL, which was taken as the absolute distance from the nose bridge to the tail.

Plate 8. The diversity of the horning condition among Ankole cattle. The names of the cows standing from left are *Kachweka* (i.e. broken horns), *Nkungu* (i.e. polled), *Nshara* (i.e. drooping horns).

Data analysis

The filled questionnaires were then coded and keyed into the SPSS computer software. Data analysis was then performed using Statistical Analysis Systems, Ver. 9.1.3 (SAS, 2004). Reproductive parameters were assessed using general linear models, with LPS and counties as fixed effects and age as a covariate. The model used was

$$y = \mu + l_i + c_j + c_j(s_k) + a_l + e_{ijkl} \sim \mathrm{N}(0,\ \sigma^2) \qquad (1)$$

where y is the observation of the trait in production system i, in county j, in subcounty k and for animal age l. μ is the overall mean, l_i the effect of production system ($i = 3$), c_j the county effect ($j = 5$), $c_j(s_k)$ the effect of subcounty within counties ($k = 19$), a_1 the effect of age ($l = 2$), e_{ijkl} the random effect on the trait, independently and identically distributed with mean = 0 and variance = σ^2.

Mixed models maximum likelihood procedure was used to analyse linear body measurements (Plate 1). The measurements were height at withers (HW), HG, BL, ear length (EL), horn length (HL), distance between horn tips (HS) and BW. Other than LPS and sex, all the other possible effects were not significant and were therefore dropped. The model used is

$$y = \mu + l_i(s_j) + e_{ij} \sim \mathrm{N}(0,\ \sigma_e^2) \qquad (2)$$

where y is the observation of the animal trait, μ the overall mean, l_i the effect of the production system ($i = 3$), s_j the effect of sex ($j = 2$) and e_{ij} the random effect as explained in (1).

Correlation coefficients between HW, HG, BL, EL, HL, HS and BW were computed on a within-sex basis to determine linear associations between them. Age was not a significant factor in equation (i), and the physiological status of cows sampled for the linear measurement analysis was similar (all were dry at the time of data collection); hence, the animals were evaluated as a homogenous group. Linear regression of HW on HG, HW on BL and HG on BW was conducted within each sex category of Ankole cattle.

Results

Reproductive and production performance of Ankole cattle

From the survey, age at sexual maturity (ASM) ranged between 12 and 36 months for both for male and female Ankole cattle, averaging 23.6 ± 0.5 and 22.7 ± 0.5 months, respectively. However, the age for females was not

Plate 9. Three generations in one photograph, standing in the front row, from left to right is a dam, daughter and grand-daughter.

affected ($P > 0.05$) by LPS and counties (Table 3). Average age at first calving (AFC) was 33.2 ± 0.5 months, and ranged between 24 and 45 months. Gomba and Kiboga counties had higher AFC ($P \leq 0.05$) than the other counties. Calving interval (CI) averaged 12.9 ± 0.8 months and ranged between 12 and 18 months, but did not differ significantly between LPS and counties. The average lactation length (LL) differed between LPS ($P \leq 0.01$) and counties ($P \leq 0.001$). LL was 5.5 months for the crop livestock, 6.3 months for agropastoral and 7.4 months in pastoral areas (Table 3). Kazo County had the highest mean LL (8.5 months) that differed ($P \leq 0.001$) from the rest.

Milking was being done once a day in 34.2 percent of all the households. In contrast, milking twice was found in 56.0 percent of the crop livestock, 60.0 percent of

Figure 1. Map of Uganda showing the study areas.

Table 1. Physical and demographic features of the districts studied.

