REPRODUCTION IN *BOS INDICUS* CATTLE IN NORTHERN AUSTRALIA

INTRODUCTION

K.W. ENTWISTLE*

The introduction of *Bos indicus* genotypes into established populations of British (*Bos taurus*) breeds has had a significant impact on cattle production in northern Australia. The widespread acceptance and use of these genotypes, and in particular the Brahman, is reflected in the fact that approximately 53 percentof the Queensland beef herd now contains *Bos indicus* infusions (Anon. 1978). In the Northern Territory and in northern Western Australia the use of these genotypes has also been considerable but less substantial than in Queensland (Turner 1975).

Brahmans, Sahiwals, a breed originally introduced for crossbreeding with *Bos taurus* dairy cattle in the tropics, and a Sangar breed, the Africander, have been used either in crossbreeding programmes or in the synthesis of derived breeds such as the Droughtmaster and Belmont Red. The productive advantages of *Bos indicus* genotypes over *Bos taurus* breeds in northern Australia have been well documented (Vercoe 1974; Turner 1975). However a weakness in the productive potential of Brahman crosses and Brahman-derived breeds has been that their reproductive performance has been no better and in some cases lower than that of *Bos taurus* breeds in the tropics (Seebeck 1973; Turner 1975). In contrast Africander cross and Africander-derived breeds have higher fertility (Seifert and Kennedy 1972; Seebeck 1973; Rudder *et al*. 1976).

Of the factors influencing lifetime reproductive performance, age and weight at puberty are important and these parameters are examined in relation to breed differences between a number of *Bos indicus* genotypes, their reciprocal crosses and lines of *Bos taurus* cattle. Environmental influences of external and internal parasites on age and weight at puberty are also examined in the first paper in the series.

Selective combination of the productive attributes of two or more genotypes is a common approach in animal breeding. The fertility of the cow and the bull in relation to differences in calving rate between Africander cross and Brahman cross lines and their reciprocal crosses is discussed in the following paper.

The use of the Sahiwal in beef breeding programmes in northern Australia has been a relatively recent development, and limited performance data are available. Sahiwal-Shorthorn crosses have been reported to have comparable growth rates to Brahman-Shorthorn crosses (Winks *et al*. 1978) and thecomparative reproductive performance of these crosses forms the basis of the third paper.

A number' of variables have been reported to help predict pregnancy rate including age, lactation status, body condition, live weight, and liveweight change during and prior to mating. However since a number of these variables are correlated with one another, it has not been clear which may be the most important and which may have'effects that are independent of the others. Reproductive data from a Droughtmaster herd are used to examine the use of these variables in predicting pregnancy rate.

The development of sound management systems for young bulls necessitates a knowledge of the'factors influencing attainment of puberty, and of the age at

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* Department of Tropical Veterinary Science, James Cook University, Townsville, Qld 4811.

which puberty is reached. Preliminary results of a study in *Bos indicus* and *Bos taurus* bulls using patency of the seminiferous cords as a criterion for defining the onset of puberty are reported in the fifth paper.

A male contribution to lowered herd fertility in *Bos indicus* genotypes has been suggested (Seebeck 1973; Endo *et al.* 1978). One component of the bull fertility complex is testis sperm production potential (TSP) which is dependent on both testis sperm concentration/gm (SPG) and on testis size. In *Bos taurus* strains SPG is relatively constant and hence TSP is largely a function of testis size (Amann 1970). However comparable information from *Bos taurus* strain bulls is lacking and preliminary results of a study of SPG and TSP in bulls of these genotypes are presented in the final paper.

