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Pasture use and management strategies in the Ankole pastoral system in Uganda

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Abstract

The Bahima ethnic group have been crossbreeding autochthonous Ankole with Holstein-Friesian cattle. Separate herds (pure Ankole and crossbreds) are common. A survey was conducted to characterize pasture utilization and management in the Ankole region to gain a better understanding of current and emerging practices. Herds are largely grazed by continuous stocking although there are efforts to establish paddocks. Factors considered for pasture allocation to cattle genotypes were high-quality feed, limited shrubs/weeds and close proximity to homestead for 80, 80 and 30% of farmers, respectively. Cross-bred cattle were kept on medium/high-quality, and Ankole cattle on medium/low-quality pastures. Pastures for cross-bred cattle yielded 0·17 t ha^{-1} more dry matter than pastures allocated to Ankole cattle. Crude protein (CP) content of Ankole pasture was significantly ($P < 0·05$) lower than CP of cross-bred pasture (6·3% compared with 7·3%). Neutral detergent fibre content was similar (72·8% vs. 69·8%) for both pasture types. Farmers' perceptions of indicator plant species were important for allocation of pasture. *Hyparrhenia rufa, Brachiaria spp.*, *Themeda triandra* and *Chloris gayana* were identified as the preferred pasture species. *Sporobolus pyramidalis* and *Cymbopogon afronardus* were the most undesirable pasture species. *Brachiaria spp.* offers an opportunity for utilization as hay for dry season supplementation.

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Introduction

In large parts of Africa, livestock production systems in semi-arid areas are generally based on conversion of pasture into milk and meat by grazing cows without any supplementation (Abdalla *et al.*, 1999; Sottie *et al.*, 2009). Livestock production by the Bahima ethnic group in south-western Uganda is not exceptional. The Bahima traditionally kept exclusively long-horned Ankole cattle, but recent studies report that Ankole cattle keepers have begun cross-breeding pure Ankole with Holstein-Friesian cattle (Sserunkuuma and Olson, 1998; Alary *et al.*, 2007; Wurzinger *et al.*, 2008). Separate herds consisting of either pure Ankole or cross-bred animals are common. Previous studies report a positive contribution to milk production by cross-breeding Ankole and Holstein–Friesian cattle (Wang *et al.*, 1992; Grimaud *et al.*, 2007). However, introduction of European *Bos taurus* breeds in the tropics is limited by a number of problems caused by nutritional and environmental factors (Igono and Aliu, 1982; Matias, 1998; Komwihangilo *et al.*, 2009). The quantity and quality of pasture are major challenges owing to critical feed shortages, especially during the dry seasons. Before the introduction of cross-breds, livestock keepers coped with pasture deficits mainly by transferring their animals to areas outside villages where there was plenty of grazing land available (Mulindwa *et al.*, 2009). However, unlike pure Ankole cattle, cross-breds are unable to trek long distances and are consequently more vulnerable during droughts. In hot climates, high ambient temperatures, high direct and indirect solar radiation, lack of air movement and humidity are the main environmental factors imposing strains on

animals. These result in a decline in production, such as weight loss or infertility (Finch, 1984). There is a need to understand how farmers are coping with challenges related to pasture management and use, given current shifts in their cattle breeding strategy. Traditional range management has received little attention so far (Mapinduzi *et al.*, 2003; Kyagaba, 2004) because management of rangelands in East Africa depends to a large extent on pastoralists' indigenous knowledge. Understanding indigenous ecological knowledge will complement design and implementation of sustainable development programmes to benefit vulnerable people in emerging production systems in the Ankole subregion. The objective of the study was to describe how farmers decide to allocate pasture to either cross-bred cattle or Ankole cattle. An additional aim was a better understanding of the implications of farmers' decisions on pasture utilization and management in a rain-fed, extensive dairy production area. Ultimately this benchmark information can be used to assist in the design of strategies/technology options that will contribute to sustainable livestock development programmes.

Materials and methods

Study area

This study was carried out in Kiruhura district, southwestern Uganda. The area is characterized by a mix of undulating plains and sloping to moderately steep topography. The mean annual rainfall for Mbarara (meteorological site at Kakoba 1963 –2008) is 931 mm with a coefficient of variation of 16% (Mulindwa *et al.*, 2009). Rainfall is bimodal peaking in April and May and September to November, with two prolonged dry seasons in June to August and December to February. Temperatures are moderate, peaking at 29°C with a variation of 2–7°C. Two separate herds comprising Ankole or Ankole × Holstein-Friesian cattle are grazed on separate pastures throughout the year on ten farms selected for sampling. In this study, the term 'genotype' is used to describe the herd type with which a pasture was stocked, i.e. either Ankole or Ankole × Holstein Friesian. Where appropriate, the grazing terminology follows Allen *et al.* (2010).

