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Effects of grazing and feedlot finishing duration on the performance of three beef cattle genotypes in Uganda

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ABSTRACT

Beef production in Uganda is progressing from the traditional pastoral practices to sedentary semi-intensive systems. Consequently, farmers are continuously crossbreeding the indigenous cattle with exotic genotypes to improve meat yield. This study was conducted on-farm to evaluate the effects of feeding systems and feeding durations on performance of three locally available genotypes. A $2 \times 3 \times 3$ factorial experiment was used to randomly allot 108 young bulls (9–15 months old), 36 for each of the three genotypes; Ankole x Holstein Friesian (AXF) (175 ± 22 kg), pure Boran (208 ± 34 kg) and a composite genotype (212 ± 35 kg). The bulls were allotted to two feeding systems and three finishing durations. The feeding systems comprised sole grazing as the control where animals only grazed natural pastures and feedlot finishing where animals were fed a locally formulated total mixed ration containing 200 maize stover, 300 maize bran, 447 brewers' spent grain, 50 molasses and 3 salt (NaCl) as g/kg on dry matter (DM) basis. The three durations were 60, 90 and 120 days excluding 14 days of adaptation period. Data was collected on feed intake, growth, slaughter and carcass characteristics. The Boran consumed less DM per kg of body weight gain than the AXF and composite. Feed conversion ratio (kg DM/kg body weight gain) ranged between 6.3 ± 0.6 to 8.2 ± 1.5 at the feedlot and 11.1 ± 4.1 to 17 ± 4.0 for all genotypes and all durations. Growth and slaughter characteristics did not vary ($P > 0.05$) between genotypes. However, carcass quality grade scores were higher ($P < 0.05$) in the pure Boran and the composite genotypes than in the AXF crossbreds at 120 days of finishing. Average daily live weight gain (ADG) for all genotypes was approximately twice under feedlot finishing compared to sole grazing while hot carcass weight under feedlot was only higher than that of sole grazing by 30 kg in AXF, 37 kg in Boran and 45 kg in composite genotype at 120 days of finishing. Hot carcass weight and dressing percentages were similar ($P > 0.05$) between genotypes irrespective of the feeding system for all durations but hot carcass weight was higher ($P < 0.05$) at the feedlot for all durations. Therefore, intensification through feedlotting is a viable option for improving beef production. However, understanding the appropriate levels of crossing between genotypes is needed to achieve the desired improvement in productivity from crossbreds.

1. Introduction

Beef production in Uganda is progressing from the traditional pastoral practices to sedentary semi-intensive systems on private ranches (Wurzinger et al., 2009; Mbabazi and Ahmed, 2012). Traditionally, pastoral communities within the cattle corridor of Uganda practiced nomadism and transhumance on communal lands to sustain animals, which provided beef to both the rural and urban populations. However, due to changing human population patterns with the consequential increase of pressure on communal grazing land, traditional pastoral production practices are becoming less practical. For example, increasing human population pressure is increasingly limiting flexibility of livestock movement due to loss of corridors between wet and dry season grazing areas (Byenkya et al., 2014). While forages are adequate during the wet season, the dry season forage is characterized by limited availability and accessibility coupled with low nutritive

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quality (Selemani et al., 2013). As a result, weight gained by animals during the wet season is often eroded by weight loss resulting from low nutrient intake and higher maintenance requirements for walking longer distances in search for feeds and in many cases water during the dry season. Mwilawa (2012) reported weight loss of 45 g per day for grazing Tanzanian Short Horn Zebu and Boran during the dry season. To cope with the negative effects of feed scarcity on animal performance, many farmers often sell some of their livestock. In Uganda, young bulls and old cows are reported to account for over 80% of the animals sold during such periods (Ruhangawebale, 2010). The young bulls are slaughtered at low live body weights resulting in very low carcass weights compared to bulls from established beef production systems where young animals are finished on high concentrate diets and slaughtered at higher slaughter and carcass weights (Piedrafita et al., 2003).

While the indigenous genotypes are well adapted to the tropical production environment characterized by heat, endemic diseases and seasonal forage quantity and quality fluctuations, their slow growth rates and smaller mature live body weights limit their potential for meat production. However, lack of selection programs in the production systems also in part contributes to the low production levels of the indigenous genotypes. Average daily gain of 270 g for grazing Ankole cattle and its crossbreds with Boran and Friesian has been reported (Asizua et al., 2009) compared to 517 g per day reported in Creole breed, a tropical breed in USA (Agastin et al., 2013). Arguably, many progressive farmers in their attempt to improve the genetics of the indigenous genotypes, indiscriminately crossbreed (Mbabazi and Ahmed, 2012) with improved beef genotypes such as the improved Boran (550–850 kg mature body weight (Rege et al., 2001)) and Bosmara (544 − 950 kg mature live body weight (Animal Genetics Training Resources (AGTR), 2009)) and dairy exotic genotypes, especially Holstein Friesian whose bulls can weigh 750 kg at 26 months (Geay and Micol, 1989). Moreover, it has been argued that as livestock production systems evolve through intensification, support to smallholder farmers to provide more efficient beef and dairy genotypes and improvement of animal management practices may be an appropriate option for improved pro-poor livestock production (McDermott et al., 2010; Rege et al., 2011). However, the extent to which crossbreeding is improving productivity of beef cattle in the pastoral and agro-pastoral communities still remains uncertain. Similarly, information as to whether the crossbreds outperform the indigenous genotypes in terms of meat yield and efficiency of feed utilization under the intensive systems is still limited. Although various studies have demonstrated positive influence of crossbred genotypes on beef production (Asizua et al., 2009; Mwilawa, 2012; Asimwe et al., 2015), information on the influence of duration of feeding on body weight gain and carcass yield under different production systems remains limited. This study, therefore, sought to evaluate growth, feed utilization and carcass characteristics of the three beef cattle genotypes (*i.e.* Ankole x Holstein Friesian, pure Boran and a composite genotype comprising Ankole, Holstein Friesian, Boran and Bonsmara) under grazing and feedlot finishing.

