Review

Recent research into the production potential of indigenous cattle with special reference to the Sanga

S.J. Schoeman
Department of Livestock Science, University of Pretoria, Pretoria 0002, Republic of South Africa

Received 26 March 1988; accepted 15 December 1988

Presented at the Symposium on 'Training of Animal Scientists' at the 27th Annual Congress of the South African Society of Animal Production at the University of the Orange Free State, Bloemfontein, on 28—31 March 1988

A review based on recent research is presented on the production of Sanga (Nguni) cattle in South and South West Africa. The high calving rate of Sanga cattle (89,6%) compared to an average of 77,4% of four other breeds was the most outstanding feature. Nguni heifers reached puberty much earlier (349,9 days) than Bonsmara (419,0 days) and Drakensberger (407,2 days) breeds. Low calving losses were evident even with an early mating system (12 months). Indigenous cattle breeds are more tick resistant and may possibly be more efficient in production than exotic breeds. Evaluation of indigenous breeds in crossbreeding systems owing to their outstanding maternal performance is recommended.

'n Oorsig gebaseer op die jongste navorsing oor produksie van Sanga(Nguni)-beeste in Suid- en Suidwes-Afrika word aangebied. Die hoë kalfpersentasie van 89,6% vir Sanga-beeste teenoor 'n gemiddeld van 77,4% vir vier ander rasse was die mees uitstaande kenmerk. Nguni-verse het puberteit heelwat vroeër (349,9 dae) as Bonsmara- (419,0 dae) en Drakensbergerverse (407,2 dae) bereik. Lae kalfmortaliteit selfs met 'n vroeë paringstelsel (12 maande) is aangetoon. Inheemse beesrasse is meer bosluisweerstandbiedend en kan selfs meer doeltreffend in produksie as eksotiese beesrasse wees. Die evaluering van inheemse rasse in kruisteeltstelsels as gevolg van hulle besondere maternale prestasies word aanbeveel.

Keywords: Calving rate, efficiency, indigenous cattle, Nguni, production, Sanga.

Introduction

There are many cattle breeds in Southern Africa. All cattle breeds may be classified into two major types, namely humpless and humped. The former group is taxonomically classified as *Bos taurus* and is exotic to Southern Africa. These breeds, introduced more recently into the country, are not necessarily well adapted to all South African environments.

Humped cattle types may be classified into two groups, namely those with thoracic humps (Zebu) and those with cervico-thoracic humps (Sanga) (Mason, 1969). Zebu cattle are also not indigenous to Southern Africa.

All Sanga types evolved from crosses between Zebu and humpless Hamitic longhorn cattle in central and eastern Africa. Sanga cattle accompanied black tribes in their migrations to the southern regions of Africa. These cattle are known in Zululand as the Nguni (Brown, 1959) and in Northern Transvaal as the Pedi. Sanga cattle breeds in Zimbabwe and Zambia are known as the Nkone (previously known as Matabele cattle) and in Botswana as Tswana and Tuli, the latter being an improved yellow type (Goodwin, 1976). In the northern parts of South West Africa (Ovambo, Kavango and the Caprivi) all types are referred to as Sanga cattle.

The Afrikaner breed was developed by Dutch settlers from Hottentot cattle. More recently the Bonsmara breed was developed from crosses between Afrikaner and *Bos taurus* breeds such as Shorthorn and Hereford, while the Drakensberger probably originated from crosses between the Afrikaner and Friesian types (Dreyer, 1982).

Indigenous Sanga cattle types thus share a common origin and differ from Zebu cattle in that they have a sub-metacentric *Y*-chromosome (as in *Bos taurus*), compared to an acrocentric *Y*-chromosome (as in *Bos indicus* or Zebu) (Meyer, 1981).

The objective of this paper is, therefore, to review some of the most recent information on the production performance of indigenous breeds with special reference to Sanga cattle in South and South West Africa and to emphasize the role they can play in efficient livestock production in extensive production areas under proper management conditions. Comprehensive reviews on performance of indigenous cattle breeds in other parts of Southern Africa were published by Maule (1973) and Hetzel (1988) and may be consulted for further details.

