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Evaluation of Bonsmara and Belmont Red cattle breeds in South Africa. 1. Productive performance

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Abstract. The productive performance of progeny by Bonsmara and Belmont Red sires was compared in contemporarily reared groups in South Africa. Measurements on 4279 pedigreed progeny of 96 Bonsmara sires and 18 Belmont Red sires were recorded over 15 years in 4 diverse climatic regions of South Africa. Growth traits were measured on growing stock from birth to 18 months at pasture. Weight gain, feed conversion rate, frame size, scrotal circumference and visually assessed 'functional efficiency' scores were recorded on male progeny fed high protein rations. Carcass traits were measured on a subset of the male progeny. Age at first calving, and repeated measurements of calving date and calving interval were recorded on breeding females as indicators of reproductive performance. Tick counts were made on males and females across a range of ages during times of heavy field infestation.

There were differences in progeny performance for some traits. Bonsmara sired animals generally scored higher than Belmont Red progeny for functional efficiency. Belmont Red sired calves were lighter at birth (35.9 *v.* 37.3; $P<0.05$) and cows by Belmont Red sires had a shorter average calving interval (440 *v.* 455; $P<0.05$). Sire breed by region interaction was not important. The differences in scored and measured traits generally reflected differences in selection policies adopted by the breed societies. Variation in growth and fertility traits due to sire was greater than variation due to breed and demonstrated the potential for identifying superior individuals. The performance of the sire breeds for the range of traits and environments studied advocated that selected Bonsmara and Belmont Red animals from South African herds would be suitable for inclusion in breeding programs in Australian Belmont Red herds.

Additional keywords: adaptability, breed comparison, fertility, growth.

Introduction

Derived from Sanga (Afrikaner) and British (Hereford and Shorthorn) breeds, Bonsmara and Belmont Red cattle were developed in separate countries and are 2 of only a few tropically adapted *Bos taurus* breeds in the world. The 500 million cattle present in the tropical and subtropical regions of the world are predominantly adapted *Bos indicus* types (FAO 1999). Owing to their inherently higher fertility (Mackinnon *et al*. 1989) and meat quality attributes (Gazzola *et al*. 1999), Sanga and *Bos taurus* animals with adaptive capability (Frisch 1999) have the potential to boost the production of high quality beef from tropical regions (Burrow *et al*. 2003; Seifert and Rudder 1984).

In Australia, stringent guidelines have been introduced for the grading of beef for retail product (Thompson 2002). The grading system guidelines were based on eating quality specifications and make it difficult for carcasses with high *Bos indicus* content to attain higher grades of quality assurance and emphasise the value of using adapted *Bos taurus* breeds. The standards imposed have challenged beef producers in the harsh climates of northern Australia to alter management strategies in order to attract premium prices for their beef. The Belmont Red breed developed in Australia in the 1950s (nominally a 50 : 25 : 25 ratio of Afrikaner, Hereford and Shorthorn breed components) has been a part of the initial development of composite breeds by the large pastoral companies in northern Australia, substituting for reduced *Bos indicus* (primarily Brahman) content to help meet market specifications yet maintain tropical adaptability of northern Australian cattle (Rudder *et al*. 1976; Seifert and Rudder 1984). The Bonsmara, developed in South Africa in the 1940s (nominally a 62:19:19 ratio of Afrikaner, Hereford and Shorthorn breeding), was introduced to Australia in 1995 providing an

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alternative candidate breed for use in further composite breed development.

In 2003, the Belmont Red Association of Australia reported 31 registered herds with 7605 active registered animals. In contrast, the Bonsmara Society in South Africa, at the same time, had 342 breeders with 52 033 registered animals, more than any other breed in South Africa. The South African Brahman breed ranked second with 23 650 registered animals. The size of the Bonsmara herd in South Africa indicates the popularity of the breed and the potential for identification of superior animals for use in Australian breeding programs.

The value of the Belmont Red and Bonsmara breeds to beef production systems has been well documented. Resistance to internal helminths (Turner and Short 1972), ticks (Frisch and O'Neill 1998*b*; Seifert 1984) and heat (Vercoe *et al*. 1972) of Belmont Red cattle was intermediate between susceptible Hereford × Shorthorn cattle and resistant Brahman derived cattle. Belmont Red animals compared favourably for handling ease (Burrow and Corbet 2000; Fordyce *et al*. 1982) when evaluated with other breeds. Although growth rates of Belmont Red cattle at pasture in subtropical Australia have generally not exceeded those of Brahman or large European breeds and their crossbreds (Frisch and O'Neill 1998*a*; Rudder *et al*. 1976), they have consistently been superior to those of British breeds (Coates and Bean 1978; Tierney *et al*. 1992*b*). Reproductive rates (Mackinnon *et al*. 1989; Seebeck 1973) and carcass and meat quality traits (Gazzola *et al*. 1999; Tierney *et al*. 1992*a*) of Belmont Red animals in the subtropics have generally been better than those of Brahman derived breeds, and similar or better than those of *Bos taurus* breeds.

The performance of Bonsmara cattle compared with other breeds in southern Africa has been reported for growth (Eloff and Ludemann 1977; Trail *et al*. 1977), carcass and meat quality (Strydom *et al*. 2000*a*, 2000*b*), reproduction (Lademann and Schoeman 1994; Light *et al*. 1982) and tick resistance (Fivaz and De Waal 1993; Rechav and Kostrzewski 1991). These reports indicated that the overall productivity of the Bonsmara compared favourably with other breeds across the range of traits, similar to the findings from the Belmont Red comparative studies in Australia.

Preliminary reports of Seifert *et al*. (1985, 1988) found no differences in weight traits when Bonsmara and Belmont Red breeds were compared directly in South Africa. In a small sample of the population (n = 90), Strydom *et al*. (2001) found no differences in carcass traits between Belmont Red animals and lines of the Bonsmara breed. Despite differences in selection emphasis placed on each of the breeds since their development, and despite the phylogenetic distance between them (Strydom *et al*. 2001), the reported similarities in progeny performance of Bonsmara and Belmont Red sires suggests similar genetic potential for growth and carcass traits.

Since the reports of Seifert *et al*. (1985, 1988), an additional 10 years data have been collected in South Africa, including measures of feedlot performance, tick resistance and reproductive performance of progeny from Bonsmara and Belmont Red sires providing further information for charaterisation of the breeds for economically important traits. The objective of the current study is to evaluate the historical database with the aim of quantifying phenotypic performance of the 2 breeds across a range of production traits and environments. In addition to providing information to compare the breeds, the pooled dataset provides a unique opportunity to study the genetic and non-genetic components of trait variation. The second paper in this series reports estimates of heritability and genetic correlation between important traits.