2. Materials and methods

2.1. Study site

This study was conducted between February and August 2012 at Betar Ranchers, a private ranch located in Mubende district found within the cattle corridor in central Uganda. Mubende district lies along the longitude 31° 40′ E and latitude 00° 30′ N at an altitude of 1300 m above sea level. Annual rainfall in the area ranges between 850 mm and 1300 mm distributed between two wet seasons of April-May and September-November. Annual temperatures range was between 15 to 28 °C. The predominant grass pasture species in the area include Signal grass (*Brachiaria brizantha, Brachiaria ruziziensis),* Rat's tail (*Sporobolous pyramidalis*), Star grass (*Cynodon dactylon*), Couch grass (*Digitaria scalarum*) with sparse distribution of legumes such as Glycine (*Neonotonia wightii*), Greenleaf desmodium (*Desmodium intortum*) and Silverleaf desmodium (*Desmodium uncinatum*). Predominant tree species included Acacia (*Acacia hockii*), Albizia (*Albizia coriaria*, *Albizia zygia*) and Bushwillow trees (*Combretum* spp.).

2.2. Experimental design and treatments

A 2 × 3 × 3 factorial experiment was used to randomly allocate 108 young bulls, of three genotypes aged between 9 and 15 months, to two feeding systems and three finishing durations. The three genotypes comprised Ankole x Holstein Friesian (AXF), pure Boran and a composite genotype consisting of crosses between Ankole, Holstein Friesian, Boran and Bonsmara genotypes. The initial live weights of the bulls were 175 ± 22, 208 ± 34 and 212 ± 35 kg for AXF, pure Boran and the Composite genotypes, respectively. The feeding systems to which bulls were allocated comprised of sole grazing, a practice commonly used by farmers as a control, and feedlot finishing. The durations of feeding included 60, 90 and 120 days after which bulls were removed for slaughter. Each of the two feeding system was randomly allocated 54 young bulls, 18 from each of the three genotypes of Ankole x Holstein Friesian (AXF), pure Boran and the composite genotype. For each genotype, animals were stratified by initial weight and assigned to the three durations of finishing such that bulls in each stratum were randomly allocated to each treatment. While for growth, slaughter and carcass characteristics the individual animal was considered as the experimental unit, for feed intake, pens were used as the experimental unit. For each genotype, duplicate pens with 3 bulls each were used for the different durations of finishing. The experimental pen provided 12 m^2 per bull irrespective of the genotype. All the bulls of the different genotypes at the feedlot were first subjected to a 14-day adaptation period during which they were allowed to get used to confinement in the pens and feedlot diets. Data from the adaptation period were excluded from data for the different durations of finishing.

2.3. Experimental feeds and feeding

Natural pastures with watering points distributed at random points with an average of at least one trough per square kilometre provided water for the grazing animals. The natural pastures were maintained through routine bush clearing and weeding especially during the wet season. Grazing animals were released from the night kraal at 08:00 h and returned by 18:00 h. Meanwhile, feedlot bulls were offered a locally formulated total mixed ration (TMR) consisting of maize stover, wet brewers spent grain, maize bran, molasses and salt. The maize stover was chopped to pieces of about 3–6 cm using John Deere forage chopper. For ease of uniform mixing, the molasses was diluted with water in a ratio of 1:1. Maize bran (375 g/kg DM), brewer's spent grain (558.75 g/kg DM), molasses (62.5 g/kg DM) and salt (3.75 g/kg DM) were formulated and blended to form a concentrate that was later used as a premix. The premix was then blended with maize stover to form the TMR. The TMR was comprised of g/kg DM: 200 maize stover, 300 maize bran, 447 brewers' spent grain, 50 molasses and 3 salt. The TMR was formulated to provide 130 g/kg DM of CP and 10 MJ/kg DM of ME. The formulated ration targeted to meet requirements for ADG of 1000 g/animal/day (NRC, 1984). The TMR was offered *ad libitum* by adding 10% of the previous day's intake to the daily offer. Throughout the experimental period, free access was provided to water and Maclik mineral block, which consisted of the following elemental components (%): Ca (2.6), P (1.4), Na (31.93), Cl (49.28), Mg (1.8), Cu (0.32), Co (0.04), Fe (0.5), K (0.006), I (0.02), Zn (0.36), Mn (0.28) and S (0.36); and compounds (%): CaO (3.64), P_2O_5 (3.21) and NaCl (81.21); and Ca:P ratio (1.8:1).

