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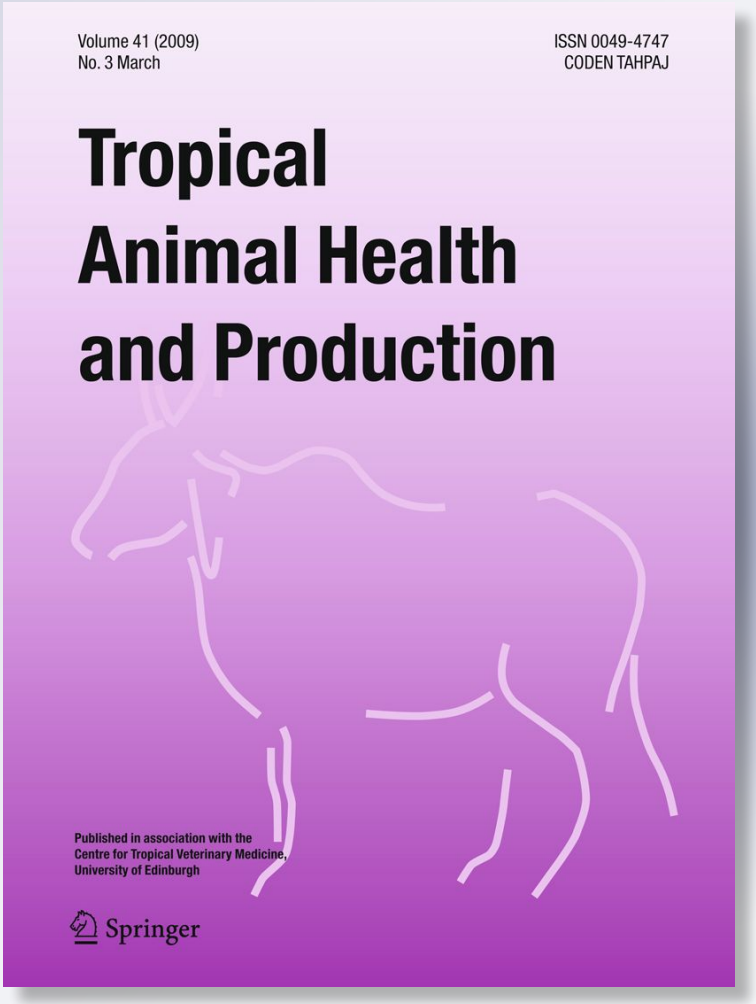

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ORIGINAL RESEARCH

Pastoralists' indigenous selection criteria and other breeding practices of the long-horned Ankole cattle in Uganda

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Abstract The criteria for identification, selection and kinship assignment of Ankole cattle and their roles to pastoralists were studied on 248 farms in Kiboga, Mbarara, Mpigi and Sembabule districts of Uganda using a questionnaire, administered during one-to-one interviews. Farms were randomly sampled along transects originating from the headquarters of each of the 19 sub-counties studied. We found that male Ankole cattle are reared for income from sales, meat for home use and ceremonies, aesthetic value and to maintain cultural heritage. Female cattle are mainly kept for milk production, income from sales, heritage and aesthetics, and in few cases, for home use as meat. Other functions included savings, manure and butter production. All cattle are named at birth with coat colour or pattern being the main identification criterion; hence, it is also useful in assigning kinship. Selection criteria for males are more stringent than for females. On most farms, all females are kept for further breeding and are only culled in cases of poor reproductive health. Primary emphasis in selecting males is on the performance of ancestors in milk and reproductive traits, and then on the qualities of the bull itself. Bulls are selected mainly focusing on a big body frame and size, horns that are white, large and curved upward and a plain dark red "ruhogo" coat colour. The results of this study show that pastoralists have a rich body of indigenous knowledge on this breed, and this should effectively be incorporated into planned selective improvement schemes of the Ankole cattle breed.

