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Comparison of Landim and Africander Cattle in Southern Mozambique: II. Female Fertility, Reproduction, and Beef Offtake

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ABSTRACT: Fertility and reproductive performance of Landim and Africander females were compared using data collected from 1968 to 1981 at the Chobela Research Station in Mozambique. Breeds were managed together and grouped by age and sex, except when separated for breeding. Traits were relative fertility (probability of fertile females calving from the first breeding season), age at first calving, first calving interval, and subsequent calving intervals. Calving rates were tested by χ^2 procedures with equal expected frequencies in each subclass. The statistical model included breed, the random effect of sire within breed, year-season of birth or calving, and calving group within breed. Landim survivors were more fertile ($P < .05$) than the Africander ones throughout their recorded lifetimes. Landim females

were $1.32 \pm .21$ mo (or 3%) younger at first calving and had a 48 ± 12 d (or 11%) shorter interval between first and second calving than the Africander average of 473 d. When reproductive and growth information were combined to compute an annual index of beef offtake expressed as 18-mo calf yield per unit of dam's weight at first calving, Landim cows annually yielded 30% more calf weight ($P < .001$) than Africander cows per kilogram of their own body maintenance despite lighter body weights at 18 mo. Superior fertility of Landim females led to greater beef offtake from higher calving rates. Greater fertility and relatively less feed to maintain the reproducing herd are probable mechanisms for a population to adapt to nutrient-limiting environments such as the one in southern Mozambique.

Key Words: Beef Cattle, Landim, Africander, Reproduction, Productivity Index

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Introduction

Fertility (calving rate) is an important characteristic of the indigenous breeds that may be used in the cattle systems of southern Africa. Morgado (1954) reported an average calving rate of 86% for Landim cows, but reports about Mozambique's traditional sector and elsewhere in the tropics indicate that annual calving rate seldom exceeds 50% (Pinto, 1989; Galina and Arthur, 1989b).

The need for comparisons between cattle breeds indigenous to southern Africa has been emphasized frequently, especially for reproductive performance (Maule, 1973; Buck et al., 1976; Trail, 1986; Scholtz, 1988; Tawonezvi et al., 1988a). The Landim (also called Nguni) and Africander (both indigenous to southern Africa) are the main beef cattle breeds in southern Mozambique. Studies in neighboring countries (Rakha et al., 1971; Trail et al., 1977; Buck et al., 1982; Scholtz, 1988; Tawonezvi et al., 1988a) suggest that the Africander, which was widely dis-

seminated in the Mozambican commercial sector mostly due to its large mature size, may be less productive than previously assumed mainly because of reproductive performance inferior to that of other indigenous breeds. Therefore, it is important to evaluate the relative fertility and overall performance of alternative breed choices. Our principal objective was to compare the reproductive fitness and beef productivity of Landim and Africander cattle in southern Mozambique.

Materials And Methods

This study was conducted at the Chobela Research Station, which is located in Magude in the southernmost province of Mozambique. A detailed description of the environment, animal management, and the general objectives of the station was given by Carvalheira (1992) and Carvalheira et al. (1995). The rainy season at Chobela starts in approximately mid-October and continues until the beginning of April. The calving season is managed to start with the first rains and to end in mid-February. Dates of calving (birth) were classified in two seasons, either early

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(July 1 through December 31) or late (January 1 to June 30) in the rainy season. A 3-mo controlled mating season from February to April ensures that improved nutrition comes from the new pastures provided by initiation of the rainy season. For the mating season, 25 breeding females were grouped by breed and confined to 50-ha paddocks with the service sire. All females had two breeding opportunities (i.e., exposures during mating seasons in contiguous years) to become pregnant. Females leaving the herd were reproductive culls (e.g., failure to conceive after the second exposure) and animals (especially Landim) sold to other farmers. This information was not recorded.