2.4. Experimental animals and management

Bulls of pure Boran and the composite genotype were born and raised from the BETAR ranch Ltd. while the Ankole x Friesian (AXF) crossbreds were purchased from dairy farms in Western Uganda. All bulls were exclusively grazed before the experiment started. The genotypic composition of the crossbred genotypes, *i.e.* AXF and the composite genotypes used in this study were not precise as there were no consistent breeding programs at the ranch and dairy farms. The crossbred genotypes, however, depicted the typical random crossbreeding by many commercial ranchers in south-western Uganda. The genotypic composition of the experimental animals was therefore, traced through their parents, their phenotypic characteristics and the farmer's records anecdotal recollection. The breeding herd at the ranch consisted of three purebred Boran and two purebred Bonsmara bulls while the cows comprised predominantly of purebred Boran and multiple crossbreds of Ankole, Holstein Friesian, Boran and Bonsmara. The phenotypic expressions of the experimental animals such as skin colour, presence or absence of horns, humps and dewlap, horn size and shape, and overall body conformation were further used to identify their genetics. Experimental animals were treated for internal parasites using Levafas diamond (3.0% w/v Levamisole Hydrochloride 6.0% w/v Oxyclozanide). External parasites were controlled using protaid acaricide (Cypermethrin (10% EC) + Organophosphate 20% EC) through weekly dipping for the grazing bulls and dipping every two weeks for the feedlot bulls.

2.5. Feed intake measurements

At the feedlot, the TMR was offered between 9.00 and 10.00 h to allow for *ad libitum* feeding. The refusals were removed and weighed every day between 7.00 and 9.00 h. Representative samples of the feed offered and refusals were taken daily and bulked into weekly samples for laboratory analysis. Daily average DM intake for the individual animals per pen under the feedlot system was calculated as the difference between weight of feed DM offered and that of the refusal. Feed conversion ratio was computed as a ratio of DM consumed (kg) to the live body weight gain (kg). Because maize stover was consistently the only refusal observed, intake of concentrate premix and maize stover were presented separately in the results even if the feed was offered as a TMR. For the grazing feeding system, voluntary dry matter intake (DMI) of forage was estimated using live weight and average daily gain as indicated by Undi et al. (2008). The equation; DMI (kg day^{-1}) = $(1.185 + 0.00454BW - 0.0000026BW^2 + 0.315ADG)^2$ was used, where, DMI = Forage dry matter intake, BW = Live body weight and ADG = Average daily live weight gain. Based on the initial live weights of the bulls and their subsequent weights and durations, the daily live weight of each bull was estimated and used for computing daily forage DMI.

2.6. Growth measurements

Weights of bulls were taken every month using a digital weighbridge after an overnight fasting. Initial live body weight was taken after two consecutive days of weighing. Average daily gain was computed as the average of the weight difference between initial and final weights divided by the number of days for the duration.

2.7. Slaughter measurements

All the six bulls per feeding duration for every genotype within the two feeding systems were slaughtered at the end of their respective feeding periods. Bulls were transported for about 3.0 h to a commercial abattoir located about 100 km from the ranch and slaughtered. The bulls were slaughtered after fasting for at least 24 h from when they left the ranch to the lairage where they were only allowed access to water.

Table 1
Chemical composition of feeds.

	Concentrate	Pasture	Stover	Maize bran	Spent grain
DM (g/kg feed)	490	310	880	790	280
CP (g/kg DM)	173	95	39	119	235
Crude fat	36.3	6.2	0.05	9.6	48.5
NDF (g/kg DM)	425	781	868	615	649
ADF (g/kg DM)	119	360	487	127	135
ADL (g/kg DM)	49.0	42	42	21	31
Ash (g/kg DM)	108	114	82	58	54
P (g/kg DM)	4.8	3.7	5.6	6	3.4
Ca (g/kg DM)	5.3	5.6	6.2	5.4	5.5
ME MJ/kg DM	11.4	8.0	7.3	11.2	11.9

Measurements taken at slaughter included; slaughter live body weight, carcass and non-carcass components, gut fill, empty body weight (EBW) and carcass grades. Gut fill was calculated as the difference between full and empty stomach and intestines. Empty body weight was calculated as the difference between slaughter live body weight and gut fill. Carcasses were graded according to European grading standards (Piedrafita et al., 2003) on a scale of 1–15 where a score of 1 was carcass with the worst conformation and 15 applied to carcass with best conformation. Five meat inspectors at the Uganda Meat Industries independently scored each of the carcasses during the different times of slaughter.