Keywords Selection and culling criteria · Trait preference · Ankole cattle · Ranking index

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Abbreviations

DAGRIS	Domestic Animal Genetic Resources Information System
FAO	Food and Agriculture Organisation of the United Nations
LPS	Livestock production system

Introduction

Cattle are the most important livestock species in agricultural production systems of Eastern Africa where they contribute to over one third of the gross domestic product (AfDB/OECD 2007). Indigenous cattle especially the Ankole are an important and unique animal genetic resource in so far as food security strategies of many Congolese, Rwandan,

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Tanzanian and Ugandan communities are concerned. The Ankole cattle are among the most typical Sanga cattle (Rege and Tawah 1999) and along with the Kigezi and Watusi, are among the eleven "pure" Sanga breeds not introgressed with the *Y* indicine haplotype (Hanotte et al. 2000). Sanga, an Ethiopian word meaning "bull", relates to the origin and centre of dispersal of this group of cattle breeds (DAGRIS 2006). The Sanga likely evolved in Ethiopia as a result of interbreeding between the original longhorn humpless cattle with cervico-thoracic-humped (zebu) cattle (Epstein and Mason 1984) and show a mixture of features from the two original types. These cattle were brought to Uganda by Hamitic (*Bantu*) tribes migrating from North-Eastern Africa about 600 years ago (Rege and Tawah 1999), and they represent an important genetic resource for Eastern Africa where they are kept and loved for their gentleness, beauty, tasty milk and meat, hence, the need to conserve them.

The value of animal genetic resources conservation is generally underestimated, as the current indirect values are often neglected (Philipsson et al. 2006). While Reist-Marti et al. (2003) showed that conservation of African cattle can cost effectively be done, the costs of breed reconstruction are very high (Gandini et al. 2007). The costs and associated bottlenecks of these options—i.e. conservation vs. breed reconstruction—are yet to be accurately estimated and predicted. Philipsson et al. (2006) recommended that the most efficient way to sustain a breed is to continuously keep it commercially competitive or culturally relevant. Also, there is a need to meet the increasing and future demand for milk and meat in the developing countries (Delgado et al. 1999); hence, improvement in livestock productivity is needed. Such improvements can be realised through a combination of improved husbandry and careful utilisation of the existing livestock genotypes through well-planned breeding programmes.

The implementation of effective breeding programmes relies heavily on accurate knowledge/records of animal pedigrees and performance, as well as appropriate screening of future parents. Ankole cattle herdsmen are reasonably accurate in assigning parentage and kinship of animals within their herds using memorised pedigrees (Kugonza et al. 2011a). The cattle keepers also know the breeding histories of their herds (Museveni 1997) and in all likelihood select for specific traits that meet the cultural, social and economic needs of their keepers. However, limited information exists on the criteria used by these pastoralists in selection and assigning of dyad relationships within their herds. Such information would better inform breed conservation and improvement programmes. This study was therefore undertaken to determine the breeding practices and criteria used by Ankole cattle pastoralists for the identification, selection and culling of their animals.

Materials and methods

Study area and design

This study was carried out in the Ankole cattle keeping households in the districts of Kiboga (n=60), Mbarara (n=137), Mpigi (n=30) and Sembabule (n=21) of Uganda. We used a stratified survey design, with stratification done at district, county, sub-county and parish administrative levels (Table 1). The socioeconomic characteristics of the households are presented in Table 2. The studied districts are located in three livestock production systems (LPS) namely: crop–livestock, agro-pastoral and pastoral system, described elsewhere (Kugonza et al. 2011b). Two perpendicular transects were drawn across each sub-county, and all parishes along each transect were selected.