Data and Statistical Analysis. The data consisted of dates of birth and calving of the Landim and Africander females from 1968 to 1981. The number of breeding females averaged 250 per year during the period of study, which represented 38% of the entire herd. Each breed accounted for equal proportions of the herd in every year. Data were recorded only for females that calved, which restricted the scope of this study.

The reproductive traits were relative fertility (the calving rate resulting from the first mating season of fertile females), age at first calving, lengths of first calving interval and the average of subsequent calving intervals. Relative fertility, which was equivalent to the joint probability of conceiving and subsequently retaining zygotes and embryos in fertile females, was tested by χ^2 procedures with equal expected frequencies in each subclass (females that calved following their first breeding exposure during a 3-mo mating season and females calving after their second 3-mo mating season). A mixed-effects model (GLM procedure; SAS, 1985) was used to analyze data for length of calving interval and age at first calving to evaluate breed differences. The statistical model for age at first calving (**AFC**), first calving interval (**FCI**), and subsequent calving intervals (**CI2**) was as follows:

$$y_{ijklm} = \mu + B_i + S_j(B_i) + G_k(B_i) + YS_l + \epsilon_{ijklm}$$

where

y_{ijklm} = the record of the m^{th} animal, of the i^{th} breed, belonging to the k^{th} calving group, and born to the j^{th} sire in the l^{th} year-season,

μ = the overall mean,

B_i = the i^{th} breed (Landim or Africander),

S_j = the random effect of the j^{th} sire nested within breed, which yielded the expected mean square for sire/breed to test the effect of breed (EMS = $k_1[\text{MS}(\text{sire/breed})] + k_2[\text{MS}(\text{residual})]$, where $k_1 + k_2 = 1.0$, and with df approximated by Satterthwaite's formula; Littell et al., 1991), and

G_k = the k^{th} calving group nested within breed, where $k = 1$ for females that calved after first exposure to breeding and $k = 2$ for females calving after the second exposure,

YS_l = the l^{th} year-season of birth (AFC and FCI) or the l^{th} year-season of calving (CI2), and

ϵ_{ijklm} = the vector of residuals, which was assumed $N(0, I\sigma^2)$.

Preliminary analysis showed high correlation ($r = .8$) between the effects of year-season of birth and year-season of calving. Hence, the most recent event was used. Linear contrasts of least squares means were computed from the model to test differences within classes of main effects for all traits.

The data were originally analyzed using a fixed effects model to avoid discarding information from 10% of the records that were not sire-identified. Sires of both breeds were similarly represented across years and seasons. From 59 to 73% of the expected mean squares for the effect of sire/breed were due to within-family (residual) variation. Both models (with and without the sire effect) were applied to assuage potential concern about the corresponding conclusions. Only minor differences resulted between the mixed and the fixed-effects models, which are reported as percentages in the tables. Identical conclusions were obtained.

The productivity index used to compare the annual beef offtake rates of Landim and Africander cows included calf weights at 18 mo, expected average survival and annual calving rates, and dam's weight at first calving (Buck et al., 1976; Trail and Gregory, 1981; Scholtz, 1988; Tawonezvi et al., 1988a; Dionisio and Syrstad, 1990). This productivity index (rates expressed in decimal fractions) was as follows:

$$18\text{-mo weight (kg)} \times \text{calf survival rate} \times \text{annual calving rate} \div \text{dam's body weight at first calving (kg)}$$

Least squares means for body weights at 18 mo were from a companion study (Carvalho et al., 1995). The average annual calving rate for each breed was estimated using the ratio between 365 d (year length) and length in days of the first calving interval (Scholtz, 1988; Dionisio and Syrstad, 1990). Weight at first calving was affected by age. For this reason, unadjusted weights at first calving were used instead of the age-adjusted least squares means to avoid penalizing Landim females for being much younger than Africander females at first calving.