Reproduction

It was generally accepted for many years that reproductive rates in indigenous livestock breeds were extremely low. However, in their reviews, Maule (1973) and Hetzel (1988) reported average calving percentages of between 64 and 91% and 68 and 87%, respectively, in various herds of Sanga cattle in Southern Africa. Lepen (1988) reported an average calving percentage of 83% in the Bartlow Combine Nguni herd. It was, however, only in recent years that the Sanga generated more interest amongst stock farmers. A progress report, submitted by Barnard & Venter (1983) at the SARCUSS Standing Committee for Animal Production, on performance data of Sanga cattle in comparison with other breeds at

Table 1 Calving percentages of five cattle breeds (1977 — 1986), Annual Progress Reports, Omatjenne Research Station

	Year										
Breed	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	Unweighted mean
Afrikaner	70,0	66,7	79,3	81,3	65,6	80,0	87,5	63,3	64,5	87,5	74,6[b]
Hereford	79,3	66,7	80,0	73,3	*	89,7	65,6	78,1	75,0	93,8	77,9[b]
Sanga	83,3	96,7	97,5	95,1	88,4	89,8	88,9	81,6	87,5	87,5	89,6[a]
Santa Gertrudis	86,7	73,3	86,7	56,7	71,9	83,5	93,8	82,8	82,1	78,6	79,6[b]
Simmentaler	87,9	65,5	71,0	77,4	73,3	90,3	*	*	70,0	85,2	77,6[b]
Unweighted mean	81,4	73,8	82,9	76,8	74,8	88,7	83,9	76,5	75,8	86,5	80,1

[a,b] $P<0,01$.
* Excluded due to subfertile sire.

the Omatjenne Research Station (Otjiwarongo, South West Africa) was one of the most important reasons for this renewed interest.

The Sanga herd at Omatjenne originated from animals that were culled in Kavango. Since 1977, the herd has consisted of about 30 females and their performances were compared to those of equal numbers of Afrikaner, Hereford, Santa Gertrudis and Simmentaler females under comparable management. Since 1981, however, the number of Sanga females has gradually increased. As a result, comparisons since 1984 have been based on approximately 17 kg cow biomass/ha/year. Calving rates from 1977 to 1986 are presented in Table 1. Calving rates and reconception rates of heifers are presented in Table 2. Table 3 presents a comparison of the calving rates of the Sanga cattle at Omatjenne with those of the Nguni at Bartlow Combine in Kwa Zulu and with the calving rates of Nguni cattle according to Phase A of the National Beef Cattle Performance and Progeny Testing Scheme. It is clear from Tables 1 to 3 that the fertility of the Sanga and Nguni breeds is exceptionally high. The difference in intercalving period between Nguni at Bartlow Combine and the Sanga at Omatjenne (Table 3) may possibly be due to sweeter veld at Omatjenne.

Calving rates of the Afrikaner are lower than in the other indigenous breeds as well as in exotic breeds (Tables 1 & 3). These differences are in agreement with results of several other studies in Africa as reviewed by Hetzel (1988).

Table 2 Calving percentages of first calf heifers and calving percentages of heifers (Barnard & Venter, 1983; Annual Progress Reports, Omatjenne Research Station)

Breed	Calving percentages first calf heifers (1978—1986)	Recalving percentages of heifers (1977—1982)
Afrikaner	87,1	78,0
Hereford	82,1	70,4
Sanga	91,4	92,9
Santa Gertrudis	83,1	76,7
Simmentaler	76,9	76,6
Unweighted mean	84,1	78,9

Table 3 Intercalving periods (days) of beef cattle breeds

	Source		
Breed	Barnard & Venter (1983) (1977—1982)	Scholtz (1988)[a] (1979—1985)	Lepen (1988)[b] (1972—1986)
Afrikaner	460	469	
Hereford	462	423	
Sanga	372		
Nguni		412	419
Bonsmara		434	
Santa Gertrudis	420	458	
Simmentaler	416	449	

[a] Results from Phase A, National Beef Cattle Performance and Progeny Testing Scheme.
[b] Results from Bartlow Combine Nguni herd.