Data collection and analysis

A questionnaire was pretested and was then administered by a sole interviewer to 248 cattle farming households. The number of farmer respondents per sub-county ranged

Table 1 Number of sub-counties, parishes, villages and respondent households sampled in respective counties and livestock production systems

County	Administrative sub-unit[a]			Respondents	Production system		
	Sub-counties	Parishes	Villages		Agro-pastoral n=68 % of respondents	Crop-livestock n=25	Pastoral n=155
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			

[a] The number sampled are in parentheses

Table 2 The numbers and proportions of respondents within each level of the factors investigated

Factor	Level	Number (%)
Sex of household head	Female	21 (8.5)
	Male	227 (91.5)
Age of household head	<30 years	22 (8.9)
	31–50 years	139 (56.1)
	>50 years	87 (35.1)
Literacy level of household head	Can read and/or write	172 (69.3)
	Cannot read or write	76 (30.7)
Number of household members	5 or less	27 (11.8)
	6–10	101 (44.3)
	11–15	60 (26.3)
	>16	40 (17.5)
Ethnicity of household	Bahima	168 (68.0)
	Banyarwanda	50 (20.0)
	Others[a]	30 (12.0)
Source of household income[b]	Livestock	248 (100.0)
	Crops	74 (29.8)
	Non-agricultural business	36 (14.5)
	Salary	13 (5.2)
Number of Ankole cattle kept	<50	144 (58.1)
	50–100	69 (27.8)
	>100	35 (14.1)
Breeds of cattle kept	Ankole only	110 (44.5)
	Ankole and crosses with Friesian	136 (55.0)
	Ankole and others[c]	36 (14.4)
Other livestock species kept[d]	Goats	174 (70.2)
	Sheep	80 (32.3)
	Chickens	40 (15.7)
Ownership of Ankole cattle	Household head alone	140 (56.2)
	Household head and spouse	36 (14.7)
	Whole family	71 (29.0)
Grazing land area (ha)	<100	151 (61.0)
	100–200	52 (20.8)
	>200	45 (18.2)
Ownership of grazing land	Household owned	205 (82.7)
	Rented	10 (4.0)
	Communal	20 (8.1)
	All three	13 (5.2)

[a] Others include non-Bahima Banyankole, Baganda, Banyoro, Alur

[b] Some households had more than one source of income, 60.9% got all their income from livestock

[c] Other breeds kept were Boran, Nganda and Karamojong

[d] Some households kept more than one animal species

between 10 and 20 depending on the geographical size and population density (Table 2). The filled questionnaires were coded, and data were entered and verified using SPSS computer software. Data analysis was then performed using Statistical Analysis Systems, Version 9.1.3 (SAS 2004).

The variables that were analysed for LPS, counties, ethnic groups, sex and age of household head, literacy of the household head, source of household income and number of Ankole cattle kept were (1) the purpose of keeping male and female Ankole cattle, (2) criteria for naming Ankole cattle and assigning kinship/parentage between animal pairs, (3) criteria for selection and culling of Ankole cattle, (4) relevance of the different selection criteria used in selection of Ankole cattle, (5) indicators/descriptors of economically important traits and (6) the traits for which Ankole cattle are perceived to be superior to other cattle breeds. In the preliminary analysis, variations of these factors between the class variables were not significant; hence, the entire dataset was analysed as a unit, to generate proportions of farmers in each category. Weighting of ranks of different farmers' criteria was then done according to Mbuku et al. (2006) and Kosgey et al. (2006).

Results

Purpose of the various cattle breeds kept

The purposes for which male and female Ankole cattle were being kept and the relative ranks of these roles are presented in Table 3. Male cattle were kept mainly for income generation through animal sales, and also for their beauty and for slaughter for consumption at home, in case of young calves, or during traditional ceremonies, in case of mature bulls. Conversely, female cattle were mainly kept for milk production. According to the respondents, Ankole cattle were also being kept because these cattle are part of the Bahima heritage. They also have aesthetic value (beauty) and contribute to wealth saving, production of manure and production of butter from milk. Respondents stated that Boran cattle were being reared only for income emanating from sale of live animals, while Friesian cattle and their crosses were primarily kept for milk production.