Information on 18-mo calf survival rates was unavailable. Apparent survival rates were approximated from the 224 Landim and 222 Africander calves with recorded birth dates from 1975 to 1978, all of which were expected to have 18-mo weights if they survived. Morgado (1954) reported a mortality rate at

Table 1. Calving rates from first breeding exposure and χ^2 tests for heifers, primiparous and pluriparous fertile Landim and Africander females

Female group	Calving rate				χ^2
	Landim		Africander		
	n ^a	%	n ^a	%	
Heifers	73	54	49	42	3.7*
Primiparous cows	84	86	34	72	3.7*
Pluriparous cows	221	81	164	75	2.3 ^b

^aNumber of calvings from first exposure.

* $P < .05$.

^b $P = .12$.

the Chobela station of 4 and 8% for Landim and Africander calves up to 1 yr of age (average for the period 1940 to 1949). The resultant survival rates of 96% for Landim and 92% for Africander were nearly the same as the apparent ones in this study of 96% for Landim and 93% for Africander. A productivity index value was computed for each individual. The mean difference between breeds was tested using Student's *t*-statistic.

Results And Discussion

Relative Fertility in Heifers and Cows

The probabilities of calving from first breeding exposure and the χ^2 tests of significance by breed are given in Table 1. Landim heifers were more likely to calve from first exposure than Africander heifers (54 vs 42%, $P < .05$). The remainder of the recorded females got pregnant 1 yr later at the second exposure. Hence, these calving frequencies are measures of the probability of calving in fertile heifers, which provides evidence for greater reproductive propensity (fertility) at first breeding exposure by Landim females in this stage of life.

The proportion of primiparous Landim cows calving from first breeding exposure also exceeded that of Africander heifers (86 vs 72%, $P < .05$). This result, which partly depends on greater conception rate while cows are nursing their calves, is further evidence of the inherently greater fertility of Landim compared to Africander females. Data limitations restrict inferences to only fertile females. Although constant breed proportions in the herd were maintained across years, unequal culling for unsatisfactory conception rates would bias our estimate of the total difference between these breeds.

As at younger ages, pluriparous Landim cows were more likely to calve from first breeding exposure than Africander cows (81 vs 75%, $P = .12$). This outcome further supports greater fecundity for Landim females throughout their productive life than for the Africander females in the Chobela environment. Thus, the relatively more fertile and smaller Landim survivors may indicate greater adaptive advantage to the stressful, nutrient-limiting environment in southern Mozambique. The importance of animal fitness on land and farm productivity in environments with limited nutrient supply was emphasized by Nicholson et al. (1995).

Reproductive Performance

Mean squares, degrees of freedom, and tests of significance for the main effects are presented in Table 2. Least squares means and standard errors for AFC, FCI, and CI2 by breed and calving group and linear contrasts are presented in Table 3.

Age at First Calving. Year-season of birth and calving group affected ($P < .01$) age at first calving (Table 2). Variation in AFC by year-season of birth was similar for the Landim and Africander. Environmental factors such as rainfall, nutrition during the dry season, and other factors associated with year and season of birth are known to affect age at first calving (Galina and Arthur, 1989a).

Table 2. Mean squares (MS) and degrees of freedom (df) for age at first calving (AFC, mo), first calving interval (FCI, d), and subsequent calving intervals (CI2, d) for Landim and Africander females

Source	AFC			FCI			CI2		
	df ^a	MS ^a	MS ^b	df ^a	MS ^a	MS ^b	df ^a	MS ^a	MS ^b
Breed (B)	1	.4	3.6	1	27.5	2,409.4	1	89.7	500.0
Sire/B	38	.9	—	28	1,717.6	—	46	552.6	—
Year-season	11	84.**	24.2**	11	1,475.8	3,945.5**	22	238,486.8**	12,762.2**
Group/B ^c	2	2,151.1**	3,697.9**	2	594,045.2**	1,300,314.9**	2	2,630,430.9**	3,166,849.4**
Residual	197	1.0	1.6	102	1,446.7	1,547.9	419	765.7	792.9
EMS ^d	162.9	1.0	—	118.3	1,529.9	—	408.9	708.4	—

^aMixed model.

^bFixed-effects model.

^cCalving group (i.e., first or second breeding exposure) in which female got pregnant.