Materials and methods

Animals

Through a collaborative project between CSIRO, Australia and the South African Agricultural Research Council an experiment was designed to generate pedigreed calves sired by South African Bonsmara and Australian Belmont Red bulls to allow comparison of sires and breeds across various environments for a range of production traits. Semen from Australian Belmont Red sires, sourced from CSIRO (Belmont Research Station, Rockhampton, n = 11) and Queensland commercial cattle herds (n = 7), was sent to South Africa in 3 separate shipments in 1981, 1984 and 1985. Selection of the 11 CSIRO bulls was initially for weaning weight for age, then finally for tick resistance and 18-month weight for age. Selection of the 7 privately owned Belmont Red bulls donating semen for the project was principally for 18-month weight for age with some selection pressure applied for attributes of tick resistance, conformation soundness, polledness and solid red colouring. Selection of Belmont Red bulls for use in the project also depended on their ability to clear health checks for importation of the semen into South Africa. Semen from some bulls vaccinated for leptospirosis (*Leptospira* spp.), for example, was not cleared because high blood titres from vaccinated animals could not be distinguished from titres of animals exposed to disease infection.

The Belmont Red semen together with semen sourced from South African Bonsmara sires (n = 25) selected primarily for post-weaning average daily gain (ADG), feed conversion ratio (FCR) and visually appraised 'functional efficiency' (Bonsma 1980), was used in AI programs with randomly allocated Bonsmara females to produce calf-crops from 1982 to 1998. In each of the herds, females were also joined to Bonsmara home-bred sires (n = 71) used in single-sire natural mating paddocks at the time of AI to avoid confounding of sire and calf age. Following AI programs, females were joined to the home-bred sires to fertilise those that did not conceive to artificial insemination. Selection of the sires for use in the experiment was not random and aimed at ensuring representation of the top performers in each breed. In later years Bonsmara- and Belmont Red-sired females were joined naturally to Bonsmara- and Belmont Red-sired bulls to evaluate female fertility traits. Mating generally took place in summer each year so that cows calved in spring to summer during calving periods ,which averaged 100 days. In some herd–year combinations autumn calves were born.

Locations

Progeny (n = 4279) of the selected Belmont Red (n = 18) and Bonsmara (n = 96) sires were born and raised in Government and privately owned herds representing 4 diverse regions of South Africa. The regions are generically termed lowveld, bushveld, middleveld and highveld and encompass environments characterised by uniqueness of climate, geography and vegetation. The summer dominant rainfall in the regions typically averages more than 900 mm in the lowveld areas along the eastern coastline of South Africa and around 800 mm yearly on the highveld areas of the Drakensberg range. Rainfall decreases towards the north and west, where bushveld rainfall averages around 500 mm and rainfall on the middleveld averages 450 mm annually. Climates are generally be described as mild temperate on the highveld, subtropical on the lowveld, dry subtropical in bushveld areas and semi-arid on the middleveld. Cattle stocking rates in the regions range from 2 to 10 ha per animal unit and are influenced by rainfall and soil fertility (FAO 1999). Environmental conditions in these 4 generic regions of South Africa where the collaborating herds were located are briefly described in the following sections.

The lowveld areas comprise a mixed savannah at an altitude averaging less than 200 m where hot, humid summers (average maximum 29°C) and warm, dry winters (average minimum 14°C) are experienced. Extreme daily summer temperatures over 40°C are regularly recorded. The region is climatically similar to subtropical areas of coastal eastern Australia. Parasite challenges are high and regular dipping to control tick infestation is practiced. Tick species that infest cattle in South Africa include the blue cattle tick (*Boophilus decoloratus*); and the multi-host tick species, namely the red-legged tick (*Rhipicephalus evertsi*), bont-legged tick (*Hyalomma* spp.), and the bont tick (*Amblyomma hebraeum*). Parasitic helminth burdens (predominantly *Cooperia* spp., *Haemonchus* spp. and *Trichostrongylus* spp.) follow monthly rainfall patterns (Schroder 1979), but are generally not considered a limiting factor to beef production (Tsotetsi and Mbati 2003). Horn fly (*Haematobia meridiana* and *H. thirouxi potans*) infestations have been associated with lesions populated by microfilarae in South Africa, but as for the buffalo fly (*Haematobia irritans exigua*) present in Australia (Bean *et al*. 1987), there is little evidence to associate infestations with production loss (Newsholme *et al*. 1983).

The bushveld savannah represents a great variety of plant communities with many transitions. The vegetation varies from a dense, short bushveld to a more open wooded savannah. Extending north from about Pretoria, the bushveld features cool dry winters (average minimum 5°C) and hot summers (average maximum 28°C) with high tick and helminth challenges. Altitude averages less than 1000 m and while rainfall averages 550 mm it is variable with periods of drought typical in most areas. Management practices include diet supplementation during these dry periods. The climate experienced in this region is similar to that of dry subtropical environments in northern Australia such as central and northern Queensland, the Northern Territory, and the Kimberley region of Western Australia.

The highveld temperate grassland is characterised by warm summers (average maximum 27°C) when cattle are subjected to moderate tick challenges and cold winters (average minimum 3°C) during which feed supplementation is necessary. Altitude ranges from 1200 m to 1800 m above sea level. Minimum daily temperatures can average close to zero in winter and subzero extreme temperatures are often recorded. Winter frosts occur in the higher areas of the plateau, however, snow is rare. The vegetation in the area is typically dense, sour grassland. Except for the presence of ticks and the different vegetation types, the highveld is climatically similar to temperate areas of Australia, such as the New England Tableland region of northern New South Wales.

Middleveld generically describes the semi-arid region west of the highveld adjacent to the Kalahari Desert, typified by hot summers (average maximum 32°C), cold dry winters (average minimum 3°C) and a low parasite challenge. The elevation of the middleveld varies from 600 m to 1200 m. Rainfall is unreliable with prolonged drought periods typical in most areas. This environment is similar to the semi-arid regions of much of inland Australia. The vegetative habitat on the middleveld is predominantly thornveld savannah and open grassland.

Data collection

Experimental data were collected as part of South Africa's National Beef Cattle Performance Testing Scheme, which is partitioned into 5 separate phases (A, B, C, D and E) each representing critical stages of pre- and post-weaning data collection. Phase A data collection included calving date, pedigree information and liveweights from birth to weaning of the progeny managed typically in the collaborating herds. While joining dates and pregnancy rate or calving rate were not recorded, age at first calving (AFC), calving day (days from start of the calving period; CD) and calving interval (days between subsequent calves; CI) were calculated from calving records. After weaning, male and female calves were managed separately. Phase B measurements included post-weaning liveweights at 365 and 540 days of age on both male and female progeny managed within the herds. Tick counts were collected post-weaning on 622 animals from 1984 to 1990 in the progeny groups in 3 regions (middleveld, bushveld and lowveld) using the method described by Scholtz *et al*. (1991). Animals were counted up to 3 times in summer when pasture tick infestations were greatest and the counts were averaged for each animal's summer record.