Criteria used in naming and parentage assignment of Ankole cattle

All the 248 respondents reported that as a usual practice, they give names to each of their Ankole cattle at birth, as a way of identifying them. Naming of animals and assigning of kinship for cattle dyads is done according to specific criteria. Cattle are named after their unique body coat colour or pattern according to all the respondents, but a smaller number of farmers (19.4%) additionally use the physical resemblance between individuals and their dam or sire (24.6%). The use of body coat colour ranked first, with

Table 3 Purpose of keeping male and female Ankole cattle and the ranking of the importance of these purposes

	Sex of cattle							
	Male				Female			
Purpose of Ankole cattle (n=248)	Households[a]	Households[b]	Weighted ranks[c]	Ranking index[d]	Households[a]	Households[b]	Weighted ranks[c]	Ranking index[d]
Income from cattle sales	210	152	253.2	0.42	22	167	152.5	0.26
Beauty	91	18	109.8	0.18	5	110	59.4	0.10
Meat	83	68	99.0	0.17	3	71	58.0	0.10
Heritage	44	8	51.9	0.09	10	47	17.1	0.03
Manure	18	–	22.7	0.04	–	21	6.2	0.01
Cultural ceremonies	18	2	22.4	0.04	–	41	9.3	0.02
Wealth and savings	17	–	14.3	0.02	–	39	4.8	0.01
Stud breeding	13	–	12.7	0.02	–	–	–	–
Prestige	13	–	12.5	0.02	1	15	5.7	0.01
Hides	1	–	1.2	0.00	–	3	1.5	0.00
Milk	–	–	–	–	205	222	259.7	0.44
Butter	–	–	–	–	1	46	14.7	0.02
Blood for food	–	–	–	–	–	3	2.4	0.00

[a] Households ranking purpose as important (i.e. 1,2,3,4 etc.)

[b] Households ranking purpose first

[c] The weighted rank was computed by multiplying the proportion of households that gave a rank and the rank weight. Rank 1 was weighted 3; 2 was weighted 2; and rank 3 was weighted 1

[d] Index=sum of [3 for rank 1+2 for rank 2+1 for rank 3] of a purpose divided by sum [3 for rank 1+2 for rank 2+1 for rank 3] for all purposes of keeping cattle of a particular sex

a ranking index of 0.40, followed in order of importance by use of body shape (0.25), horn curvature (0.11), nature of the backline (0.02) and presence of unique body marks (0.02). Apparently, even in cases where a herd has more than one breeding bull of the same colour, farmers claimed that they could assign the various progeny to their real sire. These assertions have been verified using molecular techniques and are reported elsewhere (Kugonza et al. 2011a). Over 20% of the respondents stated that they could identify various dyad relationships within their herds, up to great grandparent–great-grand offspring level. In contrast, 62.1% of the cattle breeders could identify dyads up to grandparent-grand offspring level, while 17.8% could only identify parent-offspring dyads.

We found that over 60 names were being used to identify cattle among most cattle herds. The names were given on the basis of body coat colour and/or pattern; horn shape, size and orientation; hump size; navel size; ear form; head size; tail shape and body length of Ankole cattle. Of the 248 households surveyed, 150 stated in detail which names/phenotypes existed in their herds. Fifty-two of the 60 documented common first names of Ankole cattle (87%) were used in all the 150 herds surveyed in five Ankole cattle keeping counties. Of the ten most popular names, *Bihogo, Gaaju* and *Siina*, which are different shades of brown, were the most popular. These names appeared in all the surveyed herds. White body coat patches, i.e. *Ngabo*, *Mayenje*, *Kyasha* and *Mpuuga* were also found in ≥75% of the herds. *Kakondo*, the most preferred horn orientation among the Bahima was not common as expected, being present in only 60% of the herds. Polled cattle or *Nkungu* were observed in half of the surveyed herds, while cattle with loose horns or *Nshara* were relatively rare (21.4%).