District	Land area (km^2)	Human population	Annual rainfall (mm)	Altitude range[1] (m.a.s.l.)
Kiboga	4 045	231 231	560–1 272	1 400–1 800
Mbarara	7 346	1 093 388	875–1 200	760–900
Mpigi	3 714	414 757	1 000–1 200	1 000–1 300
Sembabule	2 470	184t178	750–2 000	1 200–1 350

Note: Source: Ministry of Local Government, Republic of Uganda (www.molg.go.ug).
[1]a.s.l means above sea level.

agropastoral and 70.0 percent of pastoral system households. The average daily milk off take per cow was 2.2 ± 0.1 kg. The milk off take ranged between 1 and 6 kg but was not significantly affected by LPS and county (Table 3). Over 96 and 83 percent of calves born in Nyabushozi and Kazo, respectively, survived to weaning age, giving an overall survival rate in the study area of 90.0 percent. Age at weaning of calves ranged between three and nine months, with an average of six months (Table 3). However, differences in the ages between LPS and counties were not significant.

Body morphometric characteristics

The average linear body dimensions of male cattle were higher than for females except for HL (Table 4). HW, HL and horn spacing of cows differed ($P \leq 0.05$) across LPS. However, bulls only differed ($P \leq 0.05$) in horn attributes across the LPS. Generally, bulls and cows from the crop-livestock system were smaller (had shorter body dimensions) than their pastoral counterparts (Table 4).

Table 5 gives the phenotypic correlation estimates between the various traits for male and female Ankole cattle. The correlation coefficients between HW and other body parameters for male cattle were positive and different from zero ($P \leq 0.05$), with the exception of HS. A high positive correlation was also observed between BW and HG, whereas correlations between BW and EL, and BW and HS were high but negative in males. For all pairs of body measurements, correlation coefficients were much lower in females than in males, with only BW and HG; BW and HW being close in value (Table 5). Generally, HS was negatively correlated to other traits both in male and female cattle. EL was negatively correlated to BL, HS and BW in female cattle.

Regression coefficients and equations for HW on HG and BL, and BW on HG for adult male and female Ankole cattle are presented in Table 6.

Discussion

The average AFC in this study of 24–45 months contrasts highly with estimates of 42–60 and 25–61 months reported by Payne and Wilson (1999) and Rege (1999), respectively. The observed difference may be attributed to improved cattle management that encourages early maturity. Disease and nutritional management in possible combination with increased selection for reproductive efficiency in Ankole cattle by farmers should be factors driving the AFC trend. This may also be a result of a shift from the conventional selection for aesthetic traits such as coat colour and horns. CI, a parameter related to AFC has also improved to 12–18 months, comparatively better than 16–24 months reported from earlier studies of this breed (Payne and Wilson, 1999).

Although AFC and CI estimates were expected to vary across production systems, this was not the case. This apparent anomaly could be attributed to related stress levels in the different production systems. For instance, although in the pastoral LPS, inadequate and poor-quality feeds could be due to poor pastures, bush encroachment and overgrazing; in the mixed crop livestock and the agropastoral systems, it could be due to inadequate pasture land.

The average daily milk off take for Ankole cows was 2.2 kg (Table 1), higher than 1.48 kg (Petersen *et al.*,

Table 2. Number of subcounties, parishes, villages and respondent households sampled in respective counties and LPS.

County	Administrative subunit[1]			Respondents	Production system		
	Subcounties	Parishes	Villages		Agropastoral $n = 68$	Crop livestock $n = 25$	Pastoral $n = 155$
					% of respondents		
Gomba	4 (2)	15 (10)	153 (21)	30	16.7	3.3	80.0
Kazo	5 (5)	28 (19)	233 (42)	60	63.3	16.7	20.0
Kiboga	10 (6)	20 (14)	154 (60)	60	25.0	0.0	75.0
Mawoggola	5 (1)	23 (04)	140 (07)	21	28.6	4.8	66.7
Nyabushozi	7 (6)	27 (23)	207 (44)	77	5.2	16.9	77.9
Total	31 (20)	113 (70)	887 (174)	248			

[1]The number sampled are in parentheses.

Table 3. Least-square means (± s.e.) of reproductive parameters and milk yield of Ankole cattle.