After weaning, some male progeny entered Phases C and D growth tests where measurements of average daily liveweight gain (ADG) and feed conversion ratio (feed eaten per weight gained; FCR) were made on either feedlot rations at Central Testing Stations (Phase C) or supplemented at pasture on-farm (Phase D) over 140 days. Requirements for entry of the bull calves into Phases C and D were that the owner participated in Phase A, that the bull calves were eligible for Studbook registration, weighed between 220 and 270 kg and were less than 271 days of age. The requirements meant fewer numbers of

Table 1. Definition of the carcass traits measured

Trait	Unit	Description
Hot carcass weight (HCW)	kg	Weight of the hot dressed carcass
Dressing percentage (DP)	%	Ratio of the carcass weight to pre-slaughter liveweight expressed as a percentage
Carcass length (CL)	mm	Linear measurement between the cranial side of the middle of the first rib and the centre of the iliopubic fusion
Butt length (BL)	mm	Linear measurement between the centre of the iliopubic fusion and the distal edge of the hind limb
Rump fat depth (FD)	mm	Depth of fat at the P8 rump site
Eye-muscle area (EMA)	cm^2	Length multiplied by width of the rib-eye muscle (*M. longissimus thoracis*)
Marbling	Score	The amount of intra-muscular fat present in the rib-eye muscle (*M. longissimus thoracis*) scored from 0 (no marbling) to 5 (heavily marbled)
Rib lean (RL)	%	Weight of lean dissected from the prime-rib cut expressed as a percentage of the total weight of the cut
Rib fat (RF)	%	Weight of fat dissected from the prime-rib cut expressed as a percentage of the total weight of the cut
Rib bone (RB)	%	Weight of bone dissected from the prime-rib cut expressed as a percentage of the total weight of the cut

Table 2. Description and summary statistics of the measured performance traits

n, number of animals except for CD and CI where *n* represents number of records including repeated measures on 1426 cows; s.d., standard deviation; CV, coefficient of variation

Trait	Description	*n*	Mean ± s.d.	CV	Trait range	Age (days)
	Liveweights (Phases A and B)					
BWT	Birth weight (kg)	2238	36.9 ± 5.2	14.1	20–52	—
PWT	100-day weight (kg)	2872	133 ± 28.8	21.7	55–230	46–197
WWT	205-day weight (kg)	3115	201 ± 35.2	17.5	100–320	148–272
YWT	365-day weight (kg)	1276	260 ± 64.9	25.0	120–535	271–450
FWT	540-day weight (kg)	1071	326 ± 83.5	25.6	155–580	453–628
	Growth test traits (Phases C and D)					
ADG	Average daily gain (kg/day)	553	1.08 ± 0.38	35.2	0.25–2.04	333–709
FCR	Feed conversion ratio (kg/kg)	219	6.72 ± 0.65	9.7	5.04–8.75	333–435
SH	Shoulder height (mm)	559	1210 ± 49.8	4.1	1040–1389	160–584
BL	Body length (mm)	559	1385 ± 69.8	5.0	1180–1674	160–584
ST	Skin thickness (mm)	559	15.2 ± 2.22	14.6	8–21	160–584
SC	Scrotal circumference (cm)	550	33.9 ± 2.8	8.2	25.9–45.1	160–584
	Adaptive trait					
TC	Tick count	622	37 ± 26.7	72.4	1–150	360–2920
	Reproductive traits					
AFC	Age at first calving (months)	945	34.2 ± 5.7	16.7	21–55	—
CDA	Day of calving from start of calving period (days)	4203	47.7 ± 30.4	63.7	0–146	—
CIA	Interval between consecutive calving records (days)	3169	448 ± 117.3	26.2	277–948	—
	Carcass traits (Phase E)					
HCW	Hot carcass weight (kg)	121	259 ± 47.7	18.4	189–365	335–874
DP	Dressing percentage (%)	121	57.7 ± 2.41	4.2	51.7–64.2	335–874
CL	Carcass length (mm)	121	1234 ± 5.9	0.5	1116–1400	335–874
BL	Butt length (mm)	121	763 ± 4.6	6.0	670–880	335–874
FD	Rump fat depth (mm)	121	11 ± 5.5	50.0	2–32	335–874
MARB	Marbling (score)	121	2.0 ± 1.14	57.0	0–4	335–874
EMA	Eye-muscle area (cm^2)	121	74 ± 13.3	18.0	50–121	335–874
RL	Rib lean (%)	94	62.7 ± 4.51	7.2	52.1–75.4	335–874
RF	Rib fat (%)	94	22.4 ± 5.51	24.6	8.5–34.6	335–874
RB	Rib bone (%)	94	14.8 ± 2.24	15.1	6.4–18.6	335–874

animals completing the later phases of data collection. Scrotal circumference (SC), body length (shoulder to pin bones; BL) and shoulder height (shoulder to floor; SH) were also measured on the young bulls while in the growth tests. In addition to the growth traits measured, a subset of the male progeny by Bonsmara and Belmont Red sires (n = 236) in Phases C and D were scored for 'functional efficiency' attributes to compare scores between sire breeds. The concept of visual assessment of cattle for functional efficiency was described by Bonsma (1980) and used to predict overall productivity. The technique involved scoring the young bulls in their contemporary groups for attributes such as coat, temperament, pigmentation, masculinity, and conformation of sexual organs, legs and feet to set standards on a scale of 1 to 5 where 1 is defective and 5 is perfect. Skin pliability was a desirable attribute and influenced overall functional efficiency score so skin thickness was also measured on the animals in Phase C and D for breed comparison.

In Phase E of the data collection male progeny (entire and castrated) of Bonsmara and Belmont Red sires were picked randomly for testing in growth trials similar to but independent from the Phase C and D tests. The animals were grown intensively on grain-based diets for up to 140 days or supplemented at pasture for up to 20 months then slaughtered in contemporary groups of similar age and weight (approximately 14 head per group). The intensive nature of experimentally dissecting carcasses meant a restriction on numbers of animals entering Phase E and measurements of meat quality traits were not made. Carcass traits were measured on 118 young bulls and steers slaughtered at an average 260 kg carcass weight. These animals were transported by road to an abattoir less than 5 h travel from the test centres and were kept in lairage overnight. At slaughter, the carcasses were hung from the Achilles and not electrically stimulated. Definitions of the carcass traits measured are shown in Table 1. Carcass weight was measured on the hot carcass prior to chilling. The remaining carcass measurements were taken after the carcasses were chilled for 24 h.

Statistical analysis

Fixed and random effects were tested for significance for the various traits by fitting linear mixed models with the 'mixed' procedure in SAS (SAS Institute, Cary, NC). The general linear model can be represented by:

$$Y = X\beta + Z\mu + e$$

where Y is an $n \times 1$ vector of observations (e.g. liveweight), β is a $p \times 1$ vector of fixed effects (e.g. breed), X is an $n \times p$ matrix relating fixed effects to observations, μ is a $q \times 1$ vector of random effects (e.g. sire), Z is an $n \times q$ matrix relating random effects to observations, e is an $n \times 1$ vector of error or residual effects.

