Australian Journal of Experimental Agriculture, 1990, **30**, 717–25

The performance of Brahman–Shorthorn and Sahiwal–Shorthorn beef cattle in the dry tropics of northern Queensland
1. Reproductive rates and liveweights of F_1 and backcross females

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Summary. A breeding program was established at Swan's Lagoon Beef Cattle Research Station in the dry tropics of northern Queensland to evaluate the productivity of cattle which were genotypically at least one-half *Bos indicus*. Brahman or Sahiwal bulls were initially mated to *B. taurus* cows (predominantly Shorthorn) to produce the first filial generation (F_1 1/2 Brahman and F_1 1/2 Sahiwal). First backcross 3/4 Brahman and first backcross 3/4 Sahiwal were derived from crossing F_1 1/2 Brahman or F_1 1/2 Sahiwal cows to their respective sire breeds. This paper reports on the female reproductive rates and liveweight performance in 2 data sets: 1972–79, F_1 1/2 Brahman *v.* F_1 1/2 Sahiwal; 1975–83, first backcross 3/4 Brahman *v.* first backcross 3/4 Sahiwal.

In both data sets, significant differences in fertility (pregnancy rate and calving date) between F_1 or first backcross groups were infrequent, and where differences did occur, they were often inconsistent due to cross x year interactions. The difference between weaning rates and pregnancy rates (representing foetal and calf wastage) was 5 percentage units higher in Sahiwal crosses than Brahman crosses for lactating cows.

Year effects significantly (P<0.05) influencd both fertility and liveweight, demonstrating the extent of seasonal influences on cattle production in the dry tropics.

Generally Brahman-cross cows were heavier throughout than their Sahiwal counterparts. Among lactating cows, F_1 1/2 Brahman were 21 kg heavier at start of mating than F_1 1/2 Sahiwal, while first backcross 3/4 Brahman were 29 kg heavier than first backcross 3/4 Sahiwal.

Introduction

More than three-quarters of beef cattle in tropical Australia now contain some *Bos indicus* (ABS 1988). This genetic transition occurred through selective breeding because *B. indicus* types cope better with the environmental stresses of high ambient temperature and solar radiation loads, marked fluctuations in nutritional conditions and internal and external parasitic burdens (Turner 1975).

In the more favoured areas of central Queensland, cattle which are 1/2 *B. indicus* and 1/2 *B. taurus* are considered to possess the adaptive traits of *B. indicus* and the productive traits of *B. taurus* (Rudder 1978). In the harsher areas of northern Australia, some producers and extension officers consider that cattle should be more than 1/2 *B. indicus* to cope with the severe environmental stresses. This is supported by Lapworth *et al.* (1976) who found that, in a central Queensland study, 3/4 Brahman steers grew better in years of low rainfall than 1/2 Brahman steers. However, breeding for increased Brahman content of cows may have an adverse effect on fertility, because Rudder *et al.* (1976) found that 3/4 Brahman cows were less fertile than 1/2 Brahman cows in central Queensland.

Another *B. indicus* breed introduced to Australia in 1954, Sahiwal, may be an alternative for the dry tropics. However, information on the performance of Sahiwal crossbreeds for beef production is limited. Harricharan (1971) reported higher calving rates and shorter intercalving intervals in Sahiwals than in Brahmans in Guyana, whilst a similar trend was recorded in Indonesia (Hardjosubroto 1984).

Limited data on the reproductive performance of Brahman cattle in the dry tropics of Australia and the absence of quantitative productivity data on cattle containing varying proportions of either Brahman or Sahiwal led to the development of a program to examine these aspects. This paper reports on the cow reproductive performance and liveweights of the first filial and first backcross generations of *B. indicus* x *B. taurus* crosses, comparing Brahman and Sahiwal breeds of *B. indicus*.

Materials and methods

Property description, climate, soils and vegetation

The evaluation was carried out at Swan's Lagoon Beef Cattle Research Station, 100 km south of Townsville (20°05'S., 147°14'E.) in the subcoastal spear grass region of northern Queensland. This property of 36 000 ha carrying 2300 breeders and 1100 other stock is managed to provide relevant research information to extrapolate to the commercial beef industry.