Category	Factor	*n*	Reproductive parameter (months)				Milk off take/cow/day (kg)[ns]
			ASMF[ns]	AFC	LL	AWC[ns]	
Production system	Agropastoral	65	22.9 ± 0.9	32.4 ± 0.8	6.3[a]±0.3	4.0 ± 0.1	2.2 ± 0.1
	Crop-livestock	22	21.7 ± 1.2	35.5 ± 1.3	5.5[a] ± 0.4	4.1 ± 0.2	2.4 ± 0.2
	Pastoral	140	22.8 ± 0.6	32.9 ± 0.8	7.4[b] ± 0.2	4.3 ± 0.1	2.1 ± 0.1
County	Gomba	30	23.7 ± 1.4	38.2[a]±1.6	6.2[a] ± 0.4	4.2 ± 0.2	2.5 ± 0.2
	Kazo	60	22.3 ± 0.8	32.2[b] ± 0.8	8.5[a] ± 0.4	4.4 ± 0.2	2.2 ± 0.1
	Kiboga	60	24.6 ± 0.9	36.4[a] ± 0.9	5.8[b] ± 0.2	3.9 ± 0.2	2.3 ± 0.1
	Mawoggola	21	19.9 ± 1.3	31.2[b] ± 1.3	5.2[b] ± 0.9	3.9 ± 0.4	2.5 ± 0.3
	Nyabushozi	77	21.9 ± 0.9	30.0[b] ± 1.3	6.1[b] ± 0.3	4.3 ± 0.1	2.0 ± 0.1
Overall		248	22.7 ± 0.5	33.2 ± 0.5	7.2 ± 0.2	4.2 ± 0.1	2.2 ± 0.1
			(12–36)	(24–45)	(1–12)	(3–6)	(1–6)

Note: Means in the same column with different superscripts differ significantly ($P < 0.05$).
Numbers in parentheses are ranges.
ASMF, age at sexual maturity in female cattle; AFC, age at first calving; LL, lactation length; AWC, age at weaning of calf.

2003) for Ankole cows in the same location, and 1.08 kg (De Leeuw and Wilson, 1987) for indigenous Kenyan cattle kept under range conditions. Milk yield per cow per lactation, extrapolated from daily milk off take and LL was 550 kg in pastoral, 530 kg in agropastoral and 480 kg in crop- livestock areas. Differences between these values could be attributed to seasonal variations as affected by rainfall and pasture growth. Hence, better pastureland management and breeding strategies could improve milk production in Ankole cows. Values obtained in this study were comparable with 300–1100 kg for the Nkedi strain (SEA Zebu) (Payne and Hodges, 1997), a strain regarded as superior to the Ankole in milk production.

LL for the pastoral LPS was 7.4 months, 30 days longer than was reported by Twinamasiko (2001). This LL is nevertheless lower than 245–270 days for the Nguni (Rege *et al.*, 2001), which like the Ankole are Sanga cattle, but have undergone more intense selection for beef and milk production (Bester *et al.*, 2003). Ankole cattle therefore have a relatively good potential for milk production and would respond well to a combination of selection and improved management. Exceptionally high preweaning calf survival rates observed in this study may be attributed to good calf health care especially ecto- and endo-parasite control regimes among pastoralists, and to good adaptation of these cattle. The preweaning survival rate is important because it contributes to higher net calf crop (Rege *et al.*, 2001), resulting in more animals reaching breeding age, hence increased potential for more intense selection pressure and better overall herd profitability in beef ranching.