PUBERTY IN TROPICAL BREEDS OF HEIFERS AS MONITORED BY PLASMA PROGESTERONE

T.B. POST* and M.M. REICH*

MATERIALS AND METHODS

Two hundred and twelve heifers were studied representing ten breed groups described in detail previously (Anon. 1976): Africander cross (AX); Brahman cross (BX); Hereford-Shorthorn, selected (HSS); Hereford-Shorthorn, random bred (HSR); grade Africander (GA); grade Brahman (GB); and four F_2 genotypes (ABAB, ABBA, BAAB, BABA) from reciprocal matings of AX and BX breed groups. The heifers ran together on improved green panic-siratro-buffel grass pastures that varied from high quality in summer to low quality in winter. For the purposes of another experiment (G.W. Seifert, R.P. Bryan, K.G. Bean (unpublished)) heifers were divided into four parasitic control treatment groups: (1) no parasite control; (2) monthly treatment with acaracide to control ticks; (3) monthly anthelmintic treatment to control worms; and (4) acaracide plus anthelmintic monthly.

Using two plasma progesterone measurements, ten days apart, cyclic ovarian activity was monitored monthly over the period from eight to 25 months of age. Puberty was designated as the time progesterone first reached a concentration of over 1.0 ng/ml.

RESULTS AND DISCUSSION

By 25 months of age progesterone measurements demonstrated that 197 of the 212 heifers had reached puberty. The means and ranges of ages and weights at puberty for the ten breed groups and the four parasite treatment groups are shown in Table 1. The 15 heifers that failed to reach puberty consisted of two AX, three BX, three HSS, one HSR, two GA, one ABBA, one BAAB and two BABA. Five were in the no parasite control group, nine in the acaracide group, and one in the acaracide plus anthelmintic group.

Analyses of variance of the data on heifers that reached puberty indicated that breeds differed significantly ($P<0.05$) in both age and weight at puberty. Weights at puberty differed between parasite treatment groups ($P<0.05$) but age differences did not reach significance. There was no significant interaction between breeds and parasite treatment groups in either age or weight at puberty. Within breed-treatment groups coefficients of variation for age (15.0%) and weight (16.5%) at puberty were similar.

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* CSIRO, Division of Animal Production, Tropical Cattle Research Centre, Rockhampton, Qld 4708

TABLE 1 Ages and weights at puberty in ten breeds and four parasite treatment groups

Group	n	Age (days)		Weight (kg)	
		Mean	Range	Mean	Range
Breeds					
AX	52	$545^{a\dagger}$	340-760	269^{ab}	158-398
BX	41	525^{ac}	420-670	261^{abc}	158-349
HSS	23	532^{ac}	422-634	240^{bc}	173-295
HSR	12	563^{a}	420-629	236^{abc}	169-334
GA	19	511^{ac}	328-663	258^{abc}	181-338
GB	12	481^{bc}	341-580	246^{abc}	163-302
ABAB	11	494^{ac}	390-611	264^{abc}	169-350
ABBA	8	508^{ac}	405-622	279^{ab}	177-349
BAAB	8	576^{a}	421-733	283^{a}	208-360
BABA	11	536^{ac}	433-615	284^{a}	213-340
Treatments					
None	45	557^{d}	413-735	253^{d}	158-338
Acaracide	47	533^{d}	328-760	253^{d}	169-330
Anthelmintic	50	511^{d}	390-670	262^{de}	169-398
Acaracide and anthelmintic	55	522^{d}	340-735	274^{e}	163-360
Overall	197	530	328-760	261	158-360

† In each column means without at least one common superscript are different ($P<0.05$).
Means compared by Multiple Range Test of Duncan (1957).

Specific breed comparisons indicated that the superior reproductive performance of Africander cross cows was not reflected in an early age of puberty. In view of the widely held belief that Brahmans are slow in maturing it was surprising that the small number of grade Brahman heifers in this study had the lowest age of puberty.

A complicating factor was the occurrence of drought conditions during the last six months of observations. Thus, the onset of puberty was delayed in many heifers, and cyclic ovarian activity failed to be sustained in almost half the heifers that had already reached puberty.