The climate has a distinct hot, wet, summer period (wet season) and a warm, dry, winter period (dry season). The rainfall distribution and, hence pasture growth allows cattle to gain weight on native pasture over a 4–7 month period (Winks *et al.* 1974), although in years of substantial winter rainfall, cattle can gain weight throughout the dry season (McLennan *et al.* 1981).

Maximum and minimum monthly temperatures are 31 and 23°C for January and 26°C and 9°C for July. Monthly rainfall, date of the seasonal break of the dry season and annual rainfall deciles (Table 1) show that about 75% of rain falls over the 4 months, December–March. A seasonal break was defined as falls of 25 mm or more over several days during the dry season. The 1970s were mostly average to good years for rainfall whilst the 1980s tended to be poor years.

The topography is gently undulating with a mean altitude of 60 m. The soils have been mapped by Thompson and Cannon (1983). Phosphorus levels range from very low (<10 μg/g) to low (10 to 20 μg/g). Values for total nitrogen were very low to low (<0.05 to 0.15% oven-dry weight) and for organic carbon, very low to low (<0.5 to 1.5% oven-dry weight).

The natural pasture species include: *Heteropogon contortus* (black spear grass); tropical tall grasses [*H. triticeus* (giant spear grass), *Coelorachis rottboelloides* (cane grass), *Sorghum* spp., *Ophiuros exaltatus* (cane grass), *Arundinella nepalensis*]; medium grasses [*Alloteropsis semialata* (cockatoo grass), *Themeda triandra* (kangaroo grass), *Eulalia fulva* (brown top grass), *Panicum simile*, *P. effusum*, *Paspalum* spp., *Bothriochloa bladhii* (forest blue grass), *Dichanthium* spp. (blue grass), *Chrysopogon fallax* (golden beard grass), *B. pertusa* (Indian blue grass) and *Eremochloa bimaculata* (poverty grass)]; pioneer grasses [*Aristida* spp. (wire grass), *Eragrostis* spp. (love grass) and *Rhynchelytrum repens* (red Natal grass)]; legumes [*Stylosanthes humilis* (Townsville stylo), *S. hamata* cv. Verano, *Galactia* spp., and *Vigna* spp]. The *Stylosanthes* spp. are introduced, the other legumes are native. Similar pastures are found on 14 million ha of dry tropical areas of northern Queensland.

R. L. Clem and S. R. McLennan (pers. comm.) estimated from botanical composition studies of a typical native pasture area in October 1979, that *H. contortus*, tropical tall grasses, medium grasses and pioneer grasses constituted 42%, 16%, 38% and 3%, respectively, of the pasture. Pastures are generally not burnt as a management practice on the property, although occasional fires do occur.

The trees form an open savannah woodland. Principal

Table 1. Monthly rainfall (mm), date of seasonal break and annual rainfall deciles for Swan's Lagoon

Year	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total	Date of seasonal break	Decile
1971–72	31	16	0	7	77	333	533	256	157	12	4	18	1444	20.xi.71	9
1972–73	0	0	1	0	37	9	161	195	131	51	9	15	609	15.i.73	3
1973–74	10	4	61	62	243	373	804	228	103	26	37	0	1951	14.ix.73	10
1974–75	0	64	8	10	129	115	298	48	126	29	23	1	851	30.viii.74	6
1975–76	0	13	44	125	64	320	159	253	212	0	0	6	1195	8.ix.75	8
1976–77	0	0	0	110	145	329	53	369	100	57	128	0	1290	22.x.76	9
1977–78	0	0	0	0	41	83	402	164	6	47	49	12	804	24.xi.77	5
1978–79	23	29	26	1	53	194	191	201	298	34	7	21	1078	14.xi.78	7
1979–80	41	0	0	9	0	97	376	214	52	29	62	0	880	27.xii.79	6
1980–81	1	8	0	13	21	42	335	335	87	26	105	23	996	29.xii.80	7
1981–82	6	10	0	9	205	67	120	53	59	22	15	0	566	17.xi.81	3
1982–83	0	0	0	0	0	21	166	15	85	146	225	36	694	16.i.83	4
1983–84	0	1	1	8	154	31	159	18	63	0	0	1	436	23.xi.83	2
1984–85	55	0	12	61	29	67	71	104	145	47	27	39	656	7.x.84	3
1985–86	69	0	0	100	42	50	109	199	2	27	21	3	621	20.x.85	3
24-year mean	17	10	8	32	73	125	208	177	114	45	40	17	868		