Selection criteria of Ankole bulls and cows

All households studied carry out selection of potential breeding animals within their herds. Big body size and dark red coat colour at birth, were given more weight, thus were the main criteria for selecting both Ankole bulls and cows (Table 4). Selection of males was more stringent than for females. For example, bulls born in the first parity are not selected, and so are bulls with patches of an undesirable colour even if such patches are very small. These factors are, however, of no consequence when selecting females. Also, in bull selection, performance of female ancestors in milk and reproductive traits received primary emphasis, followed by the bull's own morphometric data and later on,

Table 4 Selection criteria of Ankole bulls and cows and the ranking of the importance of these selection criteria

	Type of cattle							
	Bulls				Cows			
Selection Criterion (n=248)	Households[a]	Households[b]	Weighted ranks[c]	Ranking index[d]	Households[a]	Households[b]	Weighted ranks[c]	Ranking index[d]
Red coat colour	218	71	423	0.30	114	134	224	0.28
White, large and curved horns	213	53	432	0.30	114	29	239	0.30
Big body and tall frame	224	116	487	0.34	125	79	301	0.38
Big hump	32	0	17	0.01	7	1	6	0.01
Long tail with big base	49	1	9	0.01	9	0	4	0.01
Large dewlap	66	3	19	0.01	0	0	6	0.01
Big rump	37	2	14	0.01	7	2	5	0.01
Hooves with big circumference	38	0	8	0.01	7	0	0	0.00
Large preputial sheath	31	0	6	0.00	–	–	–	–
Big testes	51	0	3	0.00	–	–	–	–

[a] Households ranking selection criterion as important (i.e. 1,2,3,4 etc.)

[b] Households ranking selection criterion first

[c] The weighted rank was computed by multiplying the proportion of households that gave a rank and the rank weight. Rank 1 was weighted 3; 2 was weighted 2; and rank 3 was weighted 1

[d] Index=sum of [3 for rank 1+2 for rank 2+1 for rank 3] of a selection criterion divided by sum [3 for rank 1+2 for rank 2+1 for rank 3] for all selection criteria of a particular type of cattle

their performance. For example, bulls are first, selected based on body frame and size (big is preferred); secondly, horns; and thirdly, coat colour. Horns that are white, large and curved upward are preferred, while coat colour should be plain dark red "ruhogo" (87.3%), or dark red with few white markings "Ruyenje" (7.9%). Other key considerations in selection of Ankole cattle include a tail with a large base, a wide and long dewlap and a pair of large testes. These are secondary criteria to those mentioned earlier, and are only considered when there are many candidate bulls available.

Among female cattle, the top three criteria in order of preference are: a long body and tall frame, red coat colour and white large curved horns (Table 4). The preferred coat colour is dark red "Bihogo". About 90% of all respondents preferred dark red-coloured cows, while the rest prefer *Mayenje* or *Ngabo*. The cows should also preferably have large and firmly attached udders.

The relative importance of the different selection criteria for Ankole cattle as given by the pastoralists are presented in Table 5. In almost all cases, more than three reasons were given by the pastoralists for selecting cattle with a particular trait. For instance, big body and a tall frame are associated with a high carcass weight and strength.

When asked how the cattle keepers are able to tell the dairy potential in bulls, three indicators that are used were mentioned, namely: big and long testes (63.9% of respondents), big thighs (11.3%) and possession of a big preputial sheath (24.7%). Drought tolerance can be predicted from stoutness of the animals (52.0%) and tall stature similar to that of a horse (48.0%). The potential of bulls to produce mostly female progeny was indicated by a bull having one big and one smaller testicle (36.6% of respondents), a bull having only one testis (17.1%), a bull having bigger than average testicles (12.2%), being in possession of a feminine face (7.3%) or having soft skin hair (17.1%).

