Performance of Boran and Crossbred Cattle for Beef Production Under Ranch Conditions in Tanzania: 1.Gestation Length and Growth to 36 Months

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Abstract

Records collected in a crossbreeding experiment involving Boran and nine groups of Boran x Bos taurus crossbred cattle in two ranches in central Tanzania were analysed. The traits studied were length of gestation (available on the crosses only) and live weight at various stages from birth to three years of age. The records were analysed by means of Statistical Analysis System (SAS) for general linear models. Length of gestation varied significantly among groups of crosses (i.e. by breed of sire). The overall mean gestation length was 282.8 days. Most crossbred groups were heavier than pure Boran both at birth and at subsequent ages. At three years of age the crosses, pooled over sire breeds, exceeded the Boran by about 10 percent. South Devon crosses were the heaviest at this age, followed by Charolais, Chianina, Brown Swiss, and Simmental crosses. These crosses were 12 to 15 percent heavier than the pure Boran. Males (steers) were about 5 percent heavier than females. The findings are generally in line with results obtained in crossbreeding experiments elsewhere and suggest that bulls of the fast growing, late maturing continental breeds could be useful as terminal sires also under Tanzanian conditions. If bulls of a dual-purpose breed, e.g. Simmental, were used, female progeny might be sold for dairy purposes. However, no firm conclusions can be drawn until data on the effect of crossbreeding on other traits, like reproductive performance and viability, have been collected and analysed.

Keywords: Crossbreeding, Boran, *Bos taurus*, growth, beef, ranching

Introduction

Beef (*i.e.* meat from cattle) is the most important output of animal production in Tanzania, contributing about 70 % of all meat produced in the country (FAO, 1998). The average carcass weight of slaughtered cattle is, however, low (slightly above 100 kg), and the average production per head of cattle (calculated as total production divided by the number of animals) is only about 15 kg. The low productivity is caused by both genetic and non-genetic factors.

This study is part of a research project, which aims at identifying breeds and breeding systems for commercial beef production in Tanzania. The article presents some findings from a beef crossbreeding experiment involving Boran cattle and nine *Bos taurus* sire breeds. It was initiated in 1974 and was scheduled to last until information on terminal backcrosses and three-way crosses had been obtained. The Boran, also known as the Large East African Zebu, is a breed indigenous to East Africa. It is considered

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superior to other indigenous Zebu breeds in growth and carcass characteristics (Mwandotto et al., 1998; Tawah and Rege, 1996; Mwatawala and Kifaro, 2001).

Materials and Methods

Study location and breeds used

The experiment was conducted on two ranches, Kongwa and Mkata, both located in central Tanzania. These ranches represent some of the most dry areas of the country, with an annual rainfall of about 600 mm.

At each of the locations ten groups of 36 Boran cows were randomly allocated to the ten sire breeds (nine exotic and Boran) each year. The breeds of sire used were Boran, Hereford, Angus, South Devon, Limousin, Simmental, Friesian, Charolais, Chianina and Brown Swiss. Natural mating was used to produce the control group (Boran) while the crosses were produced by artificial insemination using imported frozen semen. Each one of the sire breeds was represented by a minimum of five sires each year. The majority of the first crosses were born between 1975 and 1979, and these are the animals whose records have been analysed. In this data set, the Boran group was numerically the largest, while Brown Swiss halfbreds were the fewest.

Management of the animals

The following management practices prevailed throughout the study:

(i) Mating season was limited to a period of about 70 days at the end of the rains (*i.e.* in April, May and June). Any cow that cycled after the second insemination was shifted to the natural mating group and was excluded from the experiment. This was done to minimise the cost of imported semen and also to give each cow a greater chance of calving each year. Gestation length was calculated as the interval between the date of last insemination and the date of calving. For the natural mating group it was not possible to record services under ranch conditions. Therefore records of gestation length for cows carrying Boran calves are missing.

(ii) The calves were weighed within 24 hours after birth, at weaning, (at about 7 months), at 9 months of age, and later at three-monthly intervals up to 24 months of age. Thereafter, market animals (steers) continued on three-monthly weighings, while breeding females were weighed after calving, before and after breeding, and at weaning of the calf. As a result of straying, a rather large number of animals were missed at one or more weighings. The number of observations decreased from 937 at birth to 241 at 36 months. This decrease was partly due to mortality and partly because female cattle were not weighed regularly after the age of 24 months.

(iii) Male calves were castrated soon after birth by the "ellastrator" method.