species are *Eucalyptus alba* (poplar gum), *E. papuana* (sugar gum), *E. tesellaris* (Moreton Bay ash) and *E. dichromophloia* (bloodwood), with patches of *Melaleuca* spp. (tea-tree), *Grevillea striata* (beefwood), *Planchonia careya* (cockatoo apple), *Petalostigma pubescens* (quinine berry) and *Eremophila mitchellii* (sandlewood).

Development of the herds

The program commenced in 1967 to develop herds which were 1/2 and 3/4 Brahman and to develop a high grade Sahiwal herd in order to examine productivity indices in these crosses. The objectives were expanded in 1978 to develop 5 herds: 1/2 Brahman, 3/4 Brahman, 1/2 Sahiwal, 3/4 Sahiwal and high grade Sahiwal.

The development of the 5 herds is outlined in Fig. 1. The foundation cows were mixed age Shorthorns either purchased in 1962 or subsequently bred on Swan's Lagoon. Commencing in 1967, cows were inseminated with Brahman or Sahiwal semen. Insemination ceased after 1971 and natural matings under paddock conditions were then used. Purchases of Brahman and Sahiwal cross cattle were also made between 1962 and 1979. As the *B. taurus* component of these purchased cattle varied, the terms 1/2 Brahman (1/2 B), 3/4 Brahman (3/4 B), 1/2 Sahiwal (1/2 Sah) and 3/4 Sahiwal (3/4 Sah) are approximate descriptions of the crosses. High grade Sahiwal (HG Sah) refers to animals of 7/8 Sahiwal or greater.

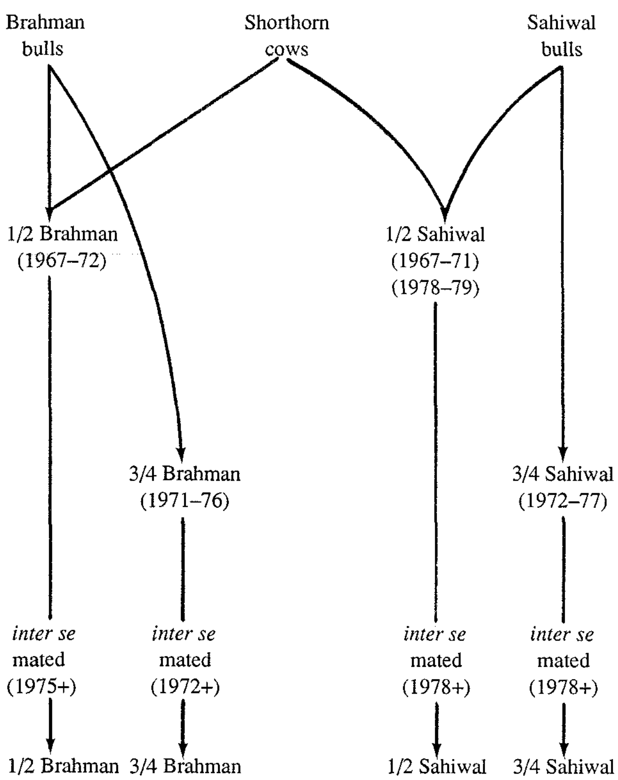

Fig. 1. Schematic outline of the development of Swan's Lagoon herds. Values in parentheses indicate years of mating to produce progeny.

The first filial generation (F_1) consisted of the progeny resulting from crossing either Brahman bulls and *B. taurus* cows (F_1 1/2 B) or Sahiwal bulls and *B. taurus* cows (F_1 1/2 Sah) and the first backcross generation was derived from crossing the F_1 1/2 B or F_1 1/2 Sah cows to their respective sire breeds (i.e. backcross 3/4 B or backcross 3/4 Sah). Subsequent *inter se* matings of F_1 and backcrosses gave F_2 and subsequent generations.