Puberty

Age and mass at the onset of puberty differ according to breed (Coetzer & Van Marle, 1972). Maule (1973) stated that in many *Bos indicus* breeds, puberty occurs much later than in European breeds and that heifers are often not mated until three, sometimes four, years of age. This was confirmed by Coetzer & Van Marle (1972) in Afrikaner cattle.

Lepen (1988) compared Drakensberger, Nguni, and Bonsmara heifers of approximately the same age (8 months) on aspects of puberty at the Bartlow Combine Breeding Station. Values for age and mass at puberty, ADG, total feed intake and FCR of Drakensberger, Bonsmara, and Nguni heifers in feedlot together with the age, mass and ADG of Nguni heifers on natural grazing are presented in Table 4. First observed oestrus was taken as age of puberty. The Nguni heifers reached puberty at a significantly ($P<0,01$) younger age and lower mass and also consumed less than half the feed compared to the Bonsmara and Drakensberger heifers. Although Bonsmaras and Drakensbergers had a better growth rate, the differences in feed conversion ratios were non-significant ($P>0,05$) between the feedlot

Table 4 Least mean squares (± SE) for age, mass, ADG, feed intake and feed conversion ratio (FCR) of Nguni (feedlot and extensive), Bonsmara and Drakensberger heifers at puberty (Lepen, 1988; Bartlow Combine Breeding Station)

	Bonsmara	Drakensberger	Nguni (Feedlot)	Nguni (Extensive)
Age (days) at puberty	419,0 ± 11,7 [a]	407,2 ± 7,4 [a]	349,9 ± 7,1 [b]	399,9 ± 6,0 [a]
Mass (kg) at puberty	341,4 ± 13,3 [a]	298,7 ± 8,4 [a]	238,2 ± 8,1 [b]	234,9 ± 3,8 [b]
ADG (kg/day)	1,08 ± 0,07 [b,d]	0,87 ± 0,05 [b]	0,76 ± 0,04 [b,c]	0,38 ± 0 [a]
Total feed intake (kg) per heifer in feedlot	1151,3 ± 102,9 [a]	708,3 ± 65,3 [a]	326,8 ± 62,5 [b]	-
FCR (kg/kg)	7,46 ± 0,04	7,03 ± 0,25	6,87 ± 0,24	

[a,b] $P<0,01$.
[c,d] $P<0,05$.

groups. The difference in age at the onset of puberty (50 days) between the feedlot and veld group of Nguni heifers was highly significant ($P<0,01$). The difference in mass between these two groups was, however, non-significant ($P>0,05$).

Early calving

Under extensive conditions the majority of beef heifers are mated so as to calve at three years of age. However, with good management, heifers may successfully be bred at a much earlier age. Lepen (1988) compared a feedlot group and a veld group of Nguni heifers by mating them at the approximate age of 13 and 16 months, respectively. The feedlot groups were, after reaching puberty, also put on the veld for the mating season. Results obtained in this study are presented in Table 5. Changes in mean cow mass of these groups are presented in Figure 1. From these results, it is apparent that Sanga cattle, mated at an early age (approx. 13 months), were by no means worse off than those mated at a later stage, provided that a proper management level was maintained.

At the Loskop Experimental Station, Scholtz (1985) also studied the effect of early mating (15 months) on reproductive performance of Nguni cattle. The average pregnancy rate was only 37%, but in the case of heifers with an adjusted yearling mass of more than 195 kg it was 73%, which corresponds favourably with the 79% for heifers mated at 27 months.