Survey on pasture structure, pasture output and management

Data were obtained by interviewing farmers, using pretested, structured questionnaires, between March and June 2008. Interviews were conducted in the vernacular Runyakole language by trained enumerators. Information was collected on pasture yield, pasture quality, pasture size, size of sampling plots, reasons for allocation of a grazing area to a genotype, pasture composition, nutritive value [crude protein (CP) and neutral detergent fibre (NDF)] of pasture plants, pasture use and management as well as soil erosion status. Paddock sizes were taken as stated by farmers and were not measured during this study. Pasture productivity assessment was made by asking farmers to give a percentage estimate of their grazing land occupied by low-, medium- and high-yielding pasture. A similar question was used for assessing pasture quality. Thorough explanations were given to farmers about the meaning of pasture quality and quantity as these two parameters were often confused by farmers.

Herbage sampling and measurements

Pasture samples were taken twice. Two separated sampling periods were chosen to enable an analysis of the effect of season on pasture yield and quality. The first sampling round took place during the late dry season between 22/3/2008 and 9/4/2008. The second sampling round was conducted during the early wet season between 7/5/2008 and 23/5/2008. The interval between sampling on the same farm was between 5 and 6 weeks. One paddock was selected from each genotype's grazing area on each farm. Areas near watering points or cattle handling facilities were avoided because of frequent disturbances by cattle activity. On selected sites, a 10-m length transect line indicated by posts (every metre) and string was established according to Gaucherand and Lavorel (2007). All pasture plants touching a post were cut and measured for various plant traits (results presented in Roschinsky, 2009). Four transects per farm were conducted, two on Ankole and two on Ankole × Holstein-Friesian pastures. During the first sampling round, two pasture yield samples were chosen randomly parallel to either side of each transect line. Transect lines used during the first sampling were also used as reference lines during the second sampling for selection of adequate pasture yield sampling sites. During the second sampling round, two pasture yield samples were taken perpendicular to each transect line to ensure random sampling. Yield sampling sites were chosen based on visual similarity with transect sites. Sample area size was 1 m^2 (0·2 m × 5 m). All herbage enclosed was harvested to ground level. During both sampling rounds, four samples per Ankole pasture and four samples per cross-bred pasture were collected. Fresh pasture matter was taken and recorded in the field. After weighing, samples were pooled according to transect site, and approximately 0·5 kg was used for further laboratory analysis. Samples were oven dried for 48 h at 65°C to obtain dry matter (DM) yield per ha. Further analyses were conducted for CP content and NDF content. CP concentration was

calculated from nitrogen (N) concentration in the herbage (N × 6·25) determined using the Kjeldahl procedure (AOAC, 1990). NDF was determined according to Van Soest (1963).

Data analysis

Survey data were not analysed statistically. Where possible percentages/frequencies, minima, maxima, mean and median values were calculated. Transect data were divided into continuous and discontinuous traits for statistical analysis (further described in Roschinsky, 2009). Fresh matter and DM were analysed using a general linear model in SAS 9.1 (SAS, 2002), using the model $y = \mu + F_i + B_j + S_k + (FB)_{ij} + (FS)_{ik} + (BS)_{jk} + \epsilon_{ijk}$ (μ = mean; F = fixed effect farm: factor levels i = 1–10; B = fixed effect genotype: factor levels j = a (Ankole), c (cross-bred); S = fixed effect season: factor levels k = 1 (late dry), 2 (early wet); FB = effect of interaction between farm and genotype; FS = effect of interaction between farm and season; BS = effect of interaction between genotype and season and ϵ = residuals). DM per cent was analysed using the same statistical procedure and model. Moisture content of pasture samples was calculated and used to determine herbage DM, as per cent. Seventy-five samples were analysed statistically for fresh matter, DM and DM contents. For analyses of CP content and NDF, a general linear model in SAS 9.1 (SAS, 2002) was used. Seventy-six samples were analysed using the model $y = \mu + F_i + B_j + S_k + (FB)_{ij} + (FS)_{ik} + \epsilon_{ijk}$ (μ = mean; F = fixed effect farm: factor levels i = 1–10; B = fixed effect genotype: factor levels j = a (Ankole), c (cross-bred); S = fixed effect season: factor levels k = 1 (late dry season), 2 (early wet season); FB = effect of interaction between farm and breed; FS = effect of interaction between farm and season and ϵ = residuals).