^dApproximate df and expected mean squares (EMS) to test the breed effect (Littell et al., 1991).

** $P < .01$.

Table 3. Least squares means (\bar{x}), estimated linear contrasts (Est), and standard errors (SE) by breed and calving group^a for age at first calving (AFC, mo), first calving interval (FCI, d) and subsequent calving intervals (CI2, d) for Landim and Africander females

Effect	AFC				FCI				CI2			
	n	\bar{x} or Est	SE	$\Delta\%$ ^a	n	\bar{x} or Est	SE	$\Delta\%$ ^a	n	\bar{x} or Est	SE	$\Delta\%$ ^a
Breed												
		mo				d				d		
Landim	134	41.2	.17	-1.94	98	424.7	7.6	1.95	273	445.8	4.1	-.34
Africander	116	42.5	.22	-.94	47	472.5	11.0	1.65	218	467.2	3.8	.13
Group ^b												
Landim												
1st yr	73	35.8	.20	-1.40	84	376.1	7.8	-1.28	221	380.9	4.4	-.32
2nd yr	61	47.6	.21	-.63	14	716.5	15.9	3.01	52	725.1	5.9	.21
Africander												
1st yr	49	35.6	.29	.00	34	383.6	10.8	.21	164	382.7	4.0	.21
2nd yr	67	47.6	.22	-.21	13	705.2	18.3	-.16	54	726.9	5.4	.15
Contrast												
Landim minus Africander		-1.32	.21**			-47.8	11.8**			-21.5	4.8**	
Early minus late season ^c		.55	.09**			.8	6.6			-16.3	3.1**	

^aPercentage of difference between least squares means from the fixed-effects model (f) and the mixed model (m): $[(\bar{x}_f - \bar{x}_m) \div \bar{x}_m] \times 100$.

^bCalving group (i.e., first or second exposure to breeding) in which female got pregnant.

^cSeason of birth for AFC and FCI, and season of calving for CI2.

** $P < .01$.

Heifers born early in the rainy season were approximately $.6 \pm .1$ mo older at first calving than those born late in the rainy season (Table 3). This outcome may seem to be inconsistent with our previous summary of weight and growth (Carvalho et al., 1995), in which calves born early in the rainy season grew more rapidly than their late-born counterparts to obtain heavier body weights at weaning and 18 mo. Early-born calves might be expected to reach puberty and first calving at younger ages. However, these early-born heifers were older at first calving because of a management decision to await feed supplies brought by the onset of rains, which also commenced the next breeding season. Consequently, these heifers waited an average of 2 mo before starting the breeding season in February.

Mean ages were 35.8 mo for Landim and 35.6 mo for Africander heifers calving after first exposure, and 47.6 mo for both Landim and Africander heifers calving after the second exposure. The bimodal distribution resulted from a management policy giving all females at least two opportunities (two breeding seasons in contiguous years) to conceive before being culled.

The effects of heifer calving group within breed and the breeding season (each $P < .001$), an adjustment for the unequal joint probabilities of conception and subsequent retention of zygotes and embryos, explained as much as 61% of the coefficient of determination ($R^2 = .98$). The calving group effect adjusted AFC for the important source of variation resulting from different proportions of females from each breed that calved from first and second exposure. Approximately 60% of heifers that calved after the first exposure were Landim and approximately 40% were

Africander. Because breeding seasons were necessarily aligned with rain-induced forage supplies, the remaining fertile heifers calved 1 yr later (the difference between the AFC means of the two calving groups was approximately 12 mo). As expected, the resultant residual breed effect on AFC was greatly diminished ($P = .54$) after adjusting for the predisposing breed difference in fertility at first breeding exposure.