CALVING PERFORMANCE OF RECIPROCALLY MATED AFRICANDER AND BRAHMAN CROSSBRED CATTLE AT BELMONT

G.W. SEIFERT,* K.G. BEAN,* and H.R. CHRISTENSEN**

ANIMALS AND METHODS

A breeding programme to produce reciprocal crossbreds between the Africander cross (AX) and Brahman cross (BX) lines of cattle (Anon. 1976) at "Belmont" commenced in 1970. Cows that had failed to conceive during the normal January-February mating period of seven weeks and were eligible for culling were

* CSIRO, Division of Animal Production, Tropical Cattle Research Centre, Rockhampton, Qld 4708.
** CSIRO, Division of Animal Health, Tropical Cattle Research Centre, Rockhampton, Qld 4708.

re-mated following pregnancy diagnosis. The late mating occurred during April-May for seven weeks in the same year during 1970, 1971 and 1972. Cows to be re-mated were randomly allocated to bulls within lactational status and age. Single sire matings were used and AX and BX bulls were allocated the same proportion of each of the breeds of cows. New 2½-year-old bulls that had been used in the initial earlier mating were used each year. Over the three years 90 AX and 142 BX cow-years were represented. Non-pregnant, late mated cows with a poor fertility record were culled for slaughter. Ages of cows ranged from three to older than ten years, and were grouped as three years, four years, 5-9 years and ten years and older classes for analyses.

Calving performance (C) was measured as calf born (1) or no calf born (0). Fertility of the cow (F) was the percentage of calves born from her previous reproductive history. Fertility of the bull was the percentage pregnancies obtained during the normal mating. The data were analysed by the least-squares method after arcsin transformation of the proportions (Snedecor and Cochran 1967).

The initial model for analyses included years, breed of bull, breed of cow, cow age, lactational status, breed of bull x breed of cow interaction, and the covariates of cow weight at mating, fertility of the cow and fertility of the bull. The data of the maidens were excluded because of complete confounding of lactational status (all dry) and fertility with this category.

RESULTS

Calving performance of the AX bulls was 13.7% ($P<0.05$) better than those of the BX bulls and AX cows 15.4% ($P<0.05$), better than BX cows in the model which did not include any of the covariates. There was no significant breed of bull x breed of cow interaction. When the linear and quadratic terms of fertility were included in the model, cow age, lactational status, breed of bull and the interaction of cow age x lactational status were significant. In the 5-9 year old class wet cows had 8.4% more calves than dry cows while in all other age groups wet cows had from 36.2% to 38.5% less calves. The regressions of calving performance on cow weight at mating and bull fertility were small and non significant.

The linear regression of calving performance on fertility was highly significant when computed separately within the BX line ($b = 0.0166$ and $r = 0.396$, $P<0.01$), but not significant for the AX line ($b = 0.0041$ and $r = 0.114$). When the quadratic term was included in the model coefficients for both the linear and quadratic terms were significant in the AX (b (linear) = 0.0280 and b (quadratic) = -0.0002 with the partial correlation $r = 0.281$). In 'the BX line the linear term only remained significant (b (linear) = 0.0181 and b (quadratic) = -0.0001 with the partial correlation $r = 0.277$).

DISCUSSION

The differences in calving performance between the AX and BX lines are consistent with those previously reported (Seifert and Kennedy 1972; Seebeck 1973; Rudder et al. 1976). The present study shows that both the BX bulls and the BX cows contribute significantly to this difference.

The significant regression of calving performance on fertility indicates a high repeatability for fertility. The less intensive culling, for reproduction because of their lower fertility, resulted in an average fertility of 47.0% for the BX cows compared to 81.7% for the AX cows. However the difference in calving of 29.1% between the AX and BX is similar to the difference reported by Seebeck

(1973). The differing significance of linear and quadratic terms for the AX and BX indicates that repeatability is greater when the range of fertility covers low levels.

The high repeatability and the elimination of a significant breed of cow effect when the data are adjusted for the fertility of the cow confirms the results obtained by Rudder and Seifert (1977). The present results confirm the need to apply rigid culling for fertility in cow herds and to seek methods of selecting highly fertile BX bulls.