Management of herds

The general policy was the maintenance of similar management practices for each crossbreed group. Except for the mating periods, all cows and offspring were run together to minimise paddock differences. The herds were run predominantly on native pasture with stocking rates of 1 breeder to 4–6 ha.

Mating procedures. Each year mating commenced in mid–late January. The mating period was for up to 162 days in 1972 but was then reduced to approximately 120 days (1973 and 1974). In subsequent years, the mating period ranged from 86 to 100 days. Depending on years and crosses, matings were either in multiple sire groups at a ratio of 4–6 bulls/100 cows or in single sire groups (commencing in 1981) at 1 bull/16–40 cows. By 1982, all cows were mated in single sire groups in 28 families; 6 1/2 B, 6 3/4 B, 6 1/2 Sah, 6 3/4 Sah and 4 HG Sah.

Cows were allocated to multiple sire mating groups according to crossbreed group. For single sire mating groups, allocation within crossbreed group depended on lactation status, non-lactating cows being allocated on liveweight within age groups and lactating cows on calving date within age groups.

Unfasted cow liveweights were recorded at the beginning and end of mating and during the dry season (October). However, these data were incomplete in earlier years of the study.

Bull selection. All bulls were examined premating for physical soundness, and a detailed examination of genitalia and semen was carried out. Only reproductively sound bulls were used. Initially, bulls were selected on pedigree information to restrict the degree of inbreeding, but as more progeny became available, replacement bulls for *inter se* joinings of the 1/2 and 3/4 herds were selected on growth rate and, to a lesser degree, tick resistance. The B and HG Sah bulls varied from 2 to 9 years of age whilst 1/2 B, 3/4 B, 1/2 Sah and 3/4 Sah bulls ranged from 2 to 4 years.

Maintenance of herd numbers and culling procedures. During the experimental period, herd numbers were built up with all female progeny being initially mated at 2 to 2.3 years of age. Overall property

Table 2. Effect of year and crossbreed group on pregnancy rate (PR, %), weaning rate (WR, %) and calving date (CD days) for F_1 1/2 Brahman (B) and F_1 1/2 Sahiwal (Sah) cows, and for first backcross 3/4 Brahman and first backcross 3/4 Sahiwal cows

Within columns and factors, means followed by a letter in common do not differ significantly at $P = 0.05$

	2-year-old heifers						3-year-old lactating cows						4-year-old lactating cows						5–9-year-old lactating cows					
	n	PR	*n*	WR	*n*	CD	*n*	PR	*n*	WR	*n*	CD	*n*	PR	*n*	WR	*n*	CD	*n*	PR	*n*	WR	*n*	CD
F_1 1/2 Brahman and 1/2 Sahiwal cows																								
Mean	262	92	261	81	218	327	229	73	229	64	159	335	166	89	156	78	134	323	498	84	474	71	375	315
s.d.		27.2		39.0		29.5		40.4		43.8		20.4		32.1		40.8		20.7		36.7		45.2		18.7
Year of mating																								
1972	83	94	82	83	72	328a																		
1973	93	88	93	76	72	340b	68	57a	68	40a	30	353a												
1974	86	94	86	84	74	313c	80	77b	80	74b	62	340b	32	95	32	84	30	341a						
1975							81	84b	81	77b	67	310c	66	89	63	80	56	319b	57	92ab	51	78a	45	321a
1976													68	82	61	72	48	309c	110	91a	98	74a	83	309b
1977																			134	88ab	131	76a	111	312b
1978																			116	68c	116	60b	75	322a
1979																			81	81b	78	69ab	61	309b
Crossbreed group																								
1/2 B	153	94	152	84	132	332a	129	64a	129	59	82	335	92	94a	85	87a	77	326	303	83	284	74	223	313a
1/2 Sah	109	90	109	78	86	322b	100	82b	100	68	77	334	74	83b	71	70b	57	320	195	85	190	68	152	317b
First backcross 3/4 Brahman and 3/4 Sahiwal cows																								
Mean	334	88	326	75	266	310	245	46	244	39	113	318	82	65	79	54	36	316	398	59	385	48	196	322
s.d.		34.9		43.8		20.6		48.4		48.5		18.7		43.0		46.5		18.8		43.4		46.2		17.3
Year of mating																								
1975	54	93a	52	86a	47	311																		
1976	67	94a	67	83ab	63	305	47	60	47	48	27	317												
1977	123	76b	121	63c	87	309	57	48	57	43	29	315	22	57	22	54								
1978	53	83ab	52	67bc	39	313	77	54	77	47	37	318	24	79	24	62	18	323a	43	54ab	43	48abc		
1979	37	95a	34	77ac	30	311	35	38	34	33	12	312	36	58	33	48	18	309b	72	81c	62	74a	45	311a
1980							29	29	29	23	8	326							95	52a	93	43b	58	327b
1981																			66	30b	66	25c	20	325b
1982																			55	87c	55	68a	43	313a
1983																			67	49a	66	32bc	30	333b
Crossbreed group																								
3/4 B	215	88	210	77	171	310	159	41	159	36	71	317	60	80a	57	71a	27	320	265	68a	254	58a	133	318a
3/4 Sah	119	88	116	73	95	309	86	51	85	42	42	319	22	50b	22	38b	9	311	133	50b	131	39b	63	325b