Ankole cows differed ($P \leq 0.05$) in HW across LPS, whereas bulls only differed in horn attributes. Bulls and cows in the crop-livestock system were shorter in body dimensions than in pastoral areas (Table 4). Linear body dimensions of Ankole cattle in the five counties that were studied clearly differed possibly because cattle in those areas have become subpopulations. Other causes could be variations in pasture biomass, livestock water

Table 4. Least-square means (± s.e.) for linear measurements (cm) for six traits in adult Ankole cattle of Uganda

Variable	Sex	*n*	Production system			Mean
			Agropastoral	Crop-livestock[1]	Pastoral	
HW	Male	120	144.8 ± 4.4	–	144.5 ± 6.9	144.6 ± 3.4
	Female	180	147.0[a]±4.4	126.1[b] ± 2.9	137.5[c] ± 2.7	139.5 ± 1.7
HG	Male	120	183.8 ± 3.2	–	181.5 ± 5.1	182.6 ± 2.8
	Female	180	169.6 ± 3.2	167.8 ± 2.2	172.6 ± 1.7	171.3 ± 1.3
BL	Male	120	212.6 ± 6.8	–	208.0 ± 8.8	210.3 ± 5.7
	Female	180	199.8 ± 6.8	204.3 ± 4.8	197.6 ± 3.8	201.4 ± 3.0
HL	Male	120	132.0[a] ± 13.0	–	176.5[b] ± 19.1	154.2 ± 12
	Female	180	151.8[a] ± 13.1	197.7[b] ± 8.2	195.1[b] ± 7.2	187.8 ± 5.6
Horn spacing (HS)	Male	120	26.2[a] ± 11.0	–	95.0[b] ± 16.3	60.6 ± 10.0
	Female	180	65.2[a] ± 11.2	81.0[a] ± 6.9	44.9[b] ± 5.9	60.2 ± 4.6
EL	Male	120	21.5 ± 0.6	–	20.0 ± 1.3	20.8 ± 0.7
	Female	180	19.8 ± 0.6	19.5 ± 0.4	19.6 ± 0.3	19.8 ± 0.3

Note: Means in the same row with different superscripts differ significantly ($P < 0.05$).
[1]In the crop-livestock system, farmers did not have crushes to confine animals; hence, bulls could not be measured.

Table 5. Correlation matrix for body measurements in adult Ankole cattle.

	HW	HG	BL	EL	HL	HS	BW
HW	1	**0.26**	0.12	**0.56**	**0.58**	0.23	**0.65**
HG	**0.82**	1	**0.28**	**0.39**	0.09	−0.03	**0.92**
BL	**0.67**	**0.68**	1	−0.15	−0.05	0.10	**0.28**
EL	**0.62**	0.18	0.61	1	0.16	−0.08	**− 0.39**
HL	**0.66**	0.43	0.32	0.55	1	0.16	−0.09
Horn Spacing (HS)	0.43	−0.02	−0.19	−0.06	**0.57**	1	−0.03
BW	**0.75**	**0.98**	**0.61**	**− 1.00**	**0.99**	−0.67	1

Above diagonal: female cattle; below diagonal: male cattle; bolded correlations are significant ($P < 0.05$).

availability and general climatic conditions associated with these areas.

Measurements for males and females significantly differed, similar to findings of other studies. Differences between linear measurements of bulls and cows are attributed to sexual dimorphism (Mwacharo *et al.*, 2006), normally associated with hormonal differences between males and females. HG and mean HW of Ankole cows were higher than previous studies (e.g. Ndumu *et al.*, 2008), possibly because of variation in the sampling frame and sample sizes used between the studies. HW in this study was also higher than data reported for other Sanga breeds (Payne and Hodges, 1997). Therefore, Ugandan Ankole cattle populations have a comparatively bigger body frame than populations elsewhere. Selective breeding of this breed could boost its competitive advantage over others and hence ensure its conservation.

Morphological descriptions are useful for distinguishing animal breeds and strains (Gatesy and Arctander, 2000) and in evaluation of breeding goals (Zechner *et al.*, 2001). Comparative measurements of morphometric traits can also provide evidence of breed relationships and size (Mwacharo *et al.*, 2006) and in some cases can be used to predict an animals' weight (Goe, Alldredge and Light, 2001; Mwacharo *et al.*, 2006). Withers height is useful for visual appraisal and determining show classes for beef cattle (Alderson, 1999). In contrast, skeletal measurements such as body height and length, and chest depth indicate inherent size better than measures related to muscle and fat deposition, such as width and girth measurements and BWs, which are affected by nutrition (Kamalzadeh, Koops and van Bruchem, 1998). For these reasons, the former were emphasized in this study.