Results

The following section presents results from our survey of pasture management and pasture composition. Existing pasture structures and utilization are described as well as farmers' knowledge of soil erosion and pasture composition on their land. Furthermore, farmers' grading of their respective grazing land and results from laboratory analysis of pasture nutrients and DM are presented. The last section contains our findings on seasonal effect on various CP%, NDF% and DM (t ha^{-1}).

Pasture structure

The number of paddocks per farm varied from one to ten (five farms: one or two paddocks; four farms: more than two paddocks; and one farm: ten paddocks). On none of the sample farms, was the Ankole grazing area further divided into paddocks. On the other hand, the cross-bred grazing area was divided into paddocks on some farms. Size of pastures analysed per farm ranged from approximately 55 to 185 ha (mean: approximately 122 ha, median: 115 ha). Estimated mean/median size of pastures stocked with cross-bred cattle (mean: 42 ha, median: 15 ha) was smaller than estimated mean/-median size of Ankole pastures (mean: 79 ha; median: 65 ha). Little investment has been made towards development of paddocks. Rotating animals using herdsmen is becoming more difficult as farmers complain of labour scarcity.

Pasture utilization

Criteria used by farmers to allocate grazing areas to cattle genotypes are presented in Table 1. The percentages of farmers giving a certain response are given in brackets. Most important factors for allocation to cross-breeds were the following: availability of high-quality feed (80%), limited shrubs/weeds (80%) and close proximity to the homestead (30%). Ankole cattle were largely grazed on areas: infested with shrubs (50%), dominated by low-quality pasture and further away from watering points (30%). Most farmers (eight of ten) were keeping cattle on pastures without any system of rotational stocking. Nine farmers kept Ankole permanently on the same pasture; seven farmers did the same with cross-breed cattle. On one farm, a rotational stocking system was used for cross-breed cattle, with 1-week stocking and 9 weeks resting period per paddock. This farm had ten fenced paddocks for the cross-bred herd and conserved forage as hay. With the exception of one farmer (who gave no

Table 1 Factors considered by farmers when allocating grazing land to a cattle genotype (Ankole or Ankole × Holstein-Friesian crossbreds).

Factor	Crossbred pastures (n = 10)	Ankole pastures (n = 10)
Water readily available	2	0
Water restricted	0	3
High-quality feed	7	1
Poor-quality feed	0	5
Limited shrubs/weeds	8	0
Infested with shrubs	0	5
Close to homestead	3	0
Distant from homestead	0	1
Not kept for dairy production	0	1

Numbers represent the number of farmers giving the respective factor.

definite answer), all others reported that they kept one of the two cattle genotypes exclusively on the selected pastures. Bush clearing was the major pasture improvement method used on all farms. Additionally, unpalatable plants, like lemongrass (*Cymbopogon afronardus*), were being cleared mainly from cross-bred cattle pastures. Farmers stressed that, unlike pure Ankole cattle, crossbreds grazed on bushy pastures tend to suffer from eye infections as well as from frequent non-infectious abortions caused by grazing on poisonous weeds.

Soil erosion, overgrazing and pasture composition

Of the 20 pastures assessed, only four were described as being subjected to soil erosion. Based on farmers' responses, no crossbred pastures were affected by soil erosion whereas 40% of Ankole pastures were affected. Two farmers reported that soil erosion on their farms has remained static, whereas the other two farmers could not indicate any trend.

Dominant plant species considered as 'good' (desirable) and 'bad' (undesirable), and their respective qualities are presented in Tables 2 and 3. Numbers in brackets indicate the frequency with which a species was mentioned by farmers. *Hyparrhenia rufa* (8) and *Brachiaria spp.* (8) were ranked as most desirable followed by *Themeda triandra* (4) and *Chloris gayana* (3). Most common attributes of 'good' species were the following: high nutrient content and high herbage yield. *Hyparrhenia rufa* was mentioned as having the additional attribute of being highly resistant to drought, unlike *Brachiaria sp* and *Themeda triandra*. The latter was reported to sprout very fast at the onset of rains.