stocking pressure dictated the retention of a maximum of 150 breeding females of each of the 4 crosses (1/2 B, 3/4 B, 1/2 Sah, 3/4 Sah) and 100 HG Sah breeding females during the dry season. Each year pregnancy diagnosis by rectal palpation was first performed in March-April, 2–3 months after the start of mating. Pregnancy diagnosis was repeated 2–6 times during the ensuing gestation. Cows were culled on the basis of poor reproductive performance, physical defects and poor temperament. Heifers and non-lactating cows that failed to conceive were culled, as was any cow that had 2 successive foetal or calf losses. In this way the effects of infertile and subfertile cows were removed from comparisons of crossbreeds. There were minor exceptions to this culling regime. In 1976 some lactating non-pregnant cows were culled because of excess numbers, whilst in 1983, after a drought year, some heifers which failed to conceive at the initial joining were retained. Most cows were culled for age by 10 years. Because of excess numbers, surplus 3/4 B cows were transferred to other locations commencing in 1979, and from 1981 onwards only cows ranging from 2 through to 7 years of age were mated in the 3/4 B herd.

Calf management. Commencing in September–October, pregnant cows were drafted into two 180 ha paddocks and checked 2–4 times weekly. After calving, cows and calves were moved to a small, centrally located yard where calves were ear tagged, weighed and identified with their dams, before being moved to an adjacent paddock. Weaning occurred from April to June (age range 5–7 months).

Dry season supplementation. Apart from 1976 and 1981 which were favourable years, NPN-based supplements were fed each dry season. From 1972 to 1975, supplements of urea and molasses were fed in drum rollers (Holroyd *et al.* 1977). From 1977 onwards, dry lick supplements of urea, salt, ammonium sulphate and molasses were used (Holroyd *et al.* 1983).

Cows in poor condition were segregated for survival feeding in 3 years of the study. In 1972, these segregated cows were fed a 'homebrew' mixture of nitrogen and energy (Burns 1971), whilst in 1979 and 1982, they were fed *ad libitum* a 4–6% urea–molasses mixture in open troughs.

Disease status and control. Cattle on the property were free of brucellosis and trichomoniasis and were vaccinated against campylobacteriosis and leptospirosis. The cattle tick (*Boophilus microplus*) and the buffalo fly (*Haematobia irritans exigua*) were the major ectoparasites, and the tick borne diseases, babesiosis and anaplasmosis were endemic. Emphasis on tick control was modified over the experimental period from a regime of dipping 4–6 times per year to one of dipping only pregnant cows once or twice at a 21-day interval in September–October prior to the calving season.