(iv) At Mkata cattle grazed only during the day and were confined to night yards during the night. This was a protective measure against predators, mainly lions and hyenas. Except for saltlicks, no supplementary feeding was offered to any of the animals in the study.

(v) The main disease control measures were vaccinations against Anthrax and Blackquarter (twice a year) and, at Mkata, preventive chemotherapy against Trypanosomiasis.

Information concerning the location, rainfall and vegetation on the two ranches is summarised in Table 1 to highlight the environment in which the animals were performing.

Table 1: Location, rainfall and vegetation of the two ranches

	Kongwa	Mkata
Location	5° 55'S to 6° 10'S	6° 30' to 6° 55'S
	36° 15'E to 36° 40'E	37° 30' to 37° 50'E
Altitude (m)	1,087	124
Size (ha)	40,016	74,295
Rainfall (mm)	539.4	607.5
Soils	*Upland red and pallied. Acidic, low in phosphorus, high in potassium.*	*Heavy black cotton Soils and grey Sandy clays.*
Grasses	*Themeda triandra, Cenchrus ciliaris, Chloris gayana, Eragrostes rizidion, Aristida spp.*	*Hyparrhenia rufa, Panicum maximum, Themeda triandra Sporobolus spp.*

Data analyses

Analysis of the data was carried out on a computer using the "Statistical Analysis System" (SAS) programmes for general linear models. These models were used to study the major sources of variation. Gestation lengths and weights at various stages (birth, weaning, one year, two years, three years) were analysed for each stage separately. Effects of ranch, breed of sire, sex, year of birth, and age of dam were included in the model for all traits studied.

All animals were weighed on the same day. Due to long calving seasons, individuals born in the same year varied considerably in age at a given weighing. For weight at weaning and subsequent ages, actual age at the weighing in question was therefore included in the model as a covariate. In order to increase the number of records included in the analyses of weights at one, two and three years of age, missing records were replaced by records from the last previous weighing (usually about three months earlier). This was another reason for including age as a covariate in the statistical model.

At one stage of the analysis a breed x farm interaction term was also included. This interaction proved, however, to be non-significant at all the three stages. The interaction term was consequently dropped from the model, and the main effects at one, two and three years of age were re-estimated. Differences between means were tested for significance by the Newman-Keuls method (described by Snedecor and Cochran, 1967) as modified by Kramer (1956) for means with unequal numbers of observations.

Results

The mean weights were plotted on a graph to give a growth curve for each ranch separately (Fig. 1). Periods of slow growth occurred soon after weaning (7 to 9 months), and also between 18 and 21 months and again between 27 and 30 (33) months of age. In the first of these three periods the cause of low gains is mostly post-weaning stress while for the others it reflects seasonal under nutrition. Seasonal variation in body weight would be expected to appear since most animals were born in the same season of the year. The graph also reflects the poorer conditions and the more serious seasonal variation at Mkata than at Kongwa.

Overall means and standard deviations for weights at birth, weaning, and one, two, and three years of age are shown in Table 2. Least squares means and their standard errors are presented in Table 3 (for gestation length, birth weight and weaning weight) and Table 4 (for weights at one, two and three years).

Table 2: Means and standard deviations (SD) of live weight at various stages

		Live weights (in kg)		
Age	**No of obs.**	**Mean**	**SD**	**Res. SD***
Birth	927	26.8	5.6	4.7
Weaning	647	125.4	27.0	19.8
1 year	584	154.6	46.6	27.0
2 years	393	248.9	59.8	32.4
3 years	344	341.4	75.4	42.7

* Residual Standard Deviation after accounting for the effects of breed, sex, age at weighing, age of dam, ranch, and year of birth

Gestation length

In all, 607 records were available on this trait. The overall mean and standard deviation were

282.8 and 7.3 days, respectively. The model accounted for only 14 per cent of the variation in gestation length, and half of this (7 per cent)

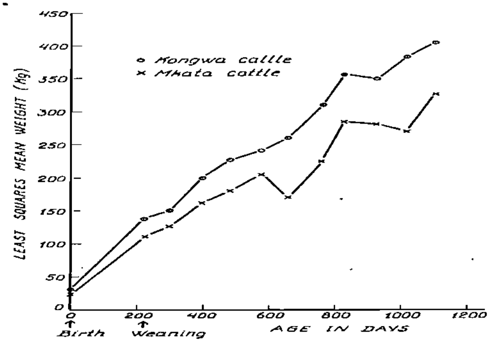

Figure.1. Growth curves for Boran and hatfberd beef cattle at Mkata and Kongwa ranch

was attributed to differences among sire breeds. The effects of ranch and sex were also found to be significant, accounting for 4 and 1 per cent of the variation, respectively. Gestation length was not significantly affected by age of dam or year of birth.