2.8. Chemical analysis

Chemical composition of the concentrate premix, pasture, maize stover, maize bran and brewers' spent grain is presented in Table 1. Dry matter was determined in a forced drought oven at 60 °C until constant weight. Ash corrected Neutral Detergent Fibre (NDF) determined without the use of amylase and ash corrected Acid Detergent Fibre (ADF) were analysed according to the procedures of Van soest et al. (1991). Crude protein (CP), calcium (Ca), phosphorous (P) and total ash were determined according to the procedures of AOAC Association of Official Analytical Chemists (1990). Crude protein was determined using the Kjeldahl method while Ca and P were determined using flame photometry and spectrophotometry, respectively. Crude fat was extracted with diethyl ether using the Soxtech method. Samples were incinerated at 600 °C for 8 h to determine total ash contents. Metabolisable energy (ME) was estimated from chemical composition of feeds following the equation: ME (MJ/kg DM) = 0.012CP + 0.031EE + 0.005CF + 0.014NFE (MAFF, 1975).

2.9. Data analysis

Means of feed intake parameters were generated using the proc means procedures of SAS (2003). The means for the three genotypes were computed within the durations of finishing.

For data on growth and slaughter characteristics, the main effects of genotype and feeding system and their interaction were fitted to the general linear model procedures with initial live body weight of bulls as a covariate:

$Y_{ij} = \mu + F_j + G_i + (FG)_{ij} + \beta(x_{ij} - \bar{x}) + e_{ij}$, where Y is an observation, μ is overall mean, F is effect of feeding system (j = 1,2), and G is effect of genotype (i = 1,2,3), and FG is the interaction between feeding system and genotype, x is the initial weight, $\bar{x}$ is the overall mean of initial weights, β is a linear regression coefficient indicating the dependence of Y_{ij} on x_{ij} and e_{ij} is random error.

Table 2
Means (± SD) of dry matter, CP and ME intake and feed conversion ratio (FCR) of AXF, Boran and composite genotypes during three durations of finishing under feedlot and grazing.

	0 – 60			0 – 90			0 – 120		
	AXF	Boran	Composite	AXF	Boran	Composite	AXF	Boran	Composite
Feedlot									
Stover DMI, kg/animal/day	1.4 ± 0.2	1.1 ± 0.1	1.2 ± 0.2	1.3 ± 0.2	1.2 ± 0.1	1.3 ± 0.2	1.3 ± 0.2	1.2 ± 0.1	1.3 ± 0.2
Concentrate DMI, kg/animal/day	3.7 ± 0.7	4.0 ± 0.5	3.9 ± 0.5	4.7 ± 1.3	4.7 ± 1.0	4.9 ± 1.2	4.7 ± 1.3	4.7 ± 1.0	4.9 ± 1.2
Total DMI, kg/animal/day	5.1 ± 0.6	5.1 ± 0.5	5.1 ± 0.6	6.1 ± 1.2	5.9 ± 1.1	6.2 ± 1.3	6.1 ± 1.2	5.9 ± 1.1	6.2 ± 1.3
DMI, % BW	2.7 ± 0.2	2.3 ± 0.2	2.2 ± 0.2	2.8 ± 0.3	2.4 ± 0.3	2.5 ± 0.4	2.8 ± 0.3	2.4 ± 0.3	2.5 ± 0.4
CP intake g/day/Animal	627 ± 107	659 ± 78	651 ± 81	691 ± 200	782 ± 166	813 ± 191	691 ± 200	782 ± 166	813 ± 191
ME, MJ/day/Animal	48.0 ± 6.4	48.5 ± 5.2	48.5 ± 5.8	58.2 ± 12.5	56.7 ± 11.2	59.2 ± 13	58.2 ± 12.5	56.7 ± 11.2	59.2 ± 13
FCR, kg DM/kg Live body weight gain	7.9 ± 0.9	6.3 ± 0.6	7.1 ± 0.8	8.3 ± 1.0	7.2 ± 1.3	8.2 ± 1.5	8.3 ± 1.0	7.2 ± 1.3	8.2 ± 1.5
Pasture									
DMI	4.4 ± 0.3	4.3 ± 0.4	4.9 ± 0.5	5.0 ± 0.5	4.9 ± 0.3	5.1 ± 0.4	4.8 ± 0.4	4.9 ± 0.5	5.0 ± 0.5
DMI, % BW	2.3 ± 0.14	2.1 ± 0.03	2.1 ± 0.1	2.3 ± 0.2	2.1 ± 0.1	2.1 ± 0.1	2.3 ± 0.1	2.2 ± 0.1	2.1 ± 0.1
CP intake g/day/Animal	419 ± 33	413 ± 34	462 ± 45	479 ± 49	464 ± 30	484 ± 43	458 ± 39	466 ± 43	477 ± 45
ME, MJ/day/Animal	35 ± 2.7	35 ± 2.9	39 ± 3.8	40 ± 4.1	39 ± 2.6	41 ± 3.6	39 ± 3.3	39 ± 3.6	40 ± 3.8
FCR, kg DM/kg Live body weight gain	11.1 ± 4.1	17 ± 4.0	13 ± 3.2	11 ± 6.2	13.5 ± 2.3	13.6 ± 5.2	9.3 ± 2.9	12.5 ± 3.2	16.3 ± 6.0

AXF – Ankole x Friesian, B – Boran, C – Composite (Boran, Bonsmara, Ankole), GP – Group pen, D – Duration, G – Genotype.