REPRODUCTIVE PERFORMANCE OF F_1 BRAHMAN-SHORTHORN AND F_1 SAHIWAL-SHORTHORN CATTLE IN NORTHERN AUSTRALIA

R.G. HOLROYD* and P.K. O'ROURKE**

MATERIALS AND METHODS

At Swan's Lagoon Research Station in the subcoastal spear grass region of north Queensland, F_1 half Brahman-Shorthorn and F_1 half Sahiwal-Shorthorn calves born November to March in 1969-70, 1970-71 and 1971-72 were first mated at approximately two years of age. Each year mating commenced in January and continued for three to five months. The data were drawn from cows in a number of different mating groups on the property over the period 1972-1978. Cows were mated to bulls of the same breed, a total of 20 sires (eight purebred Brahman; 12 F_1 half Brahman-Shorthorn) being used in multiple sire mating programmes in the Brahman cross cows. The Sahiwal cross cows were single sire mated, except in 1978 when multiple sire mating was carried out, eight sires (five purebred Sahiwal; three F_1 half Sahiwal-Shorthorn) being used over the period of observations. Bull percentages for both cow genotypes varied from 2 to 5%. Apart from the mating period, the cow groups were run together. Calves were weaned about June each year, and the culling policy was similar for both breeds.

RESULTS AND DISCUSSION

There were no significant differences in conception rate, calving rate and weaning rate of Brahman cross and Sahiwal cross cattle (Table 2). However, the loss between pregnancy testing and weaning was 15.8% units in Sahiwals and 6.6% units in Brahman cross animals, most of the losses in the Sahiwals occurring in and perinatal and early postnatal periods. Between-sire differences in losses between pregnancy testing and weaning were not important in the Sahiwal single sire mating groups, while the use of multiple sire mating groups precluded any sire comparisons between Brahman cross and Sahiwal cross.

Lowest conception rates occurred in cows mated at three years of age. Similar trends occurred with calving and weaning rates. These results agree with McClure's review (1973) of Australian literature that fertility was highest in maiden heifers, lowest during their first lactation and that the level in mature cows approached that of heifers.

Age at mating did not influence the discrepancy between conception rates and weaning rates. This contrasts with previous work that higher losses occur in heifers than in mature cows (McClure 1973).

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* Department of Primary Industries, "Swan's Lagoon", Millaroo, Qld 4807,
** Department of Primary Industries, Townsville, Qld 4810.

TABLE 2 Conception, calving and weaning rates of Brahman cross and Sahiwal cross cows

	Cows mated		Conception rate (%)		Calving rate (%)		Weaning rate (%)	
	Lactating	All	Lactating	All	Lactating	All	Lactating	All
Breed								
Half Brahman	461	702	80.0	83.6	77.5	80.6	74.5	77.0
Half Sahiwal	292	462	83.0	84.7	78.1	79.5	67.3	68.9
SE			4.1	3.2	4.3	3.4	3.9	3.1
Age at mating (years)								
2		275		92.0		87.2		80.5
3	220	245	72.0	73.9	67.7	69.3	62.1	62.7
4	159	229	85.9	87.1	84.2	85.1	78.7	79.8
5	174	193	92.3	91.0	85.9	85.0	78.2	78.3
6	134	153	82.2	84.4	79.9	80.9	70.7	70.4
7†	66	69	75.2	76.5	71.2	72.8	64.8	65.9
SE			6.6	5.6	6.9	6.0	6.2	5.5

† This mating only for groups born 1969-70 and 1970-71.

Present work is investigating inter se mating of half and three quarter Brahman cross and Sahiwal cross animals to determine if the reported decline in fertility in F_2 and subsequent generations in half Brahmans (Seebeck 1973) occurs in the Sahiwal crossbreds.

VARIABLES AFFECTING PREGNANCY RATE IN BOS INDICUS CROSS COWS

M.E. GODDARD,* K.W. ENTWISTLE* and R. DIXON**

MATERIALS AND METHODS

The data were drawn from the 1979 mating of a herd of 593 Droughtmaster cows maintained at the CSIRO "Lansdown" Research Station, 50 km south of Townsville. In this herd heifers are first mated as two year olds and mating was for a three month period commencing in late January. Live weights and body condition scores were recorded just prior to mating and again at pregnancy diagnosis in late June. An additional body condition scorerecorded from these cows in June 1978 was also used in the analyses.