Sporobolus pyramidalis (10) was ranked as the least desirable followed by *Cymbopogon afronardus* (6). *Themeda triandra* has been classified by one respondent as an undesirable species, although he did not specify why he chose to classify it as 'bad' even though he was asked after he made this categorization.

Seventy per cent of farmers acknowledged that certain plants have gradually been disappearing from their rangelands in the course of the last 10 years. Thirty per cent had not noted the disappearance of any pasture species. Pasture species noted as gradually reducing were *Hyparrhenia rufa* (5), *Chloris gayana* (2) and *Brachiaria spp.* (1). Species noticed to be gradually increasing in the course of the last 10 years were *Sporobolus pyramidalis* (4), *Lantana camara* (3) and *Cymbopogon afronardus* (1). Species identified as gradually reducing were all considered desirable, whereas those observed to be increasing were all considered undesirable.

Table 2 Plants considered 'good' by farmers and qualities assigned to these species.

Plant (times mentioned)		
Local name	**Botanical name**	**Qualities described (times mentioned)**
Emburara (8)	*Hyparrhenia rufa*	Highly nutritious (6) Increases milk production (2) Drought resistant (3) Cows produce concentrated milk (1) Fattens animals (1) Palatable (1)
Ekijubwe (8)	*Brachiaria sp.*	Highly nutritious (6) Increases milk production (2) Animals grow fat and are healthy (1) Soft (1) High herbage yield (1) Very palatable (1) Not drought resistant (1)
Orunyankokole (3)	*Chloris gayana*	Highly nutritious (1) Nitrogen source (1) Fattens animals (1) Increases milk production (1) Rare (1)
Kyooya (1)	n.s.	Soft (1)
Ekikamba (1)	n.s.	Nitrogen source (1)
Marende (1)	n.s.	Nutritious (1)
Eyojwa (4)	*Themeda triandra*	Nutritious (3) Drought resistant (2) Not drought resistant (1) Sprouts very fast after rain (1)
Orukwamba (1)	*Cynodon sp.*	Animals like it especially at rest (1)
Eyojo (1)	n.s.	Animals fatten (1) Increases milk production (1)

n.s., not significant.
'Good' plants were defined as species desired by farmers. Numbers in brackets indicate that the frequency a given species was mentioned.

Farmers' pasture quality grading and laboratory assessment of CP and NDF

Results of farmers' assessment of pasture in terms of quality are presented in Table 4. Three farmers graded their pastures into high and low quality, three farmers graded into medium and high quality, two farmers

Table 3 Plants considered 'bad' by farmers and their assigned qualities.

Plant species		
Local name	**Botanical name**	**Qualities**
Egashi (10)	*Sporobolus pyramidalis*	Causes loss of teeth in cattle (8) Hard to chew (5) Neck meat becomes harder (1) Out-competes other species (1)
Omutete (6)	*Cymbopogon afronardus*	Sharp edges injure cows' lips/mouths (2) Out-competes other species (2) Refuge for ticks and tsetse flies (1)
Ekicuguza-Mbogo (2)	n.s.	Causes diarrhoea (1)
Ekihuki (1)	*Lantanta camara*	Poisonous (1) Causes photosensitivity (1)
Kagyenz'enda (1)	n.s.	Thorny (1)
Eyojwa (1)	*Themeda triandra*	
Marende (1)	n.s.	Causes diarrhoea (1)

n.s., not significant.
'Bad' plants were defined as being undesirable for farmers. Numbers in brackets indicate the frequency a given species was mentioned.

Table 4 Farmers' pasture-quality classification of their total grazing area. Results are presented separated by farm.

	Quality estimation by farmers (%)		
Farm	**Low**	**Medium**	**High**
1	50	0	50
2	10	0	90
3	15	0	85
4	0	20	80
5	10	20	70
6	50	50	0
7	20	60	20
8	0	10	90
9	35	65	0
10	0	10	90

graded into low and medium quality, and two farmers graded into all three categories. Crossbred cattle pastures were graded into medium (5) or high (5) quality while Ankole cattle pastures were graded into medium (6) and low (3) quality with only one farm having a high-quality grade pasture for Ankole. No crossbred pasture was graded as low-quality pasture.