3. Results

3.1. Feed intake

Means (± SD) of dry matter, CP and ME intake and feed conversion ratio (FCR) of AXF, Boran and composite genotypes under the three feeding durations of bulls are presented in Table 2. At the feedlot, stover DMI was consistent across all durations of feeding and ranged between 1.3 ± 0.2 and 1.4 ± 0.2 kg DM/day for the AXF and 1.1 ± 0.1 to 1.3 ± 0.2 kg DM/day for the Boran and composite genotypes. On the contrary, concentrate premix DMI irrespective of the genotype, was about four times the stover DMI during the 60 days of feeding while at the feeding durations of 90 and 120 days, concentrate DMI was about five times that of the stover. Consequently, total voluntary DMI, CP and ME intakes followed similar trends as concentrate premix. However, DMI as percentage of live body weight was consistently higher than 2.7 ± 0.2 but less than 3.0 for the AXF while for the pure Boran and composite genotypes it ranged between 2.2 ± 0.2 and 2.5 ± 0.4 for all durations of finishing. The Boran consistently consumed less DM for every kg of body weight gain than the AXF and the composite genotypes as shown by the FCR. Table 3.

Under grazing system, estimated pasture DMI ranged between 4.3 ± 0.4 and 5.1 ± 0.4 kg irrespective of the genotype. Meanwhile, DMI of pasture as a percentage of bodyweight ranged from 2.1 ± 0.03 to 2.3 ± 0.14 across genotypes and durations of finishing. Intakes of CP (g/animal/day) and ME (MJ/animal/day) varied between 413 ± 34 to 479 ± 49 and 35 ± 2.7 to 41 ± 3.6, respectively. Dry matter intake per kg of live body weight gain per animal per day ranged between 9.3 ± 2.9 and 17 ± 4.0 kg among the three genotypes across durations of feeding. However, the AXF consistently consumed less DM per kg of weight gain than Boran and composite in all the durations of finishing.

3.2. Growth performance

Under feedlot, the AXF had lower ($P < 0.01$) initial live weight than its Boran and composite counterparts of similar age for all the durations except at 0–60 days. However, under grazing, all the genotypes had similar initial weight for all durations except 0 – 60. The bulls finished under feedlot system had higher ($P < 0.001$) average daily gain (ADG) compared to those under grazing irrespective of the genotypes, except for the composite at 60 days of finishing. At 120 days of finishing, the effects of feeding systems on both final live body weight and average daily gain was influenced ($P < 0.001$) by the genotype. It is also apparent that while ADG was similar for all the genotypes within the feeding systems, under grazing AXF had the highest but comparable ADG to Boran. The difference between the initial live weight and the final live weight for the 120 days of finishing was about twice that observed for 0–60 days of finishing in all genotypes under both feedlot and grazing system except for the composite genotype.

3.3. Carcass characteristics

Effect of feeding system and genotype on carcass characteristics under different durations of finishing is presented in Table 4. Slaughter

Table 3
Effects of feeding system and genotype on growth characteristics under different durations of finishing.

		Feedlot			Grazing				Significance		
Duration	Parameter	AXF	Boran	Composite	AXF	Boran	Composite	SEM	FS	G	FSxG
0–60	Initial weight, kg	179^{bc}	207^{ab}	223^{a}	172^{c}	198^{ab}	202^{ab}	9.7	ns	**	ns
	Final weight, kg	240^{ab}	246^{a}	238^{ab}	220^{c}	216^{c}	226^{bc}	6.0	***	ns	ns
	ADG, kg/day	0.69^{ab}	0.79^{a}	0.67^{ab}	0.37^{c}	0.32^{c}	0.48^{bc}	0.1	***	ns	ns
0–90	Initial weight, kg	178^{b}	217^{a}	220^{a}	189^{ab}	214^{a}	213^{a}	11	ns	*	ns
	Final weight, kg	285^{a}	285^{a}	280^{ab}	263^{bc}	243^{c}	248^{c}	7.3	***	ns	ns
	ADG, kg/day	0.82^{a}	0.83^{a}	0.78^{ab}	0.59^{bc}	0.39^{c}	0.44^{c}	0.08	***	ns	ns
0–120	Initial weight, kg	172^{b}	209^{a}	218^{a}	167.1^{b}	197^{ab}	192^{ab}	10	ns	**	ns
	Final weight, kg	282^{a}	287^{a}	295^{a}	263^{b}	250^{bc}	241^{c}	12.2	***	ns	**
	ADG, kg/day	0.73^{a}	0.77^{a}	0.84^{a}	0.58^{b}	0.47^{bc}	0.40^{c}	0.05	***	ns	**

[abc]Means within rows with similar superscripts are similar, ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$, ns – non significant
AXF – Ankole x Friesian, SEM – standard error of the mean, FS – Feeding system, G – Genotype.

Table 4
Effects of feeding system and genotype on carcass characteristics under different durations of finishing.