Least squares means were generated to compare sire breed effects for all traits. The fixed and random effects fitted in the linear mixed models accounted for all known sources of variation of the traits measured. The fixed effects considered for progeny growth traits were

Table 3. Least squares breed means ± s.e. and significance of model effects for weights from birth to weaning

n, number of animals; d.f., numerator degrees of freedom; CG, contemporary group defined by year and season of birth; DALS, dam age and lactational status category at mating; DOB, day of birth from the start of the calving period; B × R, breed × region interaction; n.s., *P*>0.05; *, *P*<0.05; **, *P*<0.01; ***, *P*<0.001, estimates of significant covariates are shown

	n/d.f.	Birth weight (kg)	*n*/d.f.	100-day weight (kg)	*n*/d.f.	205-day weight (kg)
Bonsmara	1647	37.3 ± 0.51	2143	133 ± 1.0	2307	199 ± 1.4
Belmont Red	591	35.9 ± 0.35	729	132 ± 1.6	808	198 ± 2.0
Fixed effects						
Breed	1	*	1	n.s.	1	n.s.
Region	3	***	3	***	3	***
CG : region	26	***	49	***	46	***
DALS	4	***	4	***	4	***
Calf sex	1	***	1	***	1	***
Calf age	—	—	1	0.81***	1	0.75***
DOB	1	0.014*	—	—	—	—
B × R	3	n.s.	3	n.s.	3	n.s.
Random effects						
Sire : breed	77	**	90	**	96	**

sire breed (Bonsmara or Belmont Red), region (lowveld, bushveld, middleveld or highveld), contemporary group (CG) defined as a combination of year (1982–1998) and season of birth (spring, summer or autumn) fitted within region, combined effects of dam age (2 to ≥5 years) and lactational status of the dam at joining (lactating or not; DALS) and sex of the calf (bull or heifer). Age of the calf (or day of birth for birth weight or calf weight for some body measurements) was fitted as a linear covariate. Fat depth was included as a covariate for carcass traits. Two-factor interactions between the main effects found to be significant (*P*<0.05) were also included. Sire within breed was fitted as a random effect.

The model for cow reproductive traits included fixed effects of sire breed, region, contemporary calving group (year and season) within region, cow age and 2-factor interactions of the main effects as described for the progeny growth trait model. The model for AFC included sire within breed as a random effect and for CD and CI the random effect of animal was included to account for repeated measures of these traits.

Region was included as a main effect in all models to account for inherent differences between regions and to examine breed by region interaction as a test for genotype × environment interaction. Tick count observations were skewed towards the lower end of the value range and a log (base 10) transformation was applied to normalise the distribution. Contemporary groups not represented by progeny of both Bonsmara and Belmont Red sires were excluded from the analysis to provide a valid breed comparison of equally treated progeny.

Descriptive characteristics of the data are presented in Table 2. The following Tables present least squares breed means, the focus of this study, and report *P*-values as a test of significance of the fixed and

Table 4. Least squares breed means ± s.e. of progeny post-weaning weights and significance of the model effects

n, number of animals; d.f., numerator degrees of freedom; CG, contemporary group defined by year and season of birth; DALS, dam age and lactational status category at mating; DOB, day of birth from the start of the calving period; B × R, breed × region interaction; n.s., *P*>0.05; *, *P*<0.05; **, *P*<0.01; ***, *P*<0.001, estimates of significant covariates are shown

	d.f.	360-day weight (kg)		540-day weight (kg)	
		Males	Females	Males	Females
Bonsmara		287 ± 2.9 *n* = 476	237 ± 2.1 *n* = 920	398 ± 6.3 *n* = 178	312 ± 3.0 *n* = 729
Belmont Red		280 ± 5.6 *n* = 105	234 ± 3.4 *n* = 261	398 ± 17.8 *n* = 33	313 ± 4.1 *n* = 254
Fixed effects					
Breed	1	n.s.	n.s.	n.s.	n.s.
Region	3	***	***	***	***
CG : region	37	***	***	***	***
DALS	4	***	***	**	***
Calf age	1	0.86***	0.70***	0.84***	0.52***
B × R	3	n.s.	n.s.	n.s.	n.s.
Random effects					
Sire : breed	71	*	*	*	*

Table 5. Least squares breed means ± s.e. for average daily gain (ADG) and feed conversion ratio (FCR) and significance of the model effects

n, number of animals; d.f., numerator degrees of freedom; CG, contemporary group defined by year and season of birth; B × R, breed × region interaction; n.s., *P*>0.05; *, *P*<0.05; **, *P*<0.01; ***, *P*<0.001, estimates of significant covariates are shown

	n/d.f.	ADG (kg/day)	*n*/d.f.	FCR (kg/kg)
Bonsmara	426	1.14 ± 0.01	169	6.83 ± 0.07
Belmont Red	127	1.11 ± 0.02	50	6.91 ± 0.16
Fixed effects				
Breed	1	n.s.	1	n.s.
Region	2	***	1	ns
CG : region	21	***	7	**
Start weight	1	0.001***	1	ns
Age	1	n.s.	1	0.008**
B × R	2	n.s.	1	n.s.
Random effects				
Sire : breed	69	n.s.	42	n.s.

random effects fitted to the models for each trait. Least squares means for all main effects are not shown to maintain clarity of the Tables. The effects included in the analyses depended on the trait studied and only main effects along with interactions and covariates accounting for a significant (*P*<0.05) proportion of trait variation were included in the final model for each trait.

Results

Birth to weaning weights

Least squares breed means for progeny weights from birth to weaning are given in Table 3. Bonsmara-sired progeny were 1.4 kg heavier (*P*<0.05) than Belmont Red-sired calves at birth but the breeds had similar (*P*>0.05) weights at 100 and 205 days. The effects of region, CG within region, DALS, calf sex and sire all contributed to variation (*P*<0.01) in liveweight of the calves. The interaction of breed and region was not an important source of variation (*P*>0.05) in any of the traits. The covariance of DOB with birth weight (*P*<0.05) indicated that calves born later in the calving period had heavier birth weights. The covariance of calf age and weight showed that an increase of 1 day in age was associated with an increase of 0.81 kg at 100-day weight and 0.75 kg at 205-day weight, respectively.

Post-weaning weights

After weaning males and females were treated separately and Table 4 gives the breed means for 360-day and 540-day weights of each sex. There were no sire breed differences (*P*>0.05) in progeny weight at either age. Relatively lower numbers of Belmont Red-sired males recording 540-day weight contributed to a large standard error of the mean for that trait. Breed by region did not contribute to variation in post-weaning weights.