Table 5 Mass and reproductive performance of two groups of Nguni heifers (Lepen, 1988)

	Feedlot group	Veld group
Number of heifers per group	15	19
Mean age at calving (days)	668,6 ± 4,3 [a]	752,7 ± 3,0 [b]
Mass at beginning of mating season (kg)	263,7 ± 4,4	250,8 ± 3,0
Mass after calving (kg)	286,3 ± 5,0 [a]	315,9 ± 3,5 [b]
Per cent heifers conceived	80,0	79,3
Calving percentage	73,3	75,9
Per cent reconceived	90,9	90,0

[a,b] $P<0,01$.

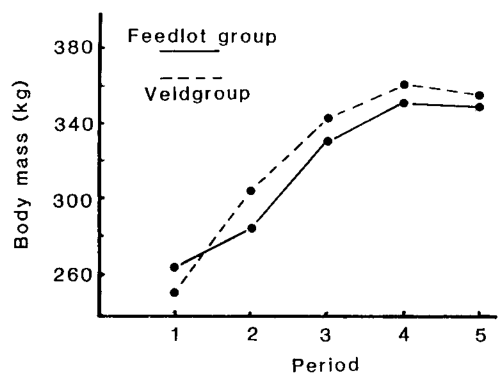

Figure 1 Changes in body mass of feedlot and veldgroup heifers (Lepen, 1988). 1 — mass at first breeding season; 2 — mass after calving; 3 — mass at second breeding season; 4 — mass at end of breeding season; 5 — mass at weaning.

Calf losses

Perinatal and pre-weaning mortality losses reflect on herd fertility and adaptability and it is apparent from Table 6 that indigenous cattle types compare favourably with exotic breeds. In this Table, neonatal and pre-weaning calf losses together with incidence of dystocia in Sanga cattle and several exotic breeds at Omatjenne are presented. Foetal mass in the Sanga cattle averages 7,2% of maternal mass at birth as against 6,8% in exotic breeds, which clearly indicates the relative ease with which Sanga females give birth to calves. This is further

Table 6 Mortality rates (%) and incidence of dystocia for cattle breeds (Omatjenne Research Station)

	Neo-natal calf losses (%) (1978—1986)	Mortality birth to weaning (%) (1978—1986)	Per cent dystocia (1980—1986)
Afrikaner	1,87	6,28	0,65
Hereford	5,56	9,43	4,79
Sanga	1,74	3,61	0
Santa Gertrudis	1,33	4,52	0
Simmentaler	7,24	6,17	4,96
Mean	3,55	6,00	2,08

supported by the zero incidence of dystocia in the Sanga herd. Lepen (1988) also reported a complete absence of dystocia in early-mated Nguni cattle as against a dystocia incidence of 30,5% and 6,2% in Simmentaler heifers at Neudam mated at 14 and 26 months, respectively, as reported by Van der Merwe (personal communication). Highly significant differences in calf mortality rates ($P<0,01$) were recorded in these two groups with an incidence of 16,1% in heifers mated at 14 months as against 3,3% in heifers mated at 26 months.

Results of Cundiff, Gregory & Koch (1974), Koch, Gregory & Cundiff (1974), and Muggli & Hohenboken (1983) indicated that lines selected for growth rate showed a higher incidence of dystocia and calf mortality rate than unselected control lines. Barlow (1978) also reported a positive relationship between growth rate and the incidence of dystocia. Roux & Scholtz (1984) attributed such a relationship to long-term selection and an over-emphasis on growth rate.

Low mortality rates in indigenous cattle breeds therefore emphasize the reproductive efficiency of these breeds in extensive production systems.

Growth rate and body size

Growth rate in beef cattle strongly influences profit margin. It is generally assumed that growth rate at any phase of growth is positively correlated to growth rate at any other phase throughout the lifetime of the animal and is also positively correlated to adult size (Preston & Willis, 1974). Scholtz & Roux (1981) suggested, however, that the different growth phases are relatively independent of each other, whereas Riska, Atchley & Ruthledge (1984) obtained negative genetic correlations between early and later growth rates in mice. This was confirmed by Thiessen & Taylor (1986) in a between-breed comparison on early and late production efficiency in cattle.