		Feedlot			Grazing			SEM	Significance	
Duration		AXF	Boran	Composite	AXF	Boran	Composite		FS	G
0–60	Slaughter weight, kg	221^{a}	230^{a}	221^{a}	200^{b}	198^{b}	206^{b}	6.0	***	ns
	EBW, kg	177^{bc}	220^{a}	235^{a}	148^{c}	175^{bc}	205^{ab}	12	**	***
	Hot carcass weight, kg	115^{a}	122^{a}	118^{a}	99^{b}	102^{b}	105^{b}	3.9	***	ns
	Dressing, %	51.6	52.9	53.1	49.1	51.8	51.1	1.6	ns	ns
	Carcass grade	7.1^{a}	6.7^{a}	6.6^{ab}	3.8^{c}	4.0^{bc}	4.3^{bc}	0.8	**	ns
0–90	Slaughter Wt, kg	264^{a}	268^{a}	261^{a}	238^{b}	219^{b}	225^{b}	7.9	***	ns
	EBW, kg	207^{b}	253^{a}	249^{a}	189^{b}	197^{b}	202^{b}	13.4	**	ns
	Hot carcass weight, kg	141^{a}	147^{a}	145^{a}	114^{b}	104^{b}	106^{b}	4.5	***	ns
	Dressing, %	53.3^{a}	54.9^{a}	55.1^{a}	47.3^{b}	47.9^{b}	47.6^{b}	0.9	***	ns
	Carcass grade	6.1^{ab}	7.5^{a}	6.7^{a}	5.4^{b}	6.0^{ab}	6.7^{a}	0.4	*	*
0–120	Slaughter weight, kg	263^{a}	274^{a}	279^{a}	236^{b}	231^{b}	220^{b}	7.2	***	ns
	EBW, kg	219^{b}	271^{a}	279^{a}	181^{c}	211^{bc}	194^{bc}	11.1	***	**
	Hot carcass weight, kg	143^{a}	151^{a}	153^{a}	113^{b}	114^{b}	108^{b}	5	***	ns
	Dressing, %	54.6^{a}	54.6^{a}	54.3^{a}	47.3^{b}	49.9^{b}	49.2^{b}	1	***	ns
	Carcass grade	7.4^{b}	9.3^{a}	9.5^{a}	5.8^{c}	5.8^{c}	6.9^{bc}	0.5	***	**

[abcd]Means within rows with similar superscripts are similar, ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$, ns – non significant, AXF – Ankole x Friesian, SEM – standard error of the mean, FS – Feeding system, G – Genotype, interaction effects are not presented because they were non-significant.

weight and hot carcass weight varied ($P < 0.05$) between feeding systems in all three durations. Carcass grade was higher in the Boran and composite genotypes at 120 days ($P < 0.01$) duration of finishing under feedlot but similar between genotypes under grazing. Dressing percentage was similar between feeding systems for all genotypes at 60 days ($P > 0.05$) but differed ($P < 0.001$) at 90 and 120 days of finishing.

4. Discussion

4.1. Feed intake

Variations in the average DMI between genotypes at the feedlot in this study show that pure Boran is a more efficient genotype compared to the AXF and composite crossbreds. The AXF and the composite genotypes required more DM per kg of live weight gain than the Boran. The higher efficiency of feed conversion of the pure Boran compared to the AXF and the composite genotypes was possibly attributed to their higher efficiency of utilization of dietary ME for maintenance due to genotypic advantage such as better adaptation to unfavorable tropical environmental conditions (Clarke et al., 2009). However, other studies have not found any differences between *Bos indicus* and *Bos taurus* in relation to efficiency of utilization of dietary ME for maintenance (Clarke et al., 2009) but dairy breeds have been reported to have higher maintenance requirements than beef breeds (Geay, 1984). While crossbreds are late maturing and have both *Bos indicus* genes that offer them adaptation to the tropical environment and *Bos taurus* genes with the propensity for fast growth, the results in this study depicted the pure Boran to be more efficient despite being an early maturing genotype. This is an indication of the need for further studies on genotype environmental interactions and its influence on performance of crossbreds among the progressive beef producers in the tropics. Furthermore, it has been argued that placing cattle on *ad libitum* concentrate diets early in life irrespective of their genotype may reduce their mature body weight (Owens et al., 1995) and hence lowering their efficiency of feed utilization earlier. Moreover, it has also been suggested that modern cattle have lower mature body weights than those produced in earlier centuries (Owens et al., 1995). The current findings have strong implication on the random crossbreeding occurring in the traditional beef production systems where farmers are continuously introducing exotic blood into the indigenous *Bos indicus* cattle to increase live body weight. This, therefore, necessitates the identification of the best crossbreds/composites in terms of the breeds and blood levels of the constituent breeds (Wurzinger et al., 2014) to make crossbreeding more economically rewarding to livestock farmers in the tropics in their quest to upgrade performance of the indigenous breeds.

Estimation of voluntary DMI and quality of nutrients consumed by grazing animals is crucial in understanding nutrient utilization and behavior of animals towards accessing the standing forage (Undi et al., 2008; Idibu et al., 2016). Under grazing, the AXF consumed less dry matter per kg of body weight gain than Boran and composite genotypes in all durations of feeding. This would imply that the AXF crossbreds were more efficient in forage harvesting and utilization. However, more robust methods of predicting cattle grazing heterogenous pasture in tropical rangelands need to be developed to understand the levels of voluntary DMI and nutrient utilization by different cattle genotypes.