The results were analysed by least squares, coding pregnant as 1 and non-pregnant as 0. The model included lactation status at mating, age and the age x lactation status interaction, and in some cases one or more of the live weights and body condition scores. Live weights and liveweight changes were included in the model as factors rather than regressions, by dividing them into weight ranges 20 kg wide.

* Department of Tropical Veterinary Science, James Cook University of North Queensland, Qld 4811.

** CSIRO, Division of Tropical Crops and Pastures, Lansdown Research Station, Townsville, Qld 4810.

RESULTS AND DISCUSSION

Although pregnancy rate was highest in seven-year-old cows the differences among cows four years old and older were not significant, and hence these age groups were pooled for further analyses. There was a significant age x lactation status interaction as shown in Table 3.

TABLE 3 The effect of age, lactation status, mean live weight (MWT) and liveweight change (ΔWT) on pregnancy rate

	2 years old		3 years old				≥4 years old			
	Non-lactating		Lactating		Non-lactating		Lactating		Non-lactating	
	%	(n)	%	(n)	%	(n)	%	(n)	%	(n)
Mean pregnancy rate	60	(94)	27	(55)	82	(61)	68	(191)	90	(153)
MWT range (kg)										
240-279	15	(13)								
280-319	58	(55)	0	(10)}	86	(7)				
320-359	80	(20)	24	(17)			20	(5)}	85	(13)
360-399	100	(6)	36	(22)	79	(19)	55	(31)		
400-439		}	50	(6)	91	(22)	65	(60)	94	(35)
≥440					69	(13)	76	(95)	89	(93)
ΔWT range (kg)										
-80 to 20			24	(38)	75	(4)	60	(92)	60	(10)
20 to 80	58	(40)	30	(16)	79	(29)	76	(95)	89	(75)
80 to 140	60	(53)			86	(28)	69	(4)	94	(68)

The effects of liveweight change have been corrected for body weight but the effects of live weight are uncorrected. Although 20 kg ranges were used for analysis, for ease of presentation larger ranges have been used in the table.

After correcting for age and lactation status any one of the following variables helped to predict pregnancy rate-live weight in January (WJAN) or in June (WJUN), body condition in January (CJAN) or in June (CJUN) or liveweight change (ΔWT) or change in body condition (ΔCON) between these dates, or body condition change from the previous June until January (ACONP). In contrast to Donaldson (1969) we found that CJUN was correlated with CJAN ($r = 0.61$).

When ACONP and CJAN were both included in the model only CJAN had a significant effect. Therefore the predictive value of ACONP appears to be largely due to its correlation with CJAN.

After correcting for CJAN, ΔCON still had a significant effect. This would be expected even if it was the static body condition throughout mating that was the important variable. Therefore the most logical measure of condition during mating is the mean of the body condition scores in January and June (MCON). Similarly mean live weight (MWT) was used instead of WJAN and WJUN in subsequent analyses.

The effect of live weight and liveweight change varied between age-lactation status groups (Table 3). In heifers the pregnancy rate rose with MWT at least until 320 kg. In non-lactating cows there is no effect of MWT but all except one cow weighed more than 320 kg. In lactating cows the pregnancy rate rose until MWT reached 440 kg after which there was no further rise. Although the difference was not significant, three-year-old cows averaged 15% lower than mature cows when lactating and 8% when non lactating, after correction for MWT.

Within age-lactation groups MCON was as good as or better than MWT at predicting pregnancy rate. This was in spite of the inaccuracy of the technique since the repeatability of two scores, three weeks apart by different observers, was 0.73. It seems likely that where cows vary greatly in mature size, weight will be less important than body composition (e.g. fat content; Siebert and Field 1975) in determining pregnancy rate. However body condition scoring was not sufficiently accurate to demonstrate this.