Indigenous cattle breeds were historically regarded as genetically incapable of high growth rates and thus inferior to the other breeds (Trail & Gregory, 1986). Lubout, Lepen & Venter (1986) showed, however, that growth performance levels of these cattle may vary from low rates of growth to high levels that compare favourably with high performing synthetic breeds.

Birth, pre- and post-weaning and adult cow masses for the five breeds in the Omatjenne trial are presented in Table 7, indicating relatively low values for Sanga cattle. Mass by age differences for various Sanga type breeds are summarized in Table 8, and show substantial differences between herds. Scholtz (1988) also compared performances of males of various breeds in Phase C of the National Beef Cattle Performance and Progeny Testing Scheme and found lower growth rates for Nguni cattle than for *Bos taurus* breeds. The Nguni, however, compared favourably with the Brahman (Table 9). Final body mass of Nguni males was only 79,4% of that of the Bonsmara and 66,1% of that of the Charolais.

Although pre-weaning average daily gain of Sanga cattle was inferior to those of other breeds, their post-weaning gain, expressed as a percentage of weaning mass (relative growth rate), was, in most cases, higher than those of other breeds (Table 7).

Feed conversion ratio

Efficiency of feed conversion is one of the most important traits in beef production. The feed conversion ratio of the Nguni exceeded that of most other breeds and compared favourably to that of other high performing breeds (Table 10) (Scholtz, 1988). Hirzel (1973) expressed the possibility that feed conversion rates for indigenous cattle may prove to be superior to those of exotic breeds under extensive conditions. Scholtz & Lombard (1984) attributed this superiority to natural selection.

Table 7 Birth, pre- and post-weaning and adult cow masses for five cattle breeds (Omatjenne Research Station)

Breed	Birth mass (1978—86) kg	Weaning mass (205 days adj.) (1978—86) kg	Pre-weaning ADG kg/day	12 Months body mass (1978—82) kg	% Increase weaning to 12 months	18 Months body mass (1978—82) kg
Afrikaner	33,5	197	0,799	229	16,24	319
Hereford	29,7	202	0,842	226	11,88	330
Sanga	29,1	180	0,734	211	17,22	297
Santa Gertrudis	34,3	234	0,975	259	10,68	345
Simmentaler	40,3	250	1,021	291	16,40	392

Breed	Birth mass (1978—86) kg	% Increase weaning to 18 months	24 Months body mass (1978—82) kg	% Increase weaning to 24 months	ADG weaning to 24 months kg/day	Adult cow mass (1977—86) kg
Afrikaner	33,5	61,93	368	86,80	0,326	487
Hereford	29,7	63,37	371	83,66	0,322	491
Sanga	29,1	65,00	327	81,67	0,280	390
Santa Gertrudis	34,3	47,44	388	65,81	0,293	511
Simmentaler	40,3	56,80	432	72,80	0,347	533

Table 8 Mass by age for different Sanga cattle herds in South and South West Africa

Herd	Breed	100-day mass (kg)	205-day mass (kg)	12-months mass (kg)	18-months mass (kg)	Reference
Bartlow Combine	Nguni	103	162	–	249	Hamburger & Ramsay (1984)
Loskop – Dept. Agric.	Nguni	107	174	–	283	Hamburger & Ramsay (1984)
Loskop – Dept. Agric.	Nguni	106	185	–	–	Scholtz (1985)
Stellenbosch – Lebowa	Pedi	91	141	–	223	Hamburger & Ramsay (1984)
Stellenbosch – Lebowa	Pedi	106	169	172	225	Lubout (1988)
Caprivi – SWA	Sanga	94	148	–	223	Hamburger & Ramsay (1984)
Omatjenne – SWA	Sanga	124	180	211	297	Omatjenne Progress Reports
Omatjenne – SWA	Afrikaner	137	197	229	319	Omatjenne Progress Reports

Table 9 Growth rates of males of different breeds of cattle in Phase C National Beef Cattle Performance and Progeny Testing Scheme (Irene; Scholtz, 1988)