When compared with exotic breeds, 175 respondents observed that Ankole cattle are superior in disease tolerance, heat/drought tolerance and longevity. Other traits in which Ankole cattle are believed to be superior to exotic dairy cattle in particular, with their ranking indices are: beautiful coat colours (0.11), high meat quality (0.09), high milk quality (0.09), ability to walk for long distances (0.06), possession of well-shaped horns (0.05), low feed demands (0.03) and a good temperament (0.02). Ankole cattle were also said to be superior to indigenous Zebu and Karamojong cattle in both body size (0.13) and body coat colour.

Criteria for culling Ankole cattle

On most farms, bulls are culled to reduce or prevent inbreeding within herds and when they grow old, both reasons being often related. On the other hand, cows are

Table 5 Relevance of the different selection criteria of Ankole cattle

Trait	*n*	Reason given by farmers for preference of trait	%
Big hump	207	High carcass weight	50.0
		Beauty	16.6
		Hardiness	8.3
		Big offspring	8.3
White, large curved horns	182	Beauty	95.6
		Self defence	3.1
		Keep a bull confined	1.3
Long tail with big base	178	High carcass weight	47.7
		Beauty	27.3
		Big offspring	4.6
Big body and tall frame	158	High carcass weight	94.7
		Strength	5.3
Big hoof size	145	High carcass weight	87.1
		Good health	12.9
Red coat colour	139	Beauty	97.1
		High market value	3.9
Large, deep sheath	117	High milking daughters	25.0
		High carcass weight	68.8
		Beauty	12.5
Large testes, deep scrotum	81	High milking daughters	88.1
		High carcass weight	11.9
Big rump	57	High carcass weight	84.2
		High milking daughters	15.8
Large udder	36	High milk yield	100

culled because of poor productive, fertility, and health performance; and old age (Table 6).

Discussion

Ankole cattle are mainly kept for income generation. These cattle provide milk which is consumed within the households or sold for income (Table 3). More importantly however, are the sales of live animals which bring in more income. The socioeconomic and cultural roles of milk, meat and live Ankole animals among households have been underscored by earlier studies (Infield et al. 2003; Nakimbugwe and Muchunguzi 2003; Wurzinger et al. 2007).

Ankole cattle pastoralists increasingly need regular income, especially to buy crop foodstuffs due to their changing dietary habits, and to pay for post-primary education for their children. This may also explain the high ranking of income generation vis-à-vis the other functions. The pressures for a regular income faced by pastoralists are expected to increase. This implies more focus in future on breeding should be put on production traits, especially milk and meat and less on traits of social cultural value such as body coat colour.

Specific criteria are used to name individual animals, assign parentage and kinship among dyads. This system has been passed on from many generations. The naming of Ankole cattle is done at birth and in this study, was being practiced by every household. The giving of names to cattle is widespread among Bantu-speaking people in Eastern and Southern Africa (Köhler-Rollefson and Rathore 2000).

Identification of Ankole cattle is primarily based on body coat colour and colour patterns. Some farmers use the two criteria in combination with the dam's and sire's identity. Names are given depending on the origin of the dam or sire and the behaviour of these cattle as reported by others (Museveni 1997; Infield 2002). However, these methods are prohibitive, because their utilisation is limited to the cattle owner's presence. Use is limited among non-Bahima cattle owners because the etymology and understanding of the names relies heavily on ethnicity.

The accuracy of the methods is also suspect, since in some herds, there is a predominance of one preferred coat colour. Memorising the identities of a herd may also be limited to small herd sizes and long lengths of time a cattle owner spends with the herd. Therefore, since successful breeding programmes rely on more accurate animal identification, the traditional system falls short, and should be replaced with methods that are more permanent and amenable to recording, such as ear tagging.

Cattle keepers are able to correctly identify the genetic relationships among animals in their herds up to some point. It is expected that beyond the second generation, relationships are very difficult to accurately remember. However, up to 67% of all respondents in this survey claimed that they memorise Ankole cattle pedigrees up to grandparent-grand offspring level. The skill of kinship assignment therefore seems to be well developed among the Ankole cattle pastoralists. However, the possible presence of errors due to human memory loss and other factors necessitates a validation study at molecular level.