Statistical analyses

A number of data subsets were identified where there were adequate cell numbers to give meaningful comparisons. These were: F_1 1/2 Brahman *v.* F_1 1/2 Sahiwal (this paper); backcross 3/4 Brahman *v.* backcross 3/4 Sahiwal (this paper); F_2 *et seq.* 1/2 Brahman *v.* F_2 *et seq.* 1/2 Sahiwal *v.* F_2 *et seq.* 3/4 Brahman *v.* F_2 *et seq.* 3/4 Sahiwal (subsequent paper).

Fertility and liveweight data were analysed by the least squares method for unequal subclass numbers (Harvey 1960), using a model with year of mating (Y) and crossbreed group (G) as factors. Non-lactating cows aged 3 years and older were not included in analyses of fertility traits, start of mating weight or average daily gain over mating period. Analyses of dry season (October) weight for cows aged 3 years and older included lactation status as an additional factor, since both previously lactating and non-lactating cows were considered. Dry season weight was adjusted for stage of gestation according to the method of Silvey and Haydock (1978). Calving date was measured as days from start of mating to calving. Two factor interactions were tested individually using a stepwise procedure progressively eliminating non-significant (P>0.05) interactions.

Maiden heifers (2 years of age) were analysed as a separate group. Preliminary analysis of lactating cows aged 3–9 years determined the age groupings to be 3, 4 and 5–9 (mature) years. Cows older than 9 years were not included in the analysis as there were very few of them.

Unless otherwise stated, significant differences were at P = 0.05. Main effect means are given in the tables as indicators of the major, overall differences. Where there was a G x Y interaction, modifications to the main effect trends are indicated in the text and discussed as appropriate.

Results

F_1 1/2 Brahman v. *F_1 1/2 Sahiwal*

Pregnancy rates. Main effects showed no significant difference between 1/2 B and 1/2 Sah in 2-year-old heifers (Table 2). However, a significant G x Y interaction occurred, where in 1972 and 1973, 1/2 B had significantly higher pregnancy rates than 1/2 Sah while the reverse occurred in 1974. With lactating cows, pregnancy rates were lowest in 3-year-olds and highest in 4-year-olds, with 5–9-year-olds being intermediate (Table 2). Year effects were significant for 3- and 5–9-year-old cows. In 4-year-old cows, 1/2 B had significantly higher pregnancy rates than 1/2 Sah, but there were no differences in 5–9-year-old cows. With 3-year-olds, there was a G x Y interaction, with 1/2 B recording significantly lower pregnancy rates than 1/2 Sah in 1973 (30 *v.* 84%) but similar values in 1974 and 1975.

Table 3. Effect of year and crossbreed group on liveweight (kg) at start of mating (SOM), average daily gain (ADG, kg/day) over mating period and dry season liveweight (DS, kg) in F_1 1/2 Brahman (B) and F_1 1/2 Sahiwal (Sah) cows, and in first backcross 3/4 Brahman and first backcross 3/4 Sahiwal cows

Within columns and factors, means followed by a letter in common do not differ signficantly at $P = 0.05$