Breed	Growth rate (g/day)	Final mass (kg)
Afrikaner	1130	407
Brahman	1156	424
Nguni	1206	375
Bonsmara	1449	472
Santa Gertrudis	1495	496
Hereford	1422	455
Charolais	1761	567
Simmentaler	1655	554

Table 10 Feed conversion ratios (FCR) of different cattle breeds

Breeds	Reference		
	Lepen (1988)	Scholtz & Lombard (1984)	Scholtz (1988)
Afrikaner		7,81	7,77
Hereford		7,04	6,95
Bonsmara	7,46 ± 0,04	7,13	7,02
Drakensberger	7,03 ± 0,25	7,34	7,32
Nguni	6,87 ± 0,24	6,80	7,07
Santa Gertrudis		7,07	6,96
Simmentaler		7,11	7,00
Charolais		6,51	6,69

Scholtz & Lombard (1984) also analysed blood and rumen samples of Hereford, Bonsmara and Nguni cattle for urea and ammonia concentrations (Table 11). Differences between these breeds were highly significant ($P<0,01$). Reasons for these differences are possibly due to grazing habits and/or differences in the rate of urea excretion by the kidneys. There are also indications in Nguni cattle that animals with higher levels of blood urea are more capable of maintaining body condition during winter periods ($r = 0,60$; $P<0,01$).

Table 11 Concentrations of blood urea and rumen ammonia in three cattle breeds (Scholtz & Lombard, 1984)

	Hereford	Bonsmara	Nguni
Urea (mmol/l)	$1,51 \pm 0,75^{a}$	$2,36 \pm 0,94^{b}$	$3,38 \pm 0,87^{c}$
Ammonia (mg/l)	$14,92 \pm 4,60^{a}$	$24,64 \pm 10,17^{b}$	$45,19 \pm 11,20^{c}$

^{a,b,c} $P<0,01$.

Cow and herd productivity

Efficiency of weaner calf production is a major factor affecting the efficiency of production systems, which may be adversely affected by the low level of efficiency of the beef breeding female (Dickerson, 1978). Roux & Scholtz (1984) recommended the ratio of weaning mass (adjusted)/cow mass ^{0,75} as a possible selection criterium for optimizing cow efficiency. Dinkel & Brown (1978) and Marshall, Frahm & Horn (1984) questioned the usefulness of calf weight to cow weight ratios as an estimation of efficiency. These ratios are biased in favour of smaller cows. They considered rather, that the amount of TDN required by both cow and calf to produce one kilogram of weaned calf is the most reliable indicator of efficiency.

Calf mass to cow mass ratios were, nevertheless, used to compare cow efficiency in the Omatjenne trial. Cow efficiency and herd efficiency indices for these five breeds are presented in Table 12. Cow efficiency index was relatively high for Simmentaler and Santa Gertrudis cows and low for Hereford and Afrikaner cows. The best herd efficiency was, however, recorded for Sanga cows, probably because of the higher weaning rate associated with this group.

Hetzel (1988) also recorded low calf weaning weights/100 kg cow weight/year for Afrikaner cows (21—28 kg), whereas the higher values for Tswana (32 kg), Tuli (33—36 kg), Bonsmara (34 kg) and Angoni (30—36 kg) cows that were recorded corresponded closely to the Omatjenne data (Table 12).

Employing all available data in this trial, Barnard & Venter (1983) obtained a higher net income per hectare from Sanga in a simulated study. This income exceeded the income from Afrikaner cows by 44%.

Table 12 Cow and herd efficiency indices of five cattle breeds (Omatjenne Research Station)

Breed	Calving %	Mortality rate %	Weaning rate %	Weaning mass kg	Adult cow mass kg	Weight of calf weaned/ 100 kg cow/year	Cow efficiency index[a]	Herd efficiency index[b]
Afrikaner	74,6	8,1	66,5	197	487	26,9	1,90	1,26
Hereford	77,9	15,0	62,9	202	491	25,9	1,94	1,22
Sanga	89,6	5,4	84,2	180	390	38,9	2,05	1,73
Santa Gertrudis	79,6	5,9	73,7	234	511	33,7	2,18	1,61
Simmentaler	77,6	13,4	64,2	250	553	29,0	2,19	1,41

[a] 205-Day adjusted calf mass / adult cow mass ^{0,75}.