Results from laboratory analysis show that CP values at the farm scale ranged from 5·6% to 8·5%. CP content was significantly ($P < 0·05$) different between pastures grazed by different genotypes (Table 5). Ankole pastures had an average CP of 7·3% and crossbred pastures an average CP of 6·3%. The lowest CP values were similar for pastures grazed by both genotypes (crossbred pastures, 5·3%; Ankole pastures, 5·5%), but CP value range was larger for pastures grazed by Ankole cattle (maximum CP% of 8·7% for crossbred pastures and 10·6% for Ankole pastures). NDF values ranged from 68·2 to 81·6%. NDF was slightly higher on crossbred range (72·8%) than on Ankole range (69·8%). The range of NDF was smaller for Ankole pastures (66·3–73·5%) than for crossbred pastures (68–93·8%).

Farmers' assessments and laboratory assessments of pasture for DM yield

Farmers' assessment of pasture quantity and laboratory-derived calculations are presented in Table 6. Farmers were asked to grade their pasture quantity (herbage yield) into three following categories: low, medium or high. Three farmers graded their pastures into categories low and high, three into medium and high, two into low and medium and two into all three categories. Most pastures were considered high or medium yielding, while low yielding was the least reported category. Although the results are not clear cut, farms for which pasture was graded into medium- and high-quantity classes were also found to have higher DM yields (e.g. farm 8: 2·23 t ha^{-1} and farm 10: 2·49 t ha^{-1}) compared with farms graded into low- and medium-quantity classes (e.g. farm 6: 1·88 t ha^{-1} and farm 9: 1·99 t ha^{-1}).

When grading is analysed according to genotype (Ankole vs. crossbred), five farmers graded crossbred pastures into medium-quantity and five into high-quantity class (Table 7). Ankole pastures were graded into low, medium and high quantity by three, six and one farmers, respectively. DM yield calculated from pasture cuts (i.e. laboratory analysis) showed a significant ($P < 0·05$) difference between pastures grazed by different genotypes (crossbred pastures 0·17 t ha^{-1} more DM than Ankole pastures). None of the farmers graded crossbred pasture into the low-quantity class. The mean of 1·96 t ha^{-1} DM in Ankole pastures is rather misleading as these areas were dominated by *Sporobolus pyramidalis* and *Cymbopogon afronardus*, species described by farmers as less palatable.

Table 5 Comparison of farmers' pasture quality class grading and nutrient analyses results of pasture samples. Results are presented separated by genotype.

	Farmers grading quality (n = 20)			Laboratory analysis for nutrients (LSMeans and ranges)			
Breed	**Low**	**Medium**	**High**	**CP (%)**	**Range CP%**	**NDF (%)**	**Range NDF %**
Ankole	0	5	5	7·3[a]	5·5–10·6	69·8	66·3–73·5
Crossbred	3	6	1	6·3[b]	5·3–8·7	72·8	68–93·8
s.e.				0·28		1·78	

s.e., standard error; CP, crude protein; NDF, neutral detergent fibre.
Superscripts indicate significant difference, ($P < 0·05$).

Table 6 Comparison of farmers' pasture quantity class grading and DM (t ha^{-1}) of pasture samples. Results are presented separated by farm.

	Pasture yield estimation by farmers (%)			Laboratory calculated yield	
Farm	**Low**	**Medium**	**High**	**DM (t ha^{-1})**	**s.e.**
1	66	0	34	2·49[a]	0·1
2	10	0	90	2·25[a]	0·1
3	5	0	95	1·63[b]	0·1
4	0	20	80	1·78[b]	0·1
5	25	35	40	2·01[ab]	0·1
6	60	40	0	1·88[b]	0·1
7	30	20	50	1·90[b]	0·1
8	0	10	90	2·23[a]	0·1
9	35	65	0	1·99[b]	0·2
10	0	10	90	2·49[a]	0·2

s.e., standard error; DM, dry matter.
Superscripts indicate significant differences, ($P < 0·05$).

Seasonal effect on DM, CP and NDF

Least-square means of the seasonal effect on DM, CP and NDF are presented in Table 8. There was no significant ($P > 0·05$) seasonal effect on DM. In wet-season pasture samples, a larger average of 0·25 t ha^{-1} DM more was measured than in dry-season pasture samples. Season did not have a significant ($P > 0·05$) influence on CP content. Season and genotype interaction was not significant ($P > 0·05$) although during the dry season CP was higher in pasture grazed by both genotypes. NDF was not significantly ($P > 0·05$) influenced by season. NDF content was higher during the dry than that during the wet season.

Discussion

This study aimed at generating information about farmers' awareness of the state of their range and how they have applied their indigenous knowledge to rangeland utilization. We will discuss pasture structure, soil erosion, pasture utilization, pasture composition and farmers' grading of pasture quality and quantity.