4.2. Growth

Results of this study show that irrespective of duration of finishing and genotype, growth rates of bulls under feedlot system is almost twice the growth rate of animals grazing natural pastures. However, the observed growth rates of the grazing bulls (0.32–0.59 kg/day) were higher than the growth rate of 0.27 kg/day earlier reported under a typical unimproved rangeland in Uganda (Asizua et al., 2009). This demonstrates that pasture management such as bush clearing and continuous weeding as practiced in grazing area of this study can result into considerable increase in growth rate of animals. However, average live weight gain of 0.67–0.84 kg/day of the different genotypes at the feedlot in this study were about half the growth rate (1.21–1.62 kg/day) of cattle in more organized feedlot operations (Schoonmaker et al., 2002; Esterhuizen et al., 2008). This could be mainly attributed to the genetic superiority or higher mature weight of animals in the developed feedlot operations. Geay (1984) argued that differences in distribution of dietary ME between maintenance and production and its efficiency of utilization could explain the observed gain among genotypes.

4.3. Slaughter and carcass characteristics

There were no genotypic differences in slaughter and carcass characteristics in all feeding durations for both feeding systems, except EBW at 60 and 120 durations of feeding and carcass grade at 90 and 120 days. Similar results have been reported between crossbreds of *Bos* *indicus* with *Bos taurus* genotypes fed under different feeding regimes (Asizua et al., 2009; Jerez-Timaure and Huerta-Leidenz, 2009). However, the genotypic differences regarding slaughter and carcass characteristics are not conclusive partly due to the limited understanding of the genetic composition of the crossbreds. After 120 days of feeding, the pure Boran and the composite genotype had better carcass grade score than the AXF bulls, demonstrating the superiority of improved beef genotypes in meat yield over crossbred genotypes with dairy genes. Nevertheless, the comparable performance of the AXF genotypes to the Boran and the composites in terms of ADG, slaughter weight and hot carcass weight provides an opportunity for utilization of the bull calves from the fast growing dairy industry in Uganda for beef production. Different studies have reported the importance of dairy genotypes (Keane, 2003) and bull calves (Nielsen and Thamsborg, 2002) for beef production. While Boran may remain the most important genotype in the production environment of this study, crossbreds provide credible alternatives to improved beef production.

5. Conclusion

This study showed that intensification through feedlot finishing using locally available agro-industrial by-products provides a more appropriate beef production strategy compared to the traditional grazing system for achieving higher live body weight and meat yield for young bulls irrespective of the genotype and duration of finishing. It is also apparent that while ADG was similar for all the genotypes within the feeding systems, the Boran genotype was more efficient in feed utilization under the feedlot. Under the grazing system, the AXF was more efficient in feed utilization. While grazing is considered the least expensive system of beef production, the relatively higher DMI per unit of live body weight gain might compromise the low cost of production. Therefore, there is need for assessing economic implications of the differences in transaction costs and the relevant levels of crossbreeding necessary for efficient finishing of young bulls under the two production systems. This would enable farmers make more informed decisions to meet the new demands for higher quality meat for the emerging middle class.

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References

Agastin, A., Naves, M., Farant, A., Godard, X., Bocage, B., Alexandre, G., Boval, M., 2013. Effects of feeding system and slaughter age on the growth and carcass characteristics of tropical-breed steers. J. Anim. Sci. 91, 3997–4006.

Animal Genetics Training Resources (AGTR), 2009. Origin, Distribution, Physical Characteristics and Peculiarity of Bonsmara. 〈http://agtr.ilri.cgiar.org/index.php?Option = com_content & view = article & id = 101 & Itemid = 118〉 (Accessed 05 August 2016).

AOAC (Association of Official Analytical Chemists), 1990. Official Methods of Analysis, 15th Edition. AOAC Inc., Arlington, Virginia 22201 USA.

Asimwe, L., Kimambo, A.E., Laswai, G.H., Mtenga, L.A., Weisbjerg, M.R., Madsen, J., Mushi, D.E., 2015. GrowthperformanceandcarcasscharacteristicsofTanzania Shorthorn Zebucattle finished onmolassesormaizegrainwith rice ormaizeby-products. Livest. Sci. 182, 112–117.

Asizua, D., Mpairwe, D., Kabi, F., Mutetikka, D., Madsen, J., 2009. Growth and slaughter characteristics of Ankole cattle and its Boran and Friesian crossbreds. South Afr. J. Anim. Sci. 39, 81–85.

Byenkya, G.S., Mugerwa, S., Barasa, S., Zziwa, E., 2014. Land use and cover change in pastoral systems of Uganda: implications on livestock management under drought induced pasture. Afr. Crop Sci. J. 22, 1013–1025.

Clarke, A.M., Drennan, M.J., McGee, M., Kenny, D.A., Evans, R.D., Berry, D.P., 2009. Intake, live animal scores/measurements and carcass composition and value of late-maturing beef and dairy breeds. Livest. Sci. 126, 57–68.

Esterhuizen, J., Groenewald, I.B., Strydom, P.E., Hugo, A., 2008. The performance and meat quality of Bonsmara steers raised in a feedlot, on conventional pastures or on organic pastures. South Afr. J. Anim. Sci. 38, 303–314.