Average daily gain and feed conversion ratio

Breed means for average daily gain (ADG) and feed conversion ratio (FCR) of male progeny in post-weaning growth tests are shown in Table 5. There was no difference (*P*>0.05) between the breeds for either trait. The effects of region and weight at the start of the test period contributed to variation in ADG (*P*<0.001) but not FCR (*P*>0.05). However, older animals on average had poorer feed conversion (*P*<0.01). Sire within breed was not a significant source of variation (*P*>0.05); this may be due to the relatively fewer animals per sire that were recorded for these traits.

Body measurements

Table 6 shows least squares breed means and significance of the model effects for shoulder height, body length, skin thickness and scrotal circumference (SC) measured on young male progeny during the growth test phases. There was no difference in shoulder height, body length or SC between the breeds (*P*>0.05) but Bonsmara-sired bulls had thicker skin (*P*<0.001). There were no differences between

Table 6. Least squares breed means ± s.e. for body measurements on young bull progeny of Bonsmara and Belmont Red sires

n, number of animals; d.f., numerator degrees of freedom; CG, contemporary group defined by year and season of birth; B × R, breed × region interaction; n.s., *P*>0.05; *, *P*<0.05; **, *P*<0.01; ***, *P*<0.001, estimates of significant covariates are shown

	n/d.f.	Shoulder height (mm)	Body length (mm)	Skin thickness (mm)	Scrotal circumference (cm)
Bonsmara	433	1210 ± 2.0	1389 ± 2.5	15.4 ± 0.11	34.1 ± 0.16
Belmont Red	126	1212 ± 3.8	1380 ± 4.3	14.5 ± 0.19	34.0 ± 0.31
Fixed effects					
Breed	1	n.s.	n.s.	***	n.s.
Region	2	***	***	**	**
CG : region	20	***	***	***	**
Weight	1	0.48***	0.69***	0.008***	0.2***
B × R	2	*	n.s.	n.s.	n.s.
Random effects					
Sire : breed	62	n.s.	n.s.	n.s.	n.s.

Table 7. Least squares breed means and significance of model effects for scored functional efficiency attributes (scored 1 = defective to 5 = perfect)

For trait: Temp, temperament; Pigm, skin pigmentation; Masc, masculinity; Epid, epididymus; s.e, standard error of the breed means; *n*, number of animals contributing to breed means; d.f., numerator degrees of freedom for model effects.
For model effects: Brd, breed effect; Reg, region; CG, contemporary management group within region; Wt, linear covariate of liveweight; B × R, breed × region interaction; n.s., *P*>0.05; *, *P*<0.05; **, *P*<0.01; ***, *P*<0.001

Category	Trait	Bonsmara	s.e.	Belmont Red	s.e.	Model effects				
						Brd	Reg	CG	Wt	B × R
n/d.f.		185		51		1	1	8	1	1
General	Overall	3.8	0.05	3.5	0.10	**	n.s.	***	***	n.s.
	Coat	4.2	0.06	4.2	0.10	n.s.	*	***	*	n.s.
	Temp	4.4	0.03	4.3	0.06	n.s.	**	***	n.s.	n.s.
	Pigm	4.9	0.02	4.9	0.03	n.s.	n.s.	***	n.s.	n.s.
Reprod	Masc	3.9	0.07	3.6	0.10	*	n.s.	***	***	n.s.
	Scrotum	4.7	0.07	4.6	0.12	n.s.	n.s.	***	n.s.	n.s.
	Epid	4.8	0.06	4.7	0.10	n.s.	n.s.	***	n.s.	n.s.
	Sheath	4.5	0.08	4.4	0.14	n.s.	n.s.	**	n.s.	n.s.
Frame	Hocks	4.0	0.07	3.7	0.12	*	n.s.	***	n.s.	n.s.
	Pastern	4.7	0.04	4.6	0.08	n.s.	***	***	**	n.s.
	Legs	4.8	0.03	4.7	0.06	n.s.	***	***	*	n.s.
	Back	4.7	0.06	4.5	0.10	*	***	***	*	n.s.
	Head	4.7	0.05	4.7	0.09	n.s.	***	***	**	n.s.
	Jaw	4.8	0.04	4.6	0.10	n.s.	n.s.	***	**	n.s.
	Face	4.8	0.04	4.8	0.07	n.s.	**	***	n.s.	n.s.
	Shoulder	4.3	0.05	4.2	0.08	n.s.	n.s.	***	***	n.s.
Hooves	Colour	4.6	0.07	4.6	0.10	n.s.	**	***	n.s.	*
	Toes	4.1	0.06	4.0	0.11	n.s.	**	***	n.s.	n.s.
	Length	4.5	0.05	4.3	0.09	*	n.s.	***	n.s.	*
	Heel	4.5	0.07	4.1	0.12	**	n.s.	***	n.s.	n.s.

sires within the breeds for any of the body measurements, which, as for ADG and FCR, may be due to the relatively lower number of progeny per sire studied.

The covariance of liveweight with all body measurements of the progeny (*P*<0.001) indicated a strong phenotypic correlation. The interaction between breed and region (*P*<0.05) for shoulder height, illustrated in Figure 1, indicated that Belmont Red progeny were taller at the shoulder (1222 ± 7.0 mm) than Bonsmara sired animals (1204 ± 7.9 mm) from the middleveld but not in other regions. The interaction between breed and region was not evident (*P* >0.05) for the other body measurements.

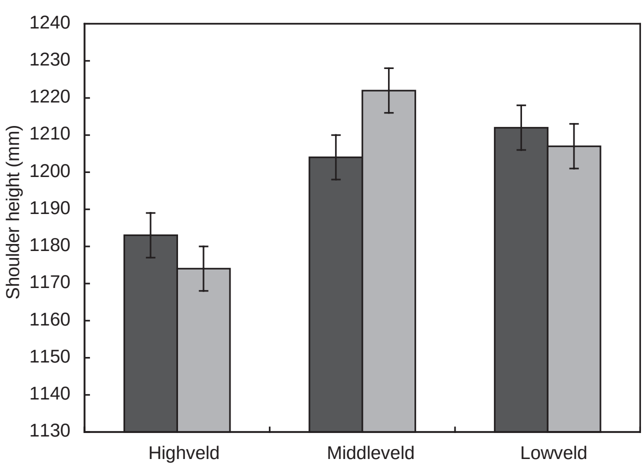

Fig. 1. Breed × region interaction for shoulder height. Dark grey bars, Bonsmara; light grey bars, Belmont Red. Vertical bars indicate ± s.e.