The Bahima livestock keepers possess immense knowledge about traditional forage species which they ably identified, and hence, there is a need to involve them in the promotion of fodder production. Possibly the greatest obstacle in improving pastures in the Ankole region is the low priority farmers place on pasture concerns relative to livestock husbandry.

Pasture structure and utilization

Fifty per cent of farms have only one or two paddocks. The limited establishment of paddocks might be explained by the usual practice of herding in the study area. It has been reported that cattle are always

Table 7 Comparison of farmers' pasture quantity class grading and DM (t ha^{-1}) of pasture samples. Results are presented according to genotype.

	Pasture yield estimation by farmers (n = 20)			Laboratory analysis yield		
Breed	**Low**	**Medium**	**High**	**DM (t ha^{-1})**	**s.e.**	**Range (t ha^{-1})**
Crossbred	0	50	50	2·13[b]	0·05	1·25–2·58
Ankole	30	60	10	1·96[a]	0·1	1·78–2·57

s.e., standard error; DM, dry matter.
Superscripts indicate significant difference, ($P < 0·05$).

Table 8 Seasonal effect on DM (t ha^{-1}), CP % and NDF %.

		Quality parameter		
Season	**N**	**DM (t ha^{-1})**	**CP%**	**NDF%**
Dry	38	1·97	7·0	73·4
Wet	36	2·12	6·6	69·2
s.e.		0·10	0·29	1·81

s.e., standard error; CP, crude protein; DM, dry matter; NDF, neutral detergent fibre.

accompanied by herdsmen who herd them to grazing areas and watering points (Wurzinger *et al.*, 2008). Despite system changes (from nomadic to sedentary lifestyle, communal to individual ownership of land) and breeding scheme alterations, the results indicate that currently a transition is in place during which traditional practices and commercial cattle management methods are used concurrently. In our opinion, there is a need to encourage well planned paddocks as these will ensure efficient use of pasture and labour, which farmers described as being a scarce resource. Studies carried out elsewhere (Corsi *et al.*, 2000) reported an increased stocking rate from 0·8 to 1·2 AU ha^{-1} $year^{-1}$ caused by the introduction of rotational stocking (AU = 450 kg of live weight).

Pasture utilization

Pasture utilization findings indicate that farmers give preferential treatment to cross-bred herds. Farmers reported during the interviews that crossbred cattle cannot walk long distances with the same ease as Ankole cattle; hence the decision to keep them near homesteads and watering points. The influence of breeds on walking behaviour has been reported (Herbel and Nelson, 1966) although a study comparing Ankole with Ankole × Holstein-Friesians did not find significant differences in walking behaviour (Huber *et al.*, 2007). The farmers' decisions are backed by previous studies in this area (Sserunkuuma and Olson, 1998; Okello *et al.*, 2005), which ascribed a high adaptability of Ankole cattle to the harsh conditions prevailing in Uganda's' rangelands, and also a capability of trekking long distances. These characteristics are obvious advantages of Ankole cattle.

The reasons which farmers gave for suitability of a plot imply that crossbred pastures need more management than Ankole cattle. Our results show that farmers choose what they consider their 'better' pastures for cross-bred cattle and enhance pasture quantity and quality by concentrating management efforts on these plots. As breeds such as Holstein-Friesian, and consequential crossbred Ankole × Holstein-Friesian cattle, have higher maintenance requirements than most tropical indigenous breeds (Chamberlain, 1989), choice of higher-quality pastures for crossbred cattle is logical. Reasons for suitability given by farmers also lead to the assumption that pastures not fit for crossbred cattle are still considered fit for Ankole cattle. According to the farmers, Ankole can tolerate pastures of poorer quality. This may also explain that the larger size of most Ankole pastures is expected to balance minor pasture quality in sustaining Ankole herds.

Soil erosion, overgrazing and pasture compostion

On the farms surveyed in our study, erosion was reported to occur only in Ankole pastures. Soil erosion is an indicator for overgrazing. Overgrazing leads to degradation of rangelands through vegetation change and soil erosion (Twinamasiko, 2001). Higher likeliness of Ankole pastures to be stocked permanently on the same plot, and shorter intervals between disturbance support the interpretation that Ankole pastures are more likely to be subjected to overgrazing than cross-bred pastures. The differences between farms with regard to soil erosion could be attributed to variations in stocking density. Mulindwa *et al.* (2009) reported that 63% of surveyed farms in this study area had stocking densities higher than carrying capacities throughout the year, while 37% were overstocked during dry months. These findings call for measures aimed at mitigating soil erosion.