After correcting for MWT, ΔWT was correlated with pregnancy rate but this was only significant in the mature cows (Table 3). It is, of course, possible that pregnancy causes a gain in weight rather than the reverse.

These results are similar to those reported by Buck et al. (1976) from Botswana, who also found an effect of lactation, a curvilinear effect of live weight and small additional effects of age and liveweight change.

ONSET OF SPERMATOGENESIS IN BOS INDICUS GENOTYPES

H.R. CHRISTENSEN*, G.W. SEIFERT** and I.M. PARSONSON***

MATERIALS AND METHODS

Testes obtained by castration from Africander cross (AX), Brahman cross (BX), Hereford-Shorthorn cross (HS) and AX and BX Reciprocal cross (RX) bull calves (Anon. 1976) at approximately 6-9 months of age were examined histologically for the presence of lumen formation in the seminiferous cords. In each of the three years, 1974, 1975 and 1976, the calves were run together from birth to weaning on the National Cattle Breeding Station, "Belmont", in central Queensland. The lowest 50% of the calf drop, based on weight per day-of-age (W/A) were castrated each year and a random sample of the castrates was used in this study. A total of 183 calves: 56 AX, 29 BX, 40 HS and 58 RX, were used in this study.

Patency (Pt) was recorded as some tubules patent (1) or no tubules patent (0) and was analysed using the least-squares method. The model for the analysis included years (Y), breeds (B) and the covariate of W/A at castration. There was no significant year x breed interaction in preliminary analyses so the interaction was not included in the final model.

RESULTS

The earliest age when patent tubules were seen was 26 weeks for AX, 26 for BX, 29 for HS and 23 for RX, while in the 1974 group patent tubules were not found until the bulls reached 34, 38, 38 and 35 weeks respectively. The range of ages at castration in the study was 23 to 42 weeks.

The least-squares constants for the analysis of variance of data on the proportion of bulls with patent seminiferous tubules were: $\mu = 0.4916$; year

* CSIRO, Division of Animal Health, Tropical Cattle Research Centre, Rockhampton, Qld 4708.
** CSIRO, Division of Animal Production, Tropical Cattle Research Centre, Rockhampton, Qld 4708.
***CSIRO, Division of Animal Health, Parkville, Vic. 3052.

effects, 1974 = -0.0404, 1975 = 0.1277, 1976 = -0.0873; breed effects, AX = 0.0244, BX = -0.2661, HS = 0.1398, RX = 0.1019.

Year and breed had significant effects on the presence of patent tubules ($F = 3.53, P<0.05$; $F = 4.96, P<0.01$ respectively) and the linear regression of Pt on W/A was significant ($b = 1.69, P<0.01$). When analysed within breeds the year effect reached significance in the AX and RX breeds but not in BX and HS, while the regression of Pt on W/A was positive and significant for the HS and RX.

DISCUSSION

First occurrence of the lumen in the seminiferous cords at 26, 26, and 23 weeks for the *Bos indicus* (AX, BX and RX) is earlier than that recorded for the White Fulani in Nigeria at 40 weeks (Aire and Akpokodje 1975) or Angoni (Short-horn Zebu) at 28 weeks in Zambia (Igboeli and Rakha 1971). Although the AX, BX and RX breeds in our study were nominally only half *Bos indicus*, patent tubules were first noted in 1974 at 34 to 38 weeks. The first appearance of canalization in the HS at 29 weeks is later than most recorded figures for *Bos taurus* bulls (20 weeks for Swedish red and white (Abdel Raouf 1960); 20 weeks for Herefords (Phillips and Andrews 1936); and 28 weeks for Holsteins (Macmillan and Hafs 1969)).

Since first occurrence of lumen formation in the RX and BX bulls coincided with minimum age of the bulls used in the study, lumen formation may occur earlier in these breeds. The significant and positive effect of the regression of Pt on W/A for the HS and RX suggests that at the time of castration more of the bulls left entire would have patent tubules and canalization may have commenced earlier than in the lower W/A bulls examined.