[b] Cow efficiency index × $\frac{\text{weaning rate (\%)}}{100}$.

Table 13 Difference in tick resistance between cattle breeds and crosses in three experiments (Scholtz, 1985)

	Hereford	Bonsmara	Nguni × Bonsmara	Nguni × Hereford	Nguni	Kavango	Nguni × Kavango
Hereford	67	**			***		
Bonsmara	**	77			***		
Nguni × Bonsmara			83		*		
Nguni × Hereford				89			
Nguni	***	***	*		100		*
Kavango						101	
Nguni × Kavango					*		101

* $P<0,10$.
** $P<0,05$.
*** $P<0,01$.

Tick resistance

An investigation into the resistance of various cattle breeds to tick infestation was carried out by Scholtz (1985) in three different surveys and the results are presented in Table 13. Ngunis were used as the reference breed with an average tick resistance index of 100. Values higher than 100 represent above-average tick resistance and *vice versa*.

It is evident that Nguni cattle are more resistant to ticks than Hereford or Bonsmara, whereas the values of Nguni × Hereford and Nguni × Bonsmara crosses seem to be near the midparent value. Highly significant repeatability estimates of 0,73 and heritability estimates of 0,26 for tick resistance were reported in this study.

Conclusions

All the available evidence indicate that cattle types indigenous to Southern Africa compare favourably with the breeds exotic to this region in terms of fertility, adaptability and productivity. The economic importance of relatively small-framed and well-adapted females compared to larger exotics with a faster growth rate is well illustrated. Clearly, indigenous cattle with their long history of natural selection may play an important role in livestock development programmes in this sub-continent. Further evaluations of indigenous breeds under different environmental conditions as well as in crossbreeding systems are recommended.

Acknowledgement

The author expresses his gratitude to the Department of Agriculture and Sea Fisheries, South West Africa, and in particular to Mr J.P. Venter for making available the Annual Progress Reports of the Omatjenne Research Station.

References

BARLOW, R., 1978. Biological ramifications of selection for pre-weaning growth in cattle. A review. *Anim. Breed. Abst.* 46, 469.

BARNARD, J.P. & VENTER, J.P., 1983. Indigenous and exotic beef cattle in South West Africa – A progress report. 15th Regular meeting (SARCUSS Standing Committee for Animal Production), Maun, Botswana.

BROWN, D.L., 1959. The Nguni breed of cattle. 1. A descriptive review. *Emp. J. exp. Agric.* 57, 276.

COETZER, W.A. & VAN MARLE, J., 1972. Die voorkoms van puberteit en daaropvolgende estrusperiode by vleisrasverse. *S. Afr. Tydskr. Veek.* 2, 17.

CUNDIFF, L.V., GREGORY, K.E. & KOCH, R.M., 1974. Effects of heterosis on reproduction in Hereford, Angus and Shorthorn cattle. *J. Anim. Sci.* 38, 711.

DICKERSON, G.E., 1978. Animal size and efficiency: Basic concepts. *Anim. Prod.* 27, 367.

DINKEL, C.A. & BROWN, M.A., 1978. An evaluation of the ratio of calf weight to cow weight as a indicator of cow efficiency. *J. Anim. Sci.* 46, 614.

DREYER, C.J., 1982. Die teeltstruktuur van die Drakensbergerbeesras en faktore wat die doeltreffendheid van produksie beïnvloed. D.Sc.(Agric)-proefskrif, Univ. Pretoria.

GOODWIN, C.P.D., 1976. The Tuli — Rhodesia's masterpiece. *Modern Farming* 4, 9.

HAMBURGER, H. & RAMSAY, K.A., 1984. The current status and future of animal production and breeding in developing countries. The Southern African Region. *Proc. 2nd Wrld. Cong. Sheep & Beef Cattle Breed.* (Pretoria), p. 24.