Accounting for the proportions of heifers that calved from first and second breeding exposures revealed a large contrast (Table 3) whereby Landim heifers were $1.32 \pm .21$ mo younger ($P < .01$) than Africander heifers at first calving. Least squares means for AFC were $41 \pm .17$ mo for the Landim and $43 \pm .22$ mo for the Africander (Table 3). These results agree with the results by Scholtz (1988) of 36 mo at AFC for Landim (Nguni) and 41 mo at AFC for Africander for the period 1976 to 1985 in South Africa. Some Zebu breeds (Boran and Horro) and their crosses with Friesian, Jersey, and Simmental averaged 43 to 60 mo at AFC in Ethiopia (Kebede, 1992).

Age at first calving is favorably related to age at puberty (Galina and Arthur, 1989a). A previous report indicated an average age at puberty of 20 mo for Landim heifers, ranging from 16 mo to 25 mo (IPA, 1987). Delayed puberty in Africander heifers was identified as one important factor affecting lifetime reproductive performance in this breed (Buck et al., 1976). Whether due to earlier puberty or not, Landim heifers in this study were younger at first calving because they were more likely to calve from first breeding exposure than were Africander heifers in this harsh Mozambican environment.

First Calving Interval. Primiparous cows averaged 2 mo after calving (beginning in November) before

beginning the next mating season (in February). This situation is a complex biological challenge for immature females, which must complete uterine involution and resume ovarian cyclicity with fertile estrus while nursing their offspring. Thus, in this study the interval between first and second calving measures reproductive performance subject to restrictions on the length of the breeding season and the length of the postpartum period preceding it.

Most females showed a tendency for calving early in the rainy season. Mean calving intervals were 12.3 mo for Landim and 12.6 mo for Africander cows calving after first exposure and 23.5 mo for Landim and 23.1 mo for Africander cows calving after the second exposure.

Calving group was an important factor influencing the length of first calving interval ($P < .01$, Table 2) without detectable interaction of breed with year-season of birth. Differences in first calving interval due to season of birth were not detected (Table 3). Similar to its effect on age at first calving, the calving group effect reduced the breed contribution ($P = .89$) by removing 52% of the total variation for first calving interval. In an extensive review about cattle reproduction in the tropics, Galina and Arthur (1989b) confirmed that year-season of birth and body condition of heifers at calving affected subsequent calving interval and milk yield.

Among the cows calving from first postpartum breeding exposure, approximately 71% were Landim and 29% were Africander. The resulting average first calving interval was 48 ± 12 d longer ($P < .01$) for the Africander (473 ± 11 d) than for the Landim, which averaged 425 ± 8 d between first and second calvings (Table 3). Scholtz (1988) reported a first calving interval of 442 d for Landim (Nguni) and 512 d for the Africander in South Africa, which further attests to the greater reproductive efficiency of the Landim compared with Africander cows under broader geographical conditions in southern Africa. Like age at first calving, differences in this study arose from different probabilities of calving from first breeding exposure in postpartum primiparous cows. Shorter calving intervals and younger ages at first calving indicate that the Landim breed is more adapted to this environment.

Subsequent Calving Intervals. Year-season of calving and calving group were important effects ($P < .01$). Calving group accounted for 77% of the total variation in this trait. The residual breed effect ($P = .72$) in these survivors was less than in fertile survivors at earlier stages of life.

Like the earlier reproductive events, there was no interaction between breed and year-season of calving affecting annual variation in calving interval. Pluriparous cows calving in the early season averaged 16 ± 3 d shorter ($P < .01$) calving intervals than cows calving after December (Table 3). This result is

consistent with our analysis of growth, whereby calves born early in the rainy season grew faster and were heavier at weaning and 18 mo than those born late in the rainy season (Carvalho et al., 1995).

Mean calving intervals did not differ for cows calving in the previous year (380 ± 4 d for Landim and 383 ± 4 d for Africander) or for cows that did not calve in the previous year (725 ± 6 d for Landim and 727 ± 5 d for Africander, Table 3). The Landim averaged nearly 22 fewer days ($P < .01$) between calvings than Africander cows (Table 3), after adjusting for the proportions of cows that calved in the previous year (i.e., 57% of Landim and 43% of Africander cows that conceived while nursing their calves), and cows that did not calve in the preceding year. Convergence in cow reproductive performance with age (48 d difference between breeds in first calving interval and 22 d difference in subsequent calving intervals) was expected because only fertile females could be considered. Compared to Zebu breeds and their crosses with European breeds in Ethiopia (Kebede, 1992), Landim cows in this study had 20% shorter average calving intervals.