Although the RX, AX and BX showed superior growth rate to the HS (W/A = 0.83, 0.81, 0.78, cf 0.62), when adjusted for W/A, the HS had the greatest proportion with patent tubules. This suggests that in this environment the HS bulls could not express their inherently high reproductive potential.

The reason for the significant year effect is not known. Apparently some environmental factor affected the development of puberty directly rather than through its effect on growth rate (W/A).

Epididymal sperm appear from 20 weeks (Aire and Akpokodje 1975) to 28 weeks (Igboeli and Rakha 1971) after tubules become patent in *Bos indicus*. Thus, from the results reported here, well-grown RX bulls could have been capable of fertilising cows at 43 weeks of age, and AX and BX bulls at 46 weeks.

SPERM PRODUCTION RATES IN *BOS INDICUS* STRAIN BULLS

K.W. ENTWISTLE*, A. WINANTEA* and R.G. HOLROYD**

MATERIALS AND METHODS

Testes were collected at castration or at slaughter from purebred Brahman (B); Brahman cross (BX - half and three quarter); Sahiwal cross (SX - three quarter and seven eighths); and purebred and three quarter Santa Gertrudis (SG) bulls of known ages between 19 and 27 months and drawn from herds in northern

* Department of Tropical Veterinary Science, James Cook University, Townsville, Qld 4811.
** Department of Primary Industries, "Swan's Lagoon", Millaroo, Qld 4807.

coastal Queensland. Material was also examined from a group of Hereford (H) bulls (18-36 months) as a check on the techniques used, but these data were not included in the analyses since accurate ages were not available.

SPG was determined in all samples by testicular homogenization techniques (Amann and Almquist 1962). In additional samples taken from a random selection of BX and SX bulls SPG was also determined by quantitative histological techniques (Swierstra 1966). Estimates of TSP were derived by multiplying SPG x 0.99 (total testicular parenchymal weight) (Swierstra 1966).

The initial least squares model for analyses included grades within breeds and a covariate of age at castration (or slaughter). As there were no significant grade within breed effects, the final model involved breed comparisons with a covariate for age.

RESULTS AND DISCUSSION

Testes from 197 bulls were examined, comprising material from 162 Bos indicus bulls and 35 H bulls. Data from 20 BX bulls (33 percent) and 8 SG bulls (12 percent) were excluded from the analyses since these bulls were judged to have testicular hypoplasia (bilateral and unilateral) or were developmentally immature. The criterion for rejection of data was based on small testis size (<60 g) combined with either very low estimates of SPG or in some cases complete absence of spermatids in testicular homogenates.

Estimates of SPG in the four Bos indicus genotypes were very similar (Table 4) but tended to be lower than for the tropical H bulls examined here, and lower than those recorded previously from a range of Bos taurus genotypes (Amann 1970). However the estimates were similar to those of 48.9×10^6 recorded for 15-17 month Friesian bulls in New Zealand (Macmillan et al. 1972). Preliminary data from older (3-4 yr) Bos indicus bulls suggest however that SPG is of a similar magnitude to that found in the present study and thus these differences may reflect inherent genetic variations between Bos indicus and Bos taurus bulls, rather than being a reflection of the slower maturity of Bos indicus bulls.

There were significant breed differences in TSP reflecting the relatively smaller testicular size of B and BX bulls. Similar findings have been reported in respect to testicular size in young (six months) BX bulls (Endo et al. 1978). However while in that study BX and SX testis sizes were similar, SX bulls in the present study had significantly greater testis weights and hence greater TSP. In all Bos indicus genotypes examined TSP was much lower than for tropical H bulls and for published estimates from Bos taurus strains.

Estimates derived from either homogenization or histological techniques were very similar (SPG, $r = 0.966$; TSP, $r = 0.958$), but for large scale investigations, the homogenization technique is more appropriate because of its rapidity, simplicity and cost.

The lower SPG recorded here combined with lower estimates of TSP due to a relatively smaller testis size appear consistent with the suggestion of lower fertility of Bos indicus bulls (Seebeck 1973). These findings suggest that selection on the basis of testis size may be a valid criterion for selection for high fertility in Bos indicus strain bulls, and this aspect is currently being examined.