Functional efficiency scores

Least squares breed means for the visually assessed traits are presented in Table 7. Bonsmara males scored higher than

Table 8. Least squares breed means ± s.e. for tick counts and significance of the model effects

n, number of animals; d.f., numerator degrees of freedom; CG, contemporary group defined by year and season of birth; B × R, breed × region interaction; n.s., *P*>0.05; *, *P*<0.05; **, *P*<0.01; ***, *P*<0.001, estimates of significant covariates are shown

	n/d.f.	Tick count	Log (tick count)
Bonsmara	378	44 ± 1.1	3.5 ± 0.05
Belmont Red	274	41 ± 1.0	3.4 ± 0.04
Fixed effects			
Breed	1	n.s.	n.s.
Region	2	***	***
CG : region	20	***	***
B × R	2	n.s.	n.s.
Random effects			
Sire : breed	43	n.s.	n.s.

Table 9. Least squares breed means ± s.e. for AFC, CD and CI measured on female progeny of Bonsmara and Belmont Red sires

n, number of records for breed means; d.f., numerator degrees of freedom; CG, contemporary group; AFC, cow age at first calving; CD, day of calving from the start of the calving period; CI, interval between calves; n.s., *P*>0.05; *, *P*<0.05; **, *P*<0.01; ***, *P*<0.001

	n/d.f.	AFC (months)	*n*/d.f.	CD (days)	*n*/d.f.	CI (days)
Bonsmara	636	35.1 ± 0.3	2635	47.7 ± 0.5	2027	455 ± 4.5
Belmont Red	309	34.6 ± 0.4	1568	46.7 ± 0.6	1142	440 ± 5.9
Fixed effects						
Breed	1	n.s.	1	n.s.	1	*
Region	3	***	3	***	3	***
CG : region	50	***	64	***	96	***
Cow age			3	***	3	***
B × R	3	n.s.	3	n.s.	3	n.s.
Random effects						
Sire : breed	95	*	112	*	102	n.s.
Animal		—	1426	**	1104	*

Belmont Reds (*P*<0.05) for overall acceptability, masculinity, hocks, back and hoof traits. Differences in scores (*P*<0.05) for coat, temperament, some frame and hoof scores were due to the region that the progeny were raised in. Contemporary management group within region was a significant source of variation (*P*<0.01) in all the traits scored and may be confounded by scorer bias. Most frame traits, coat, masculinity and overall score were influenced (*P*<0.05) by liveweight of the animals.

Breed by region interaction for jaw, hoof colour and hoof length scores (*P*<0.05) indicated that Bonsmara animals scored higher than Belmont Reds in the highveld region but not in the lowveld for those traits. The interaction may be attributable to an indirect selection effect in the Bonsmara where a certain hoof type is more suitable to the highveld than the lowveld.

Tick count

Table 8 gives the results of fitting the models to the tick count data as recorded, and with a log transformation. There was no difference (*P*>0.05) between the sire breeds in the number of ticks counted on the progeny. Differences due to region and contemporary management group (*P*<0.01) accounted for the variation in tick count. Log transformation of the tick count data did not change the significance of the main effects.

Female fertility traits

Least squares breed means of the female progeny for age at first calving (AFC) and repeated measures of calving date (CD) and the interval between subsequent calves (CI) are shown in Table 9. There were no breed differences in AFC or CD (*P*>0.05), but Belmont Red females had shorter CI than

Table 10. Least squares breed means for carcass traits measured on Bonsmara and Belmont Red male progeny

Age, age at slaughter in days; HCW, hot carcass weight; DP, dressing percentage; CL, carcass length; BL, butt length; FD, rump fat depth; EMA, eye muscle area; MARB, marbling score; RL, rib lean %; RF, rib fat %; RB, rib bone %; s.e., standard error of the means; *n*, number of animals; d.f., numerator degrees of freedom for model effects; Reg, region; CG:R, contemporary management group within region; n.s., *P*>0.05; *, *P*<0.05; **, *P*<0.01; ***, *P*<0.001

Trait	Bonsmara	s.e.	Belmont Red	s.e.	Model effects				
					Breed	Reg	CG:R	HCW	FD
n/d.f.	59	—	62		1	1	11	1	1
Age	538	2.6	532	2.5	n.s.	***	***	—	—
HCW	259	2.3	257	2.4	n.s.	***	***	—	—
DP	57.3	0.23	57.7	0.24	n.s.	***	n.s.	—	—
CL	1234	4.7	1238	4.7	n.s.	n.s.	***	*	—
BL	760	3.6	762	3.6	n.s.	*	n.s.	*	—
FD	11	0.5	12	0.6	n.s.	*	***	n.s.	
EMA	75	1.4	73	1.4	n.s.	***	n.s.	n.s.	**
MARB	2.2	0.11	2.2	0.11	n.s.	***	***	n.s.	*
RL	63	0.7	62	0.7	n.s.	n.s.	***	n.s.	*
RF	22	0.7	23	0.8	n.s.	n.s.	**	n.s.	***
RB	14	0.3	14	0.3	n.s.	n.s.	***	n.s.	*

Bonsmara cows (P<0.05). Region and calving contemporary group within region accounted for a large portion of variation (P<0.001) in the traits measured. Although least squares means are not shown for all main effects, the effect of cow age on CD and CI (P<0.001) demonstrated that older cows generally calved later in the season than younger cows, and cows generally had a longer interval between their first and second calf than between subsequent calves.

Sire within breed was a significant source of variation (P<0.05) in AFC and CD. The contribution of animal as a random effect (P<0.05) indicated covariance among repeated measures of CD and CI of the cows across calving years. Breed by region interaction did not contribute to variation (P>0.05) in any of the female fertility traits measured.

Carcass traits

Least squares breed means for carcass measurements on male progeny of Bonsmara and Belmont Red sires are given in Table 10. There was no breed differences (P>0.05) in any of the carcass traits measured. Region and contemporary group within region accounted for a large proportion of phenotypic variation (P<0.05) in the carcass traits measured. Carcass length and butt length was influenced by carcass weight (P<0.05). EMA, marbling, rib lean, rib fat and rib bone were influenced by carcass fatness, reflecting the effect of feeding regime prior to slaughter on retail beef yield. Breed by region interaction and sire within breed did not significantly affect (P>0.05) any of the carcass traits measured and are not shown in Table 10.

Discussion

Liveweights

Despite the differences in selection emphasis between the breeds, the similarity between Bonsmara and Belmont Red progeny liveweights (except birth weight) in the current study indicates similar phenotypic expression of growth traits and supports a hypothesis of similar genetic potential for growth of the breeds. The absence of significant breed by region interaction for the economically important traits indicates no re-ranking of breeds across regions.