The calving group effect substantially decreased the residual effect of breed because the unequal proportions of pregnancies resulting from first breeding exposure were ignored. The larger proportions of Landim heifers and cows that got pregnant and calved from their first exposure compared with the Africander females resulted in important differences favoring the Landim in each of the three reproductive measures studied. Because these breeds were managed together in the same herd environment, our evidence supports the hypothesis that Landim was reproductively better adapted to this environment through greater fertility at the times of first breeding exposure as heifers, and as primiparous and pluriparous cows. This portends more calves per lifetime per breeding female for Landim cattle. Although the data were restricted to performance in fertile females, which may contribute to overestimating relative performance, results showed Landim females to be 3% younger at first calving, to require 11% fewer days between first and second calving, and to average 5% shorter intervals between subsequent calvings than Africander cows. The same fundamental reason led to better reproductive performance in each case: greater probability of calving from first breeding exposure by Landim females.

Using data from South Africa's National Beef Cattle Performance and Progeny Testing Scheme, Scholtz (1988) indicated that selection has effectively increased fitness, and that in the case of the Landim (Nguni) natural selection produced an adapted and highly fertile breed in response to the difficult environmental challenges in southeastern Africa. Higher reproductive rates found in this study support other evidence that the Landim is better adapted than

Table 4. Calf weight at 18 months, calf survival rate^a, length of first calving interval, annual calving rate, cow weight at first calving, and the 18-month yearling productivity index^b

Trait	Landim	Africander
	$\bar{x} \pm SE$	$\bar{x} \pm SE$
18-mo wt, kg ^c	237.1 \pm 3.9	254.6 \pm 3.8
Calf survival rate to 18 mo, % ^a	95.8	92.5
Calving rate, %	86	77
Cow weight at first calving, kg	352 \pm 5.0	422 \pm 6.3
Productivity index ^{de}	.56 \pm .003	.43 \pm .002

^aApparent survival rate.

^bSource: Carvalheira et al. (1995).

^cLeast squares means.

^dIndex = 18-mo calf weight per unit of dam's body weight per year (kg/kg).

^eBreeds differed, $P < .001$.

the Africander breed to the (Chobela) environments of southern Mozambique and other countries in southern Africa.

Yearling (18-Month) Productivity Index. Landim cows yielded 30% more 18-mo calf weight than Africander cows (Table 4). Landim cows annually gave .13 kg more ($P < .001$) 18-mo-old calf weight per kilogram of dam's body weight. Studies from Botswana also showed less annual 18-mo calf productivity per cow for Africander than for Tswana and Tuli cows. Trail et al. (1977) found Tswana and Tuli breeds to be 18 and 44% more productive than Africander cows, yielding 155 kg of 18-mo calf weight per cow per year. Buck et al. (1982) also found Tswana, Bonsmara, and Tuli breeds to be 31, 38, and 39% more productive than Africander cows, producing 163 kg of 18-mo calf weight per cow per year. Corresponding annual yields in 18-mo calf weight in this study were 196 kg/cow for Landim and 183 kg/cow for Africander.

The apparent calf survival rate to 18 mo of age was similar (96 vs 93%) among the survivors of both breeds in these data. This rate, computed as the percentage of live calves at birth that reached 18 mo of age, may not reflect the correct averages under field conditions. Sensitivity analysis showed that fertility (calving rate) was the dominant component, followed by calf weight and dam's weight. Buck et al. (1982) indicated that profitability in range beef production depends primarily on efficient calf production, which is a function of reproductive performance, viability, and growth. Therefore, the productive advantage for the Landim was due to better reproductive performance and (less feed for maintenance of) lighter dams, which compensated for their calves' lower 18-mo weights compared with Africander calves. The index in this study did not account for the younger average age at first calving of Landim females, which would increase its productive advantage. Results indicate that the Landim breed is more productive than the Africander breed in the conditions of southern Mozambique.