Grazing has the potential to produce major shifts in species composition (Diaz *et al.*, 1994 in Diaz *et al.*, 1999). Although literature reports that floras show little response to disturbances that have been there for a long time (Lavorel *et al.*, 1999), most farmers reported an appearance of new plants and disappearance of known plants during the past decade. Interestingly, all the plants reported to have disappeared were classified as 'good' plants by farmers. All plants that had appeared recently have been classified as 'bad' plants. This could be evidence of an ongoing decline of pasture quality. Another possibility could be the fact that when grazing, animals tend to select the most palatable species, leaving less-preferred species ungrazed. Therefore, 'bad' species are not subjected to intensive stress caused by grazing (defoliation) and over time, out-compete 'good' species. Alternatively, it may just show that farmers' perception on compositional changes concentrates on plants with special importance to farmers, whether positive or negative. The extent of compositional change has not been assessed in this study so it is impossible to determine whether the introduction of crossbred cattle has influenced pasture composition. Separation of crossbred cattle from Ankole has been

happening over the last 8–22 years. The duration varied greatly between farms, and it has not been ascertained whether different breeds have always been kept on the same pastures.

Pasture quality and laboratory (CP, NDF)

The allocation of pastures to cattle genotypes by farmers follows their perception and interpretation of the qualities of indicator plant species. Medium- or high-quality graded areas were allocated to crossbred cattle. Estimated percentage of high-quality pasture seems quite high (mean of all farms: 57·5%). This suggests that most farmers are content with the quality of their pastures.

Overall, the mean CP content of pastures falls within the range measured by other studies in the same area (Long *et al.*, 1969, Mihreteab, 2000). Compared with temperate-zone pastures, with CP contents around 20% (Weinmann, 1955), average CP contents measured were low. CP figures reported in this study are generally lower than the 9·2% on cleared farms and the 8·9% on bushy farms reported by Mugasi *et al.* (2000). The CP content was higher in samples taken from Ankole-grazed than from the crossbred-grazed pastures, but there was a wider range of CP values occurring for samples taken from Ankole pastures. Reasons for the higher CP on Ankole-grazed pastures may have arisen because crossbred cows, with higher nutritional requirements because of their higher production capability (Chamberlain, 1989) may have a higher selectivity for nutritious forage components and therefore may select protein-rich plants. As the nutritional requirements of Ankole cattle are lower, owing to their lower production level, they may be less selective towards protein-rich forage plants. Consequently, this could have lead to a higher abundance of protein-rich plants in pasture samples taken from Ankole-grazed pastures. If Ankole cattle were less selective in their foraging behaviour, the resulting different mixture of pasture species compared with crossbred paddocks would coincidentally affect the CP content of forage on offer.

Farmers' assessment of their pasture in terms of quality and quantity only partly concurred with laboratory analysis. Pastures categorized as medium- and high-quality classes showed comparably high CP contents (up to 7·4%) and relatively low NDF (up to 69·8%). Farms on which pastures were graded into low and medium quality had lower CP (up to 6·7%) and relatively high NDF (up to 73%). These differences are not statistically significant but indicate a general compliance between farmers' quality assessment and the laboratory analysis.

In general, farmers categorize Ankole-grazed pastures to be of poorer quality than crossbred pastures. As mentioned earlier, CP analysed was significantly higher on Ankole pastures (7·3%) vs. crossbred pastures (6·3%). NDF contents were higher for Ankole pastures. Thus, farmers' estimations of pasture quality can be supported only partly by laboratory analyses.

The qualities that farmers attributed to each species offer an opportunity of temporal utilization for feeding cattle all year round. *Brachiaria spp* could be harvested during the rainy season, and conserved as hay and fed to cattle as a supplement to *Hyparrhenia rufa* during the dry season.

Pasture quantity grading and DM analysis

Farmers estimated a difference in pasture yield between sample pastures stocked with different breeds. Both types of quantitative assessment (farmers' estimation and laboratory analysis) indicate that there is a variation between farms in terms of DM yield, which could be attributed to differences in pasture management and stocking rates. As observed from criteria used by pastoralists to allocate grazing land, the higher DM yield on crossbred pastures confirms that farmers allocate areas with more abundant pastures to crossbreds whereas Ankole cattle are grazed on poorer pastures. Pastoralists seem to compensate pure Ankole cattle herds by allocating them to a larger percentage of the grazing area compared to crossbreds. This shows that farmers are very well able to estimate pasture yields correctly and allocate pastures the way they intend to.