Least squares means for various breeds and other factors are shown in Table 3. Gestations (or more correctly, prenatal periods, when considered property of the calf) of halfbred Chianina calves were the longest; this mean was significantly ($P<0.05$) larger than the means of halfbred Friesian, Angus, Hereford, South Devon and Charolais calves. The mean prenatal period for halfbred Friesian calves was the shortest, but differed significantly only from the means for halfbred Simmental, Limousin and Chianina calves.

Mean gestation length of male calves was 1.4 days longer than that of female calves. Gestations were on average 3.5 days longer at Kongwa than at Mkata. This difference, however, could have been the result of systematic differences between recorders on the two ranches, *e.g.* in recording calving dates.

Birth weight

The major source of variation in birth weight of calves was the difference between the two ranches, accounting for 24 per cent of the total sum of squares. Breed of sire was the second most important source (3 per cent). In contrast to gestation length, birth weight was significantly influenced by age of dam.

Charolais-sired calves were the heaviest, with a mean birth weight of 28.5 kg, followed by calves sired by Chianina bulls (Table 3). These means were significantly larger than the means for Boran and halfbred Angus, Hereford and Friesian calves. Halfbred Angus calves were the lightest (25.3 kg), but differed significantly only from the means for halfbred Charolais and Chianina calves. Calves born at Kongwa were on average 6.6 kg heavier than those born at Mkata, and male calves about 1 kg heavier than female calves. Birth weight increased with age of cow from 23.4 kg for 3 year-old to 27.9 kg for 8 year-old cows.

Table 3: Least squares means and standard errors (S.E.) of gestation length, birth weight, and weaning weight for various classes

Class	Gestation length (days) Mean	S.E.	Birth weight (kg) Mean	S.E.	Weaning weight (kg) Mean	S.E.
Breed of sire						
Boran	-		25.6^{a}	0.4	117.5^{a}	2.2
Hereford	282.2^{abc}	0.9	25.6^{a}	0.5	126.6^{ab}	2.6
Angus	280.4^{ab}	0.9	25.3^{a}	0.5	119.8^{ab}	2.7
S.Devon	282.7^{abc}	1.0	26.7^{ab}	0.5	122.4^{ab}	2.6
Limousin	284.8^{c}	0.9	27.1^{ab}	0.5	126.2^{ab}	2.7
Simmental	284.6^{bc}	1.2	26.9^{ab}	0.7	127.0^{ab}	3.7
Friesian	280.3^{a}	0.9	25.6^{a}	0.5	127.9^{ab}	2.8
Charolais	282.5^{abc}	0.9	28.5^{b}	0.6	129.5^{b}	3.0
Chianina	286.6^{c}	1.0	27.9^{b}	0.6	123.3^{ab}	3.1
B.Swiss	284.5^{abc}	1.8	26.0^{ab}	1.1	125.0^{ab}	5.8
Ranch						
Kongwa	284.9^{a}	0.7	29.8^{a}	0.3	137.4^{a}	1.8
Mkata	281.4^{b}	0.6	23.2^{b}	0.3	111.6^{b}	1.8
Sex						
Male	283.9^{a}	0.6	27.0^{a}	0.3	127.0^{a}	1.7
Female	282.5^{b}	0.6	26.1^{b}	0.3	122.0^{b}	1.7
Age of dam						
3 years	278.6	2.9	23.4	1.6	109.7	7.6
4 "	283.8	0.9	26.3	0.5	124.9	2.3
5 "	283.1	0.7	26.4	0.4	127.8	2.1
6 "	284.3	0.6	26.8	0.4	130.9	1.7
7 "	284.0	0.6	27.3	0.3	128.4	1.8
8 "	284.0	1.1	27.9	0.5	126.3	2.8
9 "	284.0	1.5	27.5	0.7	123.7	4.0

Means within column and factor (age of dam ignored) with no letters in common are significantly different at $P<0.05$

Weaning weight

Age at weighing (as a covariate) and effect of ranch were the most important sources of variation in weaning weight, each accounting for 17-18 per cent of the total sum of squares. Effects of sex and breed of sire were also significant.