Conclusions

A smaller maintenance requirement may signify an advantage in coping with the adverse environmental conditions in which cows are simultaneously stressed by lactation and by pregnancy during the feed-scarce dry season. Maule (1973) discussed the importance of body size and maintenance requirements in low feed input systems, where large (550 kg) cows required 35% more energy for maintenance than small (370 kg) ones. Also, because of interactions between body size and the forage plant ecology, smaller females may be more able to select feed to support lactation and pregnancy than larger ones, especially during the dry season when mostly scarce standing straw is available (Demment and Van Soest, 1985). Therefore, less feed (land area) for maintenance and potentially more selective feeding behavior of reproducing Landim females may contribute to their productive advantage.

The greater proportion of annual calvings by Landim cows than by Africander cows probably reflected their greater adaptation to this environment. The larger crop of Landim yearling calves more than compensated for being 18 kg lighter than their Africander counterparts. Relative fertility, manifested in calving rate, was the major factor affecting the breed differences in total performance.

Research evidence is leading to a consensus about the superiority of the Landim and other Sanga breeds over the Africander. Farmers in the traditional sector in southern Mozambique own Landim cattle exclusively. This preference is probably based on knowledge (though empirical) of the greater adaptability of Landim cattle to this restrictive environment. Several studies indicated that other Sanga breeds (e.g., Mashona, Tswana, Tuli) in the southern African region are more productive than the less-fertile Africander (Trail et al., 1977; Buck et al., 1982; Scholtz, 1988; Tawonezvi et al., 1988a,b).

Although results of the present study indicate that Landim is a productive breed by its own merit, more

information is needed about strategies to improve their contribution to farm productivity, either by selection or by crossing with other breeds. For example, the poorer productivity of Africander germplasm was also detected in crossbred offspring in Zimbabwe (Tawonezvi et al., 1988b). Crossbreeding of Sanga breeds with European or specialized tropical breeds to optimally combine the adaptability of local breeds (e.g., reproductive rate, disease resistance) with the greater beef or milk potentials of other breeds is acknowledged as a rational way to increase productivity in difficult environments (Ansell, 1985). Studies are needed to evaluate heterosis and breed complementarity in Landim crosses under similar nutrient-limiting conditions.

Implications

The Landim exceeded the Africander in producing 18-mo calf weight, especially due to superior female fertility throughout productive life. Greater calving rates and, probably, less feed for maintaining and supporting reproduction of smaller cows were favorable outcomes for this fertility advantage, which may identify the probable adaptative mechanisms for livestock populations in nutrient-limiting environments such as southern Mozambique. Hence, upgrading programs of the past were, instead, scenarios where the Landim was downgraded to the Africander. The results of this evaluation should encourage the use of Landim instead of Africander in the commercial beef cattle sector in southern Mozambique.