The studies of Seifert *et al*. (1985, 1988) reported on subsets of the data analysed in the current study and found no differences between the breeds for liveweight from birth to 18 months. In contrast, the current study reports statistically heavier birth weights of Bonsmara progeny than progeny of Belmont Red sires. The reason for the contrasting reports on birth weight is probably the result of significantly greater number of records and lower standard errors in the current study. The heavier birth weight reported for the Bonsmara calves may be linked to the longer calving intervals reported for Bonsmara cows (discussed in following sections), but the difference is unlikely to be biologically important. An increase in birth weight has been reported to be genetically correlated with increased gestation length and analogous with an increase in dystocia in many cattle breeds (Gregory *et al*. 1995). These associations by definition herald decreased reproductive performance, loss of production and increased herd management costs. However, the practical importance of the difference in birth weight reported in the current study is limited, particularly in dry tropical environments where the nutritional conditions during gestation are rarely good enough to result in very high birth weights. Incidence of dystocia and calving mortality was not recorded in the current study, but the average birth weights recorded were within the acceptable range (Nix *et al*. 1998).

Average daily gain and feed conversion ratio

The Bonsmara sires used in the current study could be expected to have greater genetic potential for ADG and FCR since these traits were used as selection criteria for Bonsmara but not Belmont Red sires. There was, however, no significant difference between the Bonsmara- and Belmont Red-sired progeny for either trait measured during feedlot tests. The lack of difference between the breeds for these traits suggests that the majority of genes responsible for the expression of post-weaning growth traits at either pasture or feedlot are similar, or that the selection pressure applied within the breeds since their development was not great enough to create genetic divergence between the breeds. It should be noted, however, that the numbers of animals of each breed available for testing ADG and especially FCR in the current study were small relative to the population size and preselection of the tested animals was likely to have the effect of a reduction of total variability in the traits and may have contributed to undetectable sire variation for the traits. Testing all animals in each contemporary group, though expensive, would have provided a more efficient sire breed comparison.

Comparative studies of Bonsmara cattle in South Africa (Eloff and Ludemann 1977; Kreiner *et al*. 1991) and Belmont Red cattle in Australia (Frisch and Vercoe 1977; Peiris *et al*. 1995; Tierney *et al*. 1986) show similarities between the breeds when their weight gain and feed utilisation on feedlot rations was compared with other *Bos taurus* and *Bos indicus* derived breeds. Generally, the studies demonstrate that Bonsmara and Belmont Red cattle, in their respective countries of origin, perform better on feedlot rations than *Bos indicus* derived breeds and similarly to *Bos taurus* breeds. Assuming similar selection emphasis across the other breeds, the results of the comparative studies in each country support the view that the selection policies adopted by the Bonsmara and Belmont Red breeds had similar consequences for feedlot ADG and FCR.

Favourable genetic correlations between feedlot ADG and post-weaning liveweight at pasture have been reported. A genetic correlation of 0.30 between ADG in the feedlot and 350-day weight at pasture of half-sibling multi-breed composite cattle at Johannesburg was reported by Schoeman and Jordaan (1998). The report of Reverter *et al.* (2003) detailed a genetic correlation of 0.28 between liveweight at the start of the finishing period (around 15 months of age) and finishing ADG pooled for Belmont Red, Santa Gertrudis, and Brahman breeds in Australia. These positive correlations suggest that selection for either increased ADG on a feedlot diet or for improved post-weaning liveweight at pasture in tropically adapted breeds will be associated with improvement in the other and support the lack of differences in post-weaning growth traits between Bonsmara and Belmont Red cattle breeds reported in the current study.

Scrotal circumference

Published genetic correlations between SC and liveweights from weaning to final weight (0.22–0.50) in Bonsmara (Maiwashe *et al.* 2002) and Belmont Red (Mackinnon *et al.* 1991; Burrow 2001) herds indicate that selection for growth traits or for SC has mutually correlated responses. The similarity of mean SC of Bonsmara and Belmont Red progeny in the current study was not surprising given the favourable genetic relationships between SC and the selection criteria of the original drafts of mating sires used. SC was included in the multi-trait selection criteria of Bonsmara mating bulls in South Africa. The Belmont Red sires used in this study were not selected for greater SC *per se*, but animals with abnormally small SC or other obvious testicular abnormality were culled prior to final selection for 550-day weight; a trait positively correlated with SC (Burrow 2001).

Female fertility traits

The analysis of fertility traits indicates that while heifers of each breed have their first calf at around the same age, the Belmont Red-sired heifers are better able to re-conceive at subsequent mating times and thereby demonstrate a greater potential to produce more calves during their breeding life. The result was unexpected given that neither breed was selected directly for female fertility traits. Differences in CI could possibly be ascribed to heterosis favouring the Belmont Red sired progeny since Belmont Reds are compared as half-breds to the full-bred Bonsmara, but there was no evidence of heterosis in other growth, adaptive or reproductive traits.

The Bonsmara breed policy of using a multi-facet selection regime may explain differences in CI between the Bonsmara and Belmont Red breeds. In addition to measured performance, potential Bonsmara breeding replacements had to pass visual assessment of functional efficiency attributes or be culled irrespective of productive performance, thereby diluting selection pressure for any particular measured trait. Visual assessment was aimed at selecting animals that were more ‘appealing’. At weaning, the most appealing calves were likely to be those whose dams had better milk production, thereby selecting indirectly for increased milk. Higher milk production in stressful environments has been associated with prolonged post-partum anoestrus (Yavas and Walton 2000) and, hence, longer intervals between calves. An analysis of ovarian activity post-calving, not measured in the current study, would be required to substantiate breed differences in the length of post-calving anoestrus period. Differences in milk production should manifest differences in the genetic components of weaning weight. To evaluate breed differences in maternal genetic components, a genetic analysis of weaning weight fitting maternal effects within breeds would be required (see Corbet *et al.* 2006 in this issue).

Selection of the Belmont Red bulls used in the current study ignored appearance and concentrated on age-adjusted liveweight, predominantly 550-day weight, a trait genetically correlated with CI (Oliveira *et al.* 1994). Burrow *et al.* (1991) demonstrated that heifers selected exclusively for weight for age had better re-conception rate and lifetime fertility than unselected heifers. CI, however, has limitations as a measure of female reproduction. Under controlled mating, for instance, negative associations exist between successive measures of CI, that is, CI of late calving cows can get shorter but CI of early calving cows cannot. In the absence of data on the other components of the complex female fertility trait, such as conception rates and calf mortality, judgment on breed differences in reproductive performance should be reserved. Nonetheless, CI was shorter for Belmont Red- than Bonsmara-sired cows in this study.

Tick count

In South Africa, the resistance of Bonsmara animals to ticks was reported to be better than Simmental and Santa Gertrudis breeds but not as high as Afrikaner, Brahman or Nguni (Rechav and Kostrzewski 1991). Other South African studies have shown that resistance of the Bonsmara breed to ticks was generally intermediate between the highly resistant Nguni and the susceptible Hereford breed (Fivaz and De Waal 1993; Scholtz *et al.* 1991; Spickett *et al.* 1989). In Australia, Burns *et al.* (1997) reported superior tick resistance of the Belmont Red compared with Simmental and Hereford breeds. Studies by Seifert (1971) and Frisch and O’Neill (1998*b*) indicated that Belmont Reds were more resistant to ticks than *Bos taurus* but not as resistant as *Bos indicus* breeds.