Boran calves were lightest, with a mean weight of 117.5 kg, but differed significantly only from the mean weight of Charolais crosses (129.5 kg). The various crosses did not differ significantly in weight at weaning. Male calves were, on average, 5 kg heavier at weaning than female calves, while the difference between the two ranches was about 26 kg in favour of Kongwa.

Table 4: Least squares means and standard errors (S.E.) of post-weaning weights (in kg) for various classes

Class	One year Mean	S.E.	Two years Mean	S.E.	Three years Mean	S.E.
Breed of sire						
Boran	143.2[a]	2.9	232.5[a]	4.2	316.3[a]	6.3
Hereford	156.6[bc]	3.7	249.0[ab]	5.4	336.6[abc]	8.2
Angus	149.3[ab]	3.7	247.9[ab]	5.2	327.9[ab]	7.9
S.Devon	157.8[bc]	3.8	256.3[b]	5.2	364.0[c]	7.8
Limousin	163.0[bc]	3.7	246.6[ab]	5.0	343.6[bc]	7.8
Simmental	161.6[bc]	5.1	264.8[b]	8.0	355.6[bc]	12.9
Friesian	167.0[c]	3.9	265.9[b]	5.9	348.1[bc]	8.5
Charolais	159.7[bc]	4.1	253.9[b]	6.2	361.8[bc]	9.3
Chianina	165.3[bc]	4.2	265.0[b]	6.3	359.4[bc]	9.4
B.Swiss	156.2[abc]	8.2	276.1[b]	12.8	357.1[bc]	18.6
Ranch						
Kongwa	170.6[a]	2.4	295.0[a]	3.5	392.7[a]	5.7
Mkata	145.4[b]	2.6	216.6[b]	3.4	301.3[b]	5.9
Sex						
Male	162.0[a]	2.3	261.1[a]	3.2	354.5[a]	5.0
Female	154.0[b]	2.3	250.5[b]	3.6	339.6[b]	6.1
Age of dam						
3 years	151.1	9.6	220.0	12.1	333.5	23.1
4 "	157.7	3.4	262.9	5.3	348.8	7.8
5 "	156.8	3.0	266.4	4.4	350,1	6.3
6 "	160.3	2.4	257.2	3.8	341.9	5.2
7 "	161.5	2.5	267.9	3.9	356.8	5.6
8 "	158.9	3.9	264.1	5.8	363.3	8.0
9 "	159.4	4.8	252.2	7.2	334.7	9.7

Means within column and factor (age of dam ignored) with no letters in common are significantly different at P<0.05

Yearling weights

Weights at one year of age were highly (P <0.001) affected by age at weighing and ranch accounting for 9 and 10 percent of the total sum of squares, respectively. Effects of year of birth, farm, breed of sire and sex were also significant, but the latter accounted for only 1 percent of the total variation. Age of dam had negligible (non-significant) effect.

At this stage halberd Friesians had the largest mean weight (167.0 kg), but differed significantly only from that of Boran and halfbred Angus cattle. Boran cattle were the lightest, with a mean weight of 143.2 kg, which was significantly (P <0.05) different from all other means except those of Angus and Brown Swiss crosses. Steers were 8 kg heavier than heifers. The difference between the two farms was about 25 kg in favour of Kongwa.

Weight at two years

At this stage, farm was the major source of variation, accounting for 34 percent of the total sum of squares. Other important sources of variation were age at weighing, year of birth and breed of sire while age of dam and sex had only minor influence.

The largest mean was obtained for the Brown Swiss crosses (276.1 kg) but this mean had a rather large sampling error (small number of records) and was significantly different only from the mean of Boran cattle (232.5 kg). Also most other crosses were significantly superior to the pure Boran. Steers exceeded heifers by about 10 kg, and cattle at Kongwa were, on average, about 68 kg heavier than cattle at Mkata.

Weight at three years

The difference between the two farms was the most important source of variation also at this stage (14 percent of total sum of squares), but also effects of age at weighing, breed of sire, year of birth and sex were significant. Again age of dam had negligible effect.

Halfbred South Devon cattle had the largest mean, but also means of Charolais, Chianina, Brown Swiss and Simmental crosses were significantly above that of pure Boran. Steers were about 15 kg heavier than female cattle. Cattle at Kongwa weighed, on average, about 91 kg more than cattle at Mkata at this stage.