The higher selection intensity of males as compared to females by the pastoralists follows conventional wisdom, since a superior bull is able to rapidly pass on its genetic superiority to more progeny. It was interesting to observe that first-born bulls are not selected for breeding. Such bulls may not be able to express their superiority well since the environment of their pre-natal and early post-natal development may have been compromised by the physiological immaturity and undeveloped mothering ability of their dam. Selection criteria of Ankole cattle (Table 4) can be grouped into three namely, criteria that enhance production/growth, those that enhance survival or adaptation and those that serve cultural roles. Large body size and frame, long tail with big base, large testes, a deep scrotum and a large udder

Table 6 Culling criteria of Ankole bulls and cows and the ranking of the importance of these culling criteria

	Type of cattle							
	Bulls				Cows			
Culling Criterion (n=248)	Households[a]	Households[b]	Weighted ranks[c]	Ranking[d]	Households[a]	Households[b]	Weighted ranks[c]	Ranking[d]
Inbreeding	153	97	385	0.35	–	–	–	–
Old age	93	39	192	0.17	70	52	182	0.28
Poor productive performance	94	28	117	0.16	76	38	173	0.27
Production of males only	50	13	85	0.08	9	3	18	0.03
Bad temperament	33	12	66	0.06	16	2	26	0.04
Poor health	31	9	52	0.05	54	19	115	0.18
High calf mortality	23	5	37	0.03	9	1	14	0.02
Infertility	22	4	35	0.03	42	12	82	0.13
Others[e]	33	6	54	0.04	13	2	17	0.02

[a] Households ranking culling criterion as important (i.e. 1,2,3,4 etc.)

[b] Households ranking culling criterion first

[c] The weighted rank was computed by multiplying the proportion of households that gave a rank and the rank weight. Rank 1 was weighted 3; 2 was weighted 2; and rank 3 was weighted 1

[d] Index=sum of [3 for rank 1+2 for rank 2+1 for rank 3] of a culling criterion divided by sum [3 for rank 1+2 for rank 2+1 for rank 3] for all culling criteria of a particular type of cattle

[e] Includes bad conformation, slow growth, unfavourable colour and bad body condition

are believed to be indicator traits for production. These findings are in agreement with Ndumu et al. (2008) who reported that performance and fitness traits are emphasized by Ankole cattle keepers when selecting cows. On the other hand, the red coat colour and the large white curving horns do not offer direct functional roles to the animals' productivity, but do confer cultural aesthetic value which cannot be underrated, as high-performing animals without these features are snubbed. As noted by a few of the respondents in the study, cattle with the deep red coat colour (*bihogo*) may fetch a higher market value than other similarly sized animals but of other colours. The big horns especially in bulls could help in fights to establish territorial dominance and pecking order. For the cows, it is plausible that possession of the long horns may help to manoeuvre through the savannah thickets while grazing on the open range. We suppose that desire for selecting cattle with a large dewlap aims at better survival and adaptation of the selected animals, as the dewlap helps in body temperature regulation. A large dewlap and loose skin provide a large surface area for perspiration under the hot and humid tropical climatic conditions under which the Ankole cattle are reared.

However, while this study found that most Ankole pastoralists prefer bulls with big and equal-sized testes, Nakimbugwe and Muchunguzi (2003) reported that there is a dominant preference for bulls with one testis, as an indicator for producing many female offspring. To our understanding, this is actually an undesirable abnormality of unilateral cryptochidism. Selection for multiple traits is known to lead to faster genetic progress when traits are highly heritable and show wide phenotypic variation (Dekkers and Van der Werf 2007). There is therefore a need to determine the genetic parameters of the different traits of interest to Ankole cattle pastoralists, such that only those traits which influence production and adaptation, and have a medium-to-high level of heritability can be incorporated into a selection programme.