HETZEL, D.J.S., 1988. Comparative productivity of the Brahman and some indigenous Sanga and *Bos indicus* breeds of East and Southern Africa. *Anim. Breed Abstr.* 56, 243.

HIRZEL, R., 1973. Discussion of paper by J.P. Maule: The role of the indigenous breeds for beef production in Southern Africa (12th SASAP Congress). *S. Afr. J. Anim. Sci.* 3, 131.

KOCH, R.M., GREGORY, K.E. & CUNDIFF, L.V., 1974. Selection in beef cattle. II. Selection response. *J. Anim. Sci.* 39, 459.

LEPEN, J.M., 1988. 'n Vergelykende produksie-evaluering van die Nguni in intensiewe en ekstensiewe stelsels. M.Sc.(Agric)-verhandeling, Univ. Pretoria.

LUBOUT, P.C., 1988. Environmental and genetic factors influencing production in a herd of Pedi cattle. M.Sc.(Agric) thesis, Univ. Pretoria.

LUBOUT, P.C., LEPEN, J.M. & VENTER, H.A.W., 1986. Factors affecting the performance of Nguni and Pedi cattle. *Proc. 3rd Wrld. Cong. on Genet. Appl. to Livest. Prod.* (Nebraska, USA), 11, 499.

MARSHALL, D.M., FRAHM, R.R. & HORN, G.W., 1984. Nutrient intake and efficiency of calf production by two-breed cross cows. *J. Anim. Sci.* 59, 317.

MASON, I.L., 1969. A world dictionary of livestock breeds, types and varieties (2nd edn.). Farnham Royal, UK, CAB.

MAULE, J.P., 1973. The role of the indigenous breeds for beef production in Southern Africa. *S. Afr. J. Anim. Sci.* 3, 111.

MEYER, E.H.H., 1981. Die waarde van chromosomale en biochemies-genetiese merkers vir diereproduksie. Nuwe genetiese ontwikkelings en uitdagings in die Landbou. Simposium, 27 Maart 1981.

MUGGLI, N. & HOHENBOKEN, W., 1983. Inheritance of maternal immunoglobin G1 concentration by the bovine neonate. *Proc. 15th Int. Congr. Genet.* (New Delhi), 1, 36.

PRESTON, T.R. & WILLIS, M.B., 1974. Intensive beef production. Pergamon Press, New York.

RISKA, B., ATCHLEY, W.R. & RUTHLEDGE, J.J., 1984. A genetic analysis of targeted growth in mice. *Genetics* 107, 79.

ROUX, C.Z. & SCHOLTZ, M.M., 1984. Breeding goals for optimal total life cycle production systems. *Proc. 2nd Wrld. Congr. Sheep & Beef Cattle Breed* (Pretoria), p 444.

SCHOLTZ, M.M., 1985. A review of some of the research on Nguni cattle undertaken by the Animal and Dairy Science Research Institute. 17th Regular meeting (SARCUSS Standing Committee for Animal Production), Cedara, Natal.

SCHOLTZ, M.M., 1988. Selection possibilities of hardy beef breeds in Africa: The Nguni example. *Proc. 3rd Wrld. Cong. Sheep & Beef Cattle Breed* (Paris) 2, 303.

SCHOLTZ, M.M. & LOMBARD, P.E., 1984. Nguni research. Genetic research and indigenous breeds exhibition. *2nd Wrld. Cong. Sheep & Beef Cattle Breed.* p. 3.

SCHOLTZ, M.M. & ROUX, C.Z., 1981. Wysiging van groei- en doeltreffendheidskurwes met behulp van seleksie. *Tegnikon* 29, 13.

THIESSEN, R.B. & TAYLOR, St. C.S., 1986. Interage correlations of food conversion efficiency with body weight, growth rate and food intake within and between British breeds of cattle. *Anim. Prod.* 43, 91.

TRAIL, J.C.M. & GREGORY, K.E., 1986. Animal breeding in Subsaharan Africa. Towards an integrated program for improving productivity. Unpubl. report.