Geay, Y., 1984. Energy and protein utilization in growing cattle. J. Anim. Sci. 58, 766–778.

Geay, Y., Micol, D., 1989. Growing and finishing cattle. In: Jarrige, R. (Ed.), Ruminant Nutrition: Recommended Allowances and Feed Tables. John Libey Eurotext, London-Paris, pp. 137.

Idibu, J., Kabi, F., Mpairwe, D., 2016. Behavioral response of pure Ankole and crossbred (Ankole xHolstein) cows to seasonal pasture variations in south-western Uganda. Appl. Anim. Behav. Sci. 174, 11–18.

Jerez-Timaure, N., Huerta-Leidenz, N., 2009. Effects of breed type and supplementation during grazing on carcass traits and meat quality of bulls fattened on improved savannah. Livest. Sci. 121, 219–226.

Keane, M.G., 2003. Beef production from Holstein–Friesian bulls and steers of New Zealand and European/American descent, and Belgian Blue × Holstein–Friesians, slaughtered at two weights. Livest. Prod. Sci. 84, 207–218.

MAFF, 1975. Energy allowances and feeding systems for ruminants. Minist. Agric. Fish. Food Technol. Bull. 33 London.

Mbabazi, M.C., Ahmed, M., 2012. Analysis of Incentives and Disincentives for Beef in Uganda., Technical Notes Series. MAFAP, FAO., Rome.

McDermott, J.J., Staal, S.J., Freeman, H.A., Herrero, M., Van de Steeg, J.A., 2010. Sustaining intensification of smallholder livestock systems in the tropics. Livest. Sci. 130, 95–109.

Mwilawa, T.J.A., 2012. Effects of Different Diets on Weight Gain, Carcass and Meat Quality Characteristics of Two Indigenous Cattle Breeds of Tanzania. Sokoine University of Agriculture, Morogoro, Tanzania.

Nielsen, B., Thamsborg, S.M., 2002. Dairy bull calves as a resource for organic beef production: a farm survey in Denmark. Livest. Prod. Sci. 75, 245–255.

NRC, 1984. Nutrient Requirements of Beef Cattle. National Academy of Sciences, Washington DC, USA.

Owens, F.N., Gill, D.R., Secrist, D.S., Coleman, S.W., 1995. Review of some aspects of growth and development of feedlot. J. Anim. Sci. 73, 3152–3172.

Piedrafita, J., Quintanilla, R., Sañudo, C., Olleta, J.-L., Campo, M. a.-M., Panea, B., Renand, G., Turin, F., Jabet, S., Osoro, K., Oliván, Ma-C., Noval, G., García, P., García, Ma-D., Oliver, Ma-A., Gispert, M., Serra, X., Espejo, M., García, S., López, M., Izquierdo, M., 2003. Carcass quality of 10 beef cattle breeds of the Southwest of Europe in their typical production systems. Livest. Prod. Sci. 82, 1–13.

Rege, J.E.O., Kahi, A.K., Okomo-Adhiambo, M.O., Mwacharo, J., Hanotte, O., 2001. Zebu cattle of Kenya: uses, performance, farmer preference, measures of genetic diversity and options for improved use. Anim. Genet. Resour. Res. 1 ILRI, Nairobi, Kenya.

Rege, J.E.O., Marshall, K., Notenbaert, A., Ojango, J.M.K., Okeyo, A.M., 2011. Pro-poor animal improvement and breeding — what can science do? Livest. Sci 136, 15–28.

Ruhangawebale, G.K., 2010. Factors affecting the level of commercialisation among cattle keepers in the pastoral areas of Uganda., school of graduate studies. Mak. Univ., Kampala 117.

SAS, 2003. Statistical Analysis System. User's guide, version 8.2. SAS Institute, INC, Carry, NC, USA.

Schoonmaker, J.P., Loerch, S.C., Fluharty, F.L., Zerby, H.N., Turner, T.B., 2002. Effect of age at feedlot entry on performance and carcass characteristics of bulls and steers. J. Anim. Sci. 80, 2247–2254.

Selemani, I.S., Eik, L.O., Holand, Ø., Ådnøy, T., Mtengeti, E., Mushi, D., 2013. Variation in quantity and quality of native forages and grazing behavior of cattle and goats in Tanzania. Livest. Sci. 157, 173–183.

Undi, M., Wilson, C., Ominski, K.H., Wittenberg, K.M., 2008. Comparison of techniques for estimation of forage dry matter intake by grazing beef cattle. Can. J. Anim. Sci. 88 (6), 93–701.

Van soest, P.J., Robertson, J.B., Lewis, B.A., 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74, 3583–3597.

Wurzinger, M., Mirkena, T., Sölkner, J., 2014. Animal breeding strategies in Africa: current issues and the way forward. J. Anim. Breed. Genet. 131, 327–328.

Wurzinger, M., Okeyo, A.M., Semambo, D., Sölkner, J., 2009. The sedentarisation process of the Bahima in Uganda: an emic view. Afr. J. Agric. Res. 4, 1154.