Our DM results confirm that farmers' yield estimations might be biased to be higher than the actual values. Proof for this could be our data of farmer pasture categorization. Although half of the farmers estimate more than 80% of their pasture to be high yielding, only 30% of our sampling pastures were categorized as high yielding. As pasture yield and pasture quality are essential for correct determination of stocking rates, further investigations are advisable for future studies.

Seasonal effect

Even though there is no significant seasonal influence on CP content, values are higher than the 3% reported for both March and June by Okello *et al.* (2005) who studied Ankole pastures in the same region. NDF content was slightly higher on crossbred range compared with Ankole range, but both figures were higher than those reported by Mugasi *et al.* (2000) (63 and 62%) who also claimed that high crude fibre level is common in tropical pastures, attributed to high temperatures which lead to lignification. The absence of a seasonal effect on NDF is not consistent with a previous study (Kagoda, 2001) during which a seasonal variation

of NDF measured in pastures in south-western Uganda could be determined. The high NDF values for the dry season in this study could be attributed to the pasture's advanced stage of maturation and lignification.

Ankole vs. crossbred cattle

During our study, farmers mentioned certain characteristics of Ankole cattle that show how well adapted they are to the local production environment. Certainly, the ability of Ankole to utilize poorer pastures is another advantage of this breed. A study by Galukande *et al.* (2008) showed that body condition score for Ankole and Ankole-Holstein-Friesian crossbreds did not differ significantly, whereas Okello *et al.* (2005) reported that despite poor conditions in dry spells, Ankole cows maintained a constant body condition score over the year. They claimed Ankole cattle were adapted to the harsh climatic conditions prevailing in the region, which was partially attributed to their ability to select richer forages from whatever is on offer. The fact that Ankole cattle are kept on areas with less herbage yield and lower-quality forage and the higher likelihood of Ankole pastures to be stocked permanently supports the conclusion that Ankole pastures are subjected to overgrazing more so than crossbred pastures. Nevertheless, farmers see the higher productive capability of crossbred cattle as an advantage. According to our results, they concentrate their management efforts on crossbred cattle. Crossbreeding is a possible solution for an increase in production without an increase in stocking rate which, as reported, already exceeds carrying capacities. The most striking feature of crossbred animals is their enormous potential for increasing per-capita production (Holloway *et al.*, 2000). The reported problems of crossbred animals have also to be taken into account: high susceptibility to endemic diseases, poor tolerance of climatic conditions, increased feed demand, higher management demand and increased demand for animal health care (De Haan, 1995; Holloway *et al.*, 2000; MAAIF, 2002; Wuletaw, 2004; Mekonnen *et al.*, 2009). These constraints make crossbred cattle less competitive with the better-adapted indigenous cattle (Syrstad, 1991; Trach, 2003). Still, farmers in the study region have initiated crossbreeding themselves and are very keen on crossbred animals. In the case of the Bahima, the cultural importance of Ankole has to be taken into consideration as well for any strategy to further develop the existing production system. Farmers have reported that they see their Ankole as a safe alternative in case the crossbreds cannot fulfil their expectations. The strong cultural and emotional bond to this breed has already led to the separation of their herds into two single genotype herds. Therefore, we do not see an urgent need to suggest further measures for preserving the Ankole breed for the future. Bahima farmers of our study region are taking care of this breed very consciously.

Conclusions

One of the first steps of introducing new technologies on these farms should be the use of rotational stocking using small-sized paddocks, which allows the pasture to be more efficiently grazed. Apart from clearing weeds, there is limited effort towards more intensive yet sustainable pasture use. We recommend that any pasture development programme should focus on species adapted to the area with which farmers are familiar and have confidence in. Given its quick growth response to rains, high levels of herbage yield and susceptibility to drought, *Brachiaria* spp. could be utilized as hay to be fed as supplement during dry season. In a further stage, suitable forage legumes could be integrated into the natural pasture to improve pasture quantity and quality (Macharia *et al.*, 2010). To ensure the sustainability of a production system involving crossbreeding, pasture management and utilization have to be improved. This will enable farmers to satisfy the nutritional requirements of an improved herd without sacrificing soil fertility and environmental sustainability.

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