TABLE 4 Testis weight, testis sperm concentration (SPG) and testis sperm production (TSP) potential in *Bos indicus* bulls

Genotype	(n)	Mean age (d)	Least squares means (±SE) corrected for age: Paired testis parenchymal weight (g)	SPG (x 10^6)	TSP (x 10^9)
B	(16)	680	235.8[a†] ±15.8	49.66[a] ±0.80	11.71[a] ±0.56
BX	(40)	605	224.5[a] ±12.7	52.48[a] ±0.46	11.78[a] ±0.32
SX	(21)	584	335.9[b] ±21.5	52.21[a] ±0.76	17.53[b] ±0.89
SG	(57)	581	327.2[b] ±17.4	51.99[a] ±0.59	17.01[b] ±0.72
H	(35)	Range 1.5-3.0 yr	465.2 ±26.5	56.63 ±0.52	26.34 ±0.92
Bos taurus (derived from Amann 1970)		1-12 yr	370-681	56-63	21.4-40.4

† Means in the same column with different superscripts differ significantly ($P<0.05$).

SUMMARY AND CONCLUSIONS

K.W. ENTWISTLE

The superior reproductive performance of AX cows and bulls reported previously and confirmed in the paper by Seifert *et al.* in this series, was not reflected in an earlier age or lower live weight at puberty in females of this line. Similarly males of this genotype did not reach puberty at an earlier age. Conversely the lower fertility of BX lines found at "Belmont" was not associated with any demonstrable differences in either age or weight at puberty in females or age at puberty of males of this line. In fact, despite the occurrence of drought conditions which delayed onset of puberty in heifers, the small number of grade Brahmans in the study had the lowest age at puberty which is at variance with published data suggesting slow maturity and a greater age at puberty in this genotype. Thus time of onset of puberty, a component of the overall fertility complex in both the male and female, appears unlikely to be a contributing factor to the differences in reproductive performance of a number of *Bos indicus* and *Bos taurus* genotypes in northern Australia.

A high repeatability for fertility in *Bos indicus* lines has been previously suggested (Rudder and Seifert 1977) and was confirmed in the present study of AX and BX lines and their reciprocal crosses. On the basis of these data rigid selection for fertility in cow herds could be expected to lead to phenotypic improvements in herd fertility. Breed variations in bull fertility confirm previous observations and highlight the need to develop selection methods for high fertility particularly in BX bulls.

In the north Queensland environment conception rates, calving rates and weaning rates were comparable in F_1 Sahiwal-Shorthorn and F_1 Brahman-Shorthorn cows although higher overall losses between confirmed pregnancy and weaning were found in Sahiwal-Shorthorn crosses. In these lines age trends in fertility were similar to those reported previously, lowest fertility occurring in cows during their first lactation. Work currently in progress designed to examine the fertility of F_2 and subsequent generations in the Sahiwal will provide objective data for assessment of the possible role of this genotype in the northern beef industry.

A number of variables including body condition, live weight and liveweight change were useful as predictors of pregnancy rate in a Bos indicus herd. Within age-lactation groups mean body condition during mating was as good as or better than mean live weight in predicting pregnancy rate. However when cows vary greatly in mature size, live weight may be less important than some measure of body composition, e.g. fat content, but condition scores are not sufficiently accurate to determine this.

Live weight had a curvilinear effect on fertility in heifers and in lactating mature cows, and there was a trend to lower fertility in cows on their first lactation. Weight change was correlated with pregnancy rate but this effect was only significant in mature cows.

Lower estimates of sperm concentration per gram and lower estimates of testis sperm production potential, the latter due in part to smaller testis size, were found in a range of Bos indicus genotypes. These findings appear consistent with other reports of lower fertility in Bos indicus bulls since testis size is related to fertility at least in Bos taurus bulls and selection on the basis of testis size may be a possible criterion for selection for fertility in Bos indicus bulls.

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