The phenotypic correlations between the morphometric measurements were positive and generally significant (Table 5). Similar results have been reported in cattle breeds elsewhere (Mwacharo *et al.*, 2006). BW was highly and positively correlated with HL (0.99) and HG (0.98) in Ankole bulls; hence, the latter two traits can reliably be used as proxies for estimating BW for this breed. However, with the exception of BW and HG, correlations between traits in Ankole cows were much lower than the corresponding values for bulls (Table 5). Regression of HW on HG and BL was linear with high R^2 values (Table 6). Observing the correlation and regression analysis, HG would be the best estimator for BW, given the high R^2 values (>90) in both bulls and cows. Previous studies in Mubende goats have also showed similar relationships (Kugonza, Bareeba and Petersen, 2001).

Commercial milk and beef production from exotic genotypes is increasingly becoming popular in Uganda in response to increasing demand for milk and quality beef. However, the negative effects of the climate change, as witnessed by increased frequency and severity of droughts in the recent past, calls for caution. A careful introduction of Ankole and its crosses to the exotic commercial dairy and beef breeds may well provide the best option under the fragile Ugandan rangelands.

There is also need to mobilize cattle owners who maintain pure Ankole cattle herds to form a breeders association, to facilitate our proposed Ankole improvement programme. The National Animal Genetic Resource Centre needs a source of pure stock to ensure that inbreeding of their herds is avoided. A credible and sustainable source of such pure stock would be the traditional farmers/keepers/owners of the Ankole breed, if they became a breed association. Involvement of farmers in the planning phase of breeding programmes ensures that they provide their support when it is eventually needed (Kosgey *et al.*, 2006). Farmers' participation could include animal identification,

Table 6. Relationship of HG with HW and BW, and BL of Ankole cows and bulls.

Regressed factors	Sex	Equation	R^2	*P* value
HW on HG	Male	$y = 80.5 + 0.72x$	0.64	0.001
	Female	$y = 149.2 + 0.16x$	0.60	0.030
HW on BL	Male	$y = 117.6 + 0.65x$	0.45	0.008
	Female	$y = 175.9 + 0.18x$	0.50	0.030
BW on HG	Male	$y = 125.2 + 0.11x$	0.95	0.008
	Female	$y = 24.2 + 2.6x$	0.98	0.006

recording, ensuring vaccination programmes are adhered to and culling of undesirable stock (Willis, 2001). On the other hand, the central government has to play a key role in providing policy and enabling infrastructural as well as technical support for such a breeding programme to succeed (Philipsson *et al.*, 2006). For the case of Uganda, an act of parliament is in existence (The Animal Breeding Act, 2001), but most sections of it are yet to be operationalized.

Conclusions

Ankole cattle show a high productive potential, although their current performance is relatively low, largely because of the suboptimal management conditions and production area constraints. Wide variations in management activities and production levels were also observed in the three LPS. However, this variation in the production levels is indicative of potential for improvement under selection and improved husbandry. HG is the sole trait that best predicted live weight in both male and female cattle, although HL and absolute BL are also relatively good proxy traits for estimation of BW.

Recommendations

In view of the ongoing climate change and its negative effects, a carefully planned improvement programme involving pure Ankole and its crosses to the exotic commercial dairy and beef breeds is therefore recommended as a sustainable option for conserving this unique cattle genetic resource. Improvement of Ankole cattle could focus on a few traits and hence keep the costs and time requirements for an improvement programme low. Traits to focus on initially should include weaning weight and ASM. Herds to be used in the selection programme should be large in size, and these are available in the three LPS studied. Strengthening of the extension service by increasing the number of service providers and improving their facilitation should be undertaken. Farmer training in proper herd management should lead to improvement in the productivity of this breed, even at current genetic potential.

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