The predominant cattle tick species present in South Africa, *Boophilus decoloratus*, is from the same genus as the tick species, *Boophilus microplus*, which infests cattle in Australia. In addition to *B. decoloratus*, however, there are multi-host tick species that parasitise cattle in South Africa not present in Australia. It could be expected, therefore, that the progeny of Australian Belmont Red sires raised in South

Africa and exposed to infestation by exotic ticks may exhibit different susceptibility to parasitism by the South African tick species. The highest tick counts measured in the current study were around 100 ticks per animal and indicated that the tick infestations encountered by the animals were large enough to have some effect on normal growth rate (Norval *et al*. 1989) and, thus, allow genetic expression of individual immunity or susceptibility. There was no difference in the number of ticks infesting Bonsmara- and Belmont Red-sired progeny raised at pasture in South Africa. The lack of difference in tick count indicates a similar underlying immune competency of both breeds that is effective against the tick species encountered and likely inherited from the Afrikaner breed of common ancestry and native to South Africa.

Coat and pigmentation scores

Sleekness of coat and darker skin pigmentation has been associated with the ability of cattle to adapt to tropical environments with high ambient air temperature and strong UV radiation (Hammond and Olson 1994; da Silva *et al*. 2001; Turner 1972). There were no differences between Bonsmara and Belmont Red-sired animals for visually scored coat and skin pigmentation attributes in the current study. The results indicate similar genetic potential of the breeds for adaptation to heat stress in tropical environments.

Body conformation

A technique of visual assessment of cattle for functional efficiency (Bonsma 1980) was adopted by the Bonsmara Breed Society to effectively control the body conformation and type of animals admitted for registration and breeding. The set standards culled for genuine anomalies and promoted aesthetics of the breed, but may have inadvertently diluted selection pressures for the post-weaning performance traits as discussed previously. The Belmont Red Association, however, did not impose registration standards but encouraged selection for measured performance. Other than the culling of animals for obvious defects that were likely to affect mating performance (e.g. unsound feet and legs or flawed sexual organs), Belmont Red sires used in the current study were not selected by visual assessment but primarily for post-weaning weight for age. The results show higher (more appealing) scores for functional efficiency and thicker skin of Bonsmara animals, but no difference in body size and growth between the breeds. The differences simply reflect the selection methods used within breeds.

Fordyce and Cooper (1995) tested the South African visual assessment technique for scoring reproductive efficiency in Brahman-cross cows in northern Australia. They found the technique was quickly learned and the scores highly repeatable. Unfortunately, the scoring system had no useful predictive value for female fertility or for growth to 27 months of age. The conclusion was that the visual assessment criteria described by Bonsma (1980) were of no practical value in assessing potential productivity of breeding animals in well-managed Brahman-cross herds.

Carcass traits

The lack of breed and sire differences in carcass traits measured in the current study is supported by the findings by Strydom *et al*. (2001) using data from the same population comparing Belmont Red animals with lines of Bonsmara cattle. Although carcass measurements could only be recorded on a subset of animals, the results indicate a consistency between the breeds for body fatness and the amount of lean beef yielded under the growing conditions experienced.

Comparative studies of the carcass traits of Bonsmara cattle in South Africa (Strydom *et al*. 2000*a*) and Belmont Red cattle in Australia (Newman *et al*. 1999*a*; Tierney *et al*. 1992*a*) demonstrated that the breeds compared similarly with other cattle breeds of varying *Bos indicus* and *Bos taurus* proportions in their respective countries. Meat quality traits, including measures of tenderness, were not measured in the current study but have been genetically linked with liveweight, finishing ADG, carcass weight and fatness traits (Reverter *et al*. 2003), all of which were similar for the breeds studied here. Other studies have reported meat quality traits of Bonsmara (Strydom *et al*. 2000*b*) and Belmont Red (Gazzola *et al*. 1999; Newman *et al*. 1999*b*) animals to be better than *Bos indicus* derived breeds and similar to those of *Bos taurus* breeds. The results indicate that despite differences in selection emphasis during their development, Bonsmara and Belmont Red breeds have similar genetic potential for expression of carcass and meat quality traits.

Conclusions

This study found that growth performance of Bonsmara and Belmont Red breeds at pasture or feedlot was similar and the breeds produced near identical carcasses. The breeds had similar resistance to ticks and scored similarly for coat and pigmentation attributes indicative of similar adaptive potential. Differences in visually scored traits favoured Bonsmara progeny and reflected differences in selection methods between the breeds. Higher birth weights of Bonsmara calves were not of major concern but should be monitored in future selection programs. While scrotal circumference of the bulls and age at first calving of the heifers of each breed was alike, a significantly longer average calving interval of Bonsmara females may be linked to stronger selection emphasis on milk production in Bonsmara cows, leading to longer periods of post-partum anoestrus. Significant sire variation, the absence of breed by region interaction, and the size of the Bonsmara population, however, indicate vast potential for the selection of superior animals suitable for use in South African and Australian herds.

The sires sampled were representative of the breeds in the mid-1980s and their progeny were tested up until 1999 across environments similar to those in Australia allowing extrapolation of the results to Australian conditions. Assuming little change in selection emphasis and similar trends in genetic gain within the populations since the time of sampling, these results have implications to breeders in both countries. Breeders in Australia using the incumbent Belmont Red rather than imported Bonsmara germ plasm can be confident with the knowledge that they have not jeopardised the productivity of their herds. Breeders in both countries can capitalise on greater selection intensity and reduced inbreeding by selecting appropriate Belmont Red and Bonsmara sires once a combined-breed genetic evaluation program is under way. Bonsmara breeders could place increased selection emphasis on reduced calving interval and less emphasis on milk production, provided it does not compromise their production and marketing systems. The selection of Belmont Red sires primarily for increased 18-month weight, a trait more easily measured than feedlot performance, had no adverse correlated responses and has implications for breeders of beef cattle worldwide.

Acknowledgments

This study reports on data collected for the South African National Beef Cattle Performance Testing Scheme. The generation of Belmont Red progeny data relied on the initiative of Australian CSIRO and South African Agricultural Department staff to form a collaborative research project in 1981 and introduce semen from Australia to South Africa. Dr George Seifert (ex CSIRO, Australia) and Dr Jan Hofmeyr (ex South African Department of Agriculture) were key personnel involved with the genesis of the collaborative project. We thank the owners of the herds involved with the project and all those responsible for collection, maintenance and retrieval of the data (especially Leslie Bergh, Bernice Mostert, Rain Gerhard and Annette Exley at the Irene Animal Improvement Institute). The study was partly funded by the CSIRO and the Cooperative Research Centre (CRC) for Cattle and Beef Quality.

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