Selection criteria for Ankole cattle to a large extent are similar to criteria used by other pastoral cattle keepers in the East African region. For example, large body-sized bulls are also preferred by the Karamojong (Loquang 2003), Kenyan Maasai (Kavana et al. 2005), Tanzanian Maasai (Yiapin 2003), Ethiopian Boran (Halake 2003) and the Beni-Amer of Eritrea (FAO 2003). Bulls whose close female relatives (grand dams, dams and female siblings) produce much milk, have higher survival rates, are drought tolerant and grow fast are also preferred by Tanzanian Masaai (Yiapin 2003), Karamojong (Loquang 2003) and Ethiopian Boran (Halake 2003).

According to the Ankole cattle keepers, their cattle are superior to the East African Zebu in body size and weight. This superiority is mainly as a result of the Ankole cattle being raised in locations that have better forage biomass yield and a relatively more conducive climate. However, Ankole cattle are inferior in milk yield when compared to

exotic dairy cattle, probably due to their inherent poorer genetic merit coupled with no known breeding programme to improve this trait. Nevertheless, the Ankole cattle, like other animal breeds that are indigenous to the tropics, are superior to their exotic counterparts in several traits. Four of the six superior traits identified in our study influence survival, while the rest influence production. Resistance to diseases, ability to withstand environmental stress (Philipsson et al. 2006) and ability to be attuned to certain vegetation types (Workneh 2000) are key reasons why indigenous livestock breeds perform better than breeds that are introduced into certain environments. All female cattle that survive to adulthood are retained for further breeding and may only be culled later in life on the basis of old age and poor fertility (Table 6). This is a case of progressive selection, whereby all the female calves that survive and grow fast are retained, and then later assessed based on fertility (calving interval) and milk yield.

The increasing commercial interests in the form of increased market demands for milk and cash incomes in Uganda have generally led to the growing population of exotic cattle breeds. Ankole cattle are therefore increasingly under threat from crossbreeding (Wurzinger et al. 2007). From our study, we observe that conservation of the Ankole cattle appears to be mainly a concern among the elderly cattle owners. The threats to the Ankole cattle breed also appear to be closely associated with urbanisation. Increasing human population in urban areas directly correlates with higher demand for livestock products. Such demand and associated cash returns logically influence peri-urban cattle owners to keep crossbred cows, because such cows are more productive compared to pure Ankole cows. Except in circumstances where Ankole cattle are comparatively bio-economically superior (i.e. in harsh environments or where infrastructure is poor), the exotic cattle and their crosses with Ankole will continue to be more attractive. These observations imply that conservation efforts must be thought through by all interested players and a sustainable strategy developed.

Conclusions

From this part of the wider study, the following conclusions can be drawn: Pastoralists' cattle serve diverse roles, are selected based on various criteria, and due to changing resource access regimes, production interests appear to be edging out cultural values and need for survival traits. Ankole cattle contribute to the livelihood of majority households, and for many, they are the only source of income. Ankole cattle keepers have a rich body of indigenous knowledge on this breed, and this knowledge should effectively be incorporated into planned selective improvement schemes for this breed.

Recommendation

During selection of both female and male Ankole cattle, most emphasis should be put on production traits. Aesthetic and adaptation traits should nevertheless be incorporated. A breeding programme should eventually be developed, clearly considering the traits of interest of cattle owners. A selection index which considers the value of the different traits should be a key tool in implementing such a programme. This will improve the competitiveness of the Ankole breed and ensure its sustainable utilisation in its current production systems in Uganda, and elsewhere.

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Ethical standards This research followed ethical standards and complied with regulations of the Uganda National Council for Science and Technology.

Conflict of interest The authors declare that they have no conflict of interest.

Author contributions Conceived and designed the study: DRK, DM, OH. Performed the study: DRK, DM, OH, OM. Analyzed the data: DRK, MN, DM. Contributed analysis tools: MN, OM. Wrote the paper: DRK, OM, OH.

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