Literature Cited

- Ansell, R. H. 1985. Cattle breeding in the tropics. *World Anim. Rev.* 54:30.
- Buck, N. G., D. Light, L. Lethola, T. Rennie, M. Mlambo, and B. Muke. 1982. Beef cattle breeding systems in Botswana: the use of indigenous breeds. *World Anim. Rev.* 43:12.
- Buck, N. G., D. Light, A. Rutherford, M. Miller, T. W. Rennie, D. Pratchett, B. S. Capper, and J.C.M. Trail. 1976. Environmental factors affecting beef cow reproductive performance in Botswana. *Anim. Prod.* 23:357.
- Carvalho, J.G.V. 1992. Comparison of the Landim and Africander cattle in southern Mozambique for growth, reproduction and total performance. M.S. Thesis. Cornell Univ., Ithaca, NY.
- Carvalho, J., R. W. Blake, E. J. Pollak, and P. J. Van Soest. 1995. Comparison of Landim and Africander cattle in southern Mozambique: I. Body weights and growth. *J. Anim. Sci.* 73:3519.
- Demment, M. W., and P. J. Van Soest. 1985. A nutritional explanation for body-size patterns of ruminant and nonruminant herbivores. *Am. Nat.* 125:641.
- Dionisio, A. C., and O. Syrstad. 1990. Productivity of Nguni and Africander cattle in Mozambique. *Live. Prod. Sci.* 24:29.
- Galina C. S., and G. H. Arthur. 1989a. Review of cattle reproduction in the tropics. Part 1. Puberty and age at first calving. *Anim. Breed. Abstr.* 57(7):583.
- Galina C. S., and G. H. Arthur. 1989b. Review of cattle reproduction in the tropics. Part 2. Parturition and calving intervals. *Anim. Breed. Abstr.* 57(8):679.
- IPA. 1987. Reproduction characteristics of male and female Landim/Nguni cattle in Mozambique. Technical Report, Instituto de Produção Animal, Maputo, Mozambique.
- Kebede, B. 1992. Estimation of additive and nonadditive genetic effects for growth, milk yield and reproduction traits of crossbred (*Bos taurus* × *Bos indicus*) cattle in wet and dry environments in Ethiopia. Ph.D Dissertation. Cornell University, Ithaca, NY.
- Littell, R. C., R. J. Freund, and P. C. Spector. 1991. SAS System for Linear Models. (3rd Ed.). p 105. SAS Inst. Inc., Cary, NC.
- Maule, J. P. 1973. The role of the indigenous breeds for beef production in southern Africa. *S. Afr. J. Anim. Sci.* 3:111.
- Morgado, F. P. 1954. Subsídios para o conhecimento das espécies pecuárias de Moçambique. *An. Serv. Ind. Anim.* 6:433.
- Nicholson, C. F., R. W. Blake, and D. R. Lee. 1995. Livestock, deforestation, and policy making: Intensification of cattle production systems in Central America revisited. *J. Dairy Sci.* 78:719.
- Pinto, F. 1989. Sector pecuário em Moçambique. Ministério da Agricultura, Mozambique.
- Rakha, A. M., G. Igboeli, and J. L. King. 1971. Calving interval, gestation and postpartum periods of indigenous central African cattle under a restricted system of breeding. *J. Anim. Sci.* 32:507.
- SAS. 1985. SAS User's Guide: Statistics (Version 5 Ed.). SAS Inst. Inc., Cary, NC.
- Scholtz, M. M. 1988. Selection possibilities of hardy beef breeds in Africa: The Nguni example. In: *Proc. 3rd World Congr. Sheep and Beef Cattle Breed.* pp 303–319. Paris, France.
- Tawonezvi, H.P.R., H. K. Ward, J.C.M. Trail, and D. Light. 1988a. Evaluation of beef breeds for rangeland weaner production in Zimbabwe. 1. Productivity of purebred cows. *Anim. Prod.* 47:351.
- Tawonezvi, H.P.R., H. K. Ward, J.C.M. Trail, and D. Light. 1988b. Evaluation of beef breeds for rangeland weaner production in Zimbabwe. 2. Productivity of crossbred cows and heterosis estimates. *Anim. Prod.* 47:361.
- Trail, J.C.M. 1986. Animal breeding in developing country situations in Africa. In: *Proc. 3rd World Congr. Genet. Appl. Live. Prod.* Lincoln, NE. XI:474.
- Trail, J.C.M., N. G. Buck, D. Light, T. W. Rennie, A. Rutherford, M. Miller, D. Pratchett, and B. S. Capper. 1977. Productivity of Africander, Tswana, Tuli and crossbred beef cattle in Botswana. *Anim. Prod.* 24:57.
- Trail, J.C.M., and K. E. Gregory. 1981. Sahiwal cattle: An evaluation of their potential contribution to milk and beef production in Africa. ILCA Monograph 3. Addis Ababa, Ethiopia.