Discussion

The significant variation in gestation length with breed of sire, sex of calf, and age of dam is well documented in the literature. Smith *et al.*(1976a,b) reported findings from a comprehensive crossbreeding experiment in the United States involving Hereford and Angus cows mated to Hereford, Angus, South Devon, Limousin, Charolais, Simmental, Brown Swiss and Chianina sires, among others. Gestation length for male calves was 1.7 days longer compared to females, in close agreement with the 1.4 days difference observed in the present study. In the U.S. study, Limousin-sired calves had the longest gestations (288.1 days) followed by Simmental, Charolais and South Devon crosses. Hereford by Angus reciprocal crosses and Jersey crosses had the shortest gestation periods. Calves from Angus cows had shorter gestations than calves from Hereford cows. Thus the ranking of the various breeds in the present experiment is in good agreement with that in the U.S. study. In both studies, older cows tended to have longer gestations, although this was not significant in our study. These findings suggest that factors that tend to increase size of the calf at birth also tend to increase gestation length or *vice versa.*

The superiority of males over females was 3 per cent for birth weight and 4 to 5 per cent for weight at weaning and subsequent stages. Similar levels of male *vs.* female superiority have been reported from a beef crossbreeding study in Western Uganda by Sacker *et al.*(1971) and later confirmed by other authors, e.g. recently by Mwatawala and Kifaro (2001) and by Holloway *et al.* (2002).

At all stages, crossbred cattle as a whole were superior in live weight compared to the Boran. The mean superiority of the crosses (pooled over breed of sire) was about 6 per cent at weaning and roughly 10 per cent at subsequent ages. The traditional British beef breeds (Hereford and Angus) were in general inferior to the continental breeds (Charolais, Chianina, Simmental and Limousin). The overall ranking is quite similar to the ranking observed in the U.S.study (Smith *et al.*, 1976b).

The superiority of the crossbred cattle over the Borans is a result of both additive and non-additive gene effects. The additive component of superiority represents a half of the additive genetic superiority of the *Bos taurus* sire breeds, while the non-additive genetic component represents the full amount of F_1 heterosis. Although the amount of heterosis involved in this study cannot be estimated, it would be expected to be higher than in crosses between *Bos taurus* breeds. Sheridan (1981) cited studies in which heterosis for live weight in Devon x Brahman and Angus x Brahman crosses ranged from 7 to 22 per cent. In Sahiwal x Holstein crosses, Taneja and Bhat (1978) obtained estimates of heterosis ranging from 3 to 8 per cent for live weight between birth and two years of age. In the W. Uganda study (see above) heterosis for live weight, between birth and two years averaged about 3 per cent in first crosses between Angus, Red Poll, and Boran sires and Ankole, Boran and small East African Zebu cows. Heterosis for live weight in Hereford x Angus crosses in the U.S. study was less than 3 per cent. Higher levels of heterosis would also be expected under stressful conditions, such as those prevailing in the tropics, due to the greater adaptability of the crosses (Cunningham, 1981). In a crossbreeding experiment in Queensland, Australia, heterosis in weight at 18 months of crosses between *Bos taurus* breeds and Brahnman ranged from zero to 16 percent (Frisch and O'Neil, 1998).

Records on viability, a very important trait in beef cattle, were not included in the data used for the present study. Another aspect of crossbreeding which might deserve consideration is the possible effect which the breed of the calf's sire might have on the subsequent reproductive performance of the cow as reported by Holloway *et al.* (2002).

Conclusion

With the above reservations, it seems justified to conclude that some of the crossbred groups outyielded the pure Boran by 10 to 15 percent. The simplest way to exploit this superiority in a sustainable manner might be to split the breeding herd into two groups during the mating season. One group of females is joined by bulls of the same breed, in this case Boran, while females of the other group are exposed to bulls of an exotic beef breed of choice. The female calves produced in the first group are reared to become replacements of lost or culled cows, while the female calves in the second group and the male calves in both groups are reared for slaughter. Alternatively, the cows in the second group could be mated to bulls of a dual-purpose breed e.g. Simmental. The male calves would still be suitable for beef, while the female calves could be sold to dairy farmers any time after weaning.

Since heterosis is likely to be so important in the present study, the performance of the crosses should not be used as a rationale for indiscriminate upgrading to the *Bos taurus* breed in the expectation of higher performance. Often this will not be the case. Rather, breeding plans should be made to exploit individual and maternal heterosis as well as breed differences in male vs. female superiority. It is hoped that results from the next phase of this study will indicate how this can be achieved under Tanzanian ranching conditions.

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