	2-year-old heifer						3-year-old lactating cows						4-year-old lactating cows						5–9-year-old lactating cows					
	n	SOM	*n*	ADG	*n*	DS	*n*	SOM	*n*	ADG	*n*	DS[A]	*n*	SOM	*n*	ADG	*n*	DS[A]	*n*	SOM	*n*	ADG	*n*	DS[A]
												F_1 1/2 Brahman and 1/2 Sahiwal												
Mean	261	302	165	0.47	227	349	221	357	147	0.07	150	394	80	413	76	0.06	134	404	409	414	372	0.23	415	403
s.d.		31.3		0.128		35.9		39.1		0.23		34.1		39.4		0.216		44.9		44.7		0.168		46.6
Year of mating																								
1972	83	330a	79	0.33a	82	359a																		
1973	92	287b			79	337b	68	341a			68	371a												
1974	86	288b	86	0.60b	66	350a	78	374b	78	0.03	82	418b	32	422	31	−0.02a	61	442a						
1975							75	354a	69	0.10			48	403	45	0.13b			49	454a	48	0.07a		
1976																	73	365b	35	431b			90	397ab
1977																			134	397c	133	0.07a	131	409ac
1978																			112	372d	112	0.50b	110	412c
1979																			79	415b	79	0.27c	84	395b
Crossbreed group																								
F_1 1/2 B	153	296a	95	0.58a	130	361a	125	361	83	0.01a	83	403a	44	424a	41	0.03	76	412	228	428a	226	0.21	243	415a
F_1 1/2 Sah	108	308b	70	0.36b	97	337b	96	353	64	0.12b	67	385b	36	401b	35	0.08	58	396	181	400b	146	0.25	172	391b
												First backcross 3/4 Brahman and 3/4 Sahiwal												
Mean	333	299	263	0.58	262	327	232	319	188	0.32	178	320	80	337	80	0.31	171	377	388	351	387	0.60	378	403
s.d.		32.1		0.124		37.3		37.6		0.161		40.7		42.3		0.165		42.9		42.6		0.239		46.0
Year of mating																								
1975	53	283ab	50	0.67a	46	334a																		
1976	67	310c			62	292b	43	343a			37	293a												
1977	123	291a	123	0.51b	86	330a	57	326b	56	0.15a	32	339b	22	337ab	22	0.19a	28	389a						
1978	53	274b	53	0.83c	38	352c	72	312c	72	0.42b	74	338b	24	320a	24	0.48b	50	392a	39	348a	39	0.52a	45	397a
1979	37	340d	37	0.31d	30	325a	34	334ab	34	0.12a	35	312a	34	353b	34	0.24a	70	377a	71	395b	71	0.21b	73	383a
1980							26	282d	26	0.58c							23	352b	93	333a	93	0.63a	78	366b
1981																			65	324ac	65	0.66a		
1982																			55	400b	55	0.31c	102	387a
1983																			65	309c	64	1.24d	80	482c
Crossbreed group																								
3/4 B	214	303	165	0.64a	169	332a	150	330a	118	0.42a	124	331a	60	353a	60	0.42a	127	390a	257	367a	257	0.72a	225	426a
3/4 Sah	119	296	98	0.52b	93	321b	82	308b	70	0.21b	54	310b	20	321b	20	0.19b	44	365b	131	335b	130	0.48b	153	380b

[A] Dry season liveweight includes previously lactating and non-lactating cows.

Weaning rates. A significant G x Y interaction occurred in 2-year-old heifers, with significantly higher weaning rates in 1/2 B than in 1/2 Sah in 1972 and 1973 but not in 1974. In lactating cows, a similar trend occurred as with pregnancy rates, with weaning rates being highest in 4-year-olds, intermediate in 5–9-year-olds and lowest in 3-year-olds (Table 2). Again, year effects were significant for 3- and 5–9-year-olds. The 1/2 B cows had significantly higher weaning rates than 1/2 Sah as 4-year-olds, but there was no difference in 5–9-year-olds. However, a significant G x Y interaction occurred in 3-year-olds, with 1/2 B having a significantly lower weaning rate in 1973 (22 *v.* 58%) but not in 1974 and 1975.

Calving date. A significant G x Y interaction was recorded for 2-year-old heifers, with 1/2 B calving later in 1972 and earlier in 1973 than 1/2 Sah, and at a comparable time to 1/2 Sah in 1974. In lactating cows, calving date decreased with cow age. Significant year effects occurred in all age groups. Significant cross effects were recorded only in 5–9-year-old cows, with 1/2 B calving earlier than 1/2 Sah (313 *v.* 317 days).

Liveweight at start of mating. Main effects showed that 1/2 Sah were heavier than 1/2 B in 2-year-old heifers (Table 3). However, there was a significant G x Y interaction, with 1/2 Sah being significantly heavier than 1/2 B at mating in 1972, as a consequence of being mated 51 days later, but of similar weight in 1973 and 1974. In lactating cows, significant year effects occurred in 3- and 5–9-year-olds but not in 4-year-olds. The 1/2 B cows were significantly heavier than 1/2 Sah as 4- and 5–9-year-olds but not as 3-year-olds.

Average daily gain over mating period. More weight was gained by 1/2 B than 1/2 Sah in 2-year-old heifers (Table 3). However there was a G x Y interaction, attributable to the greater difference between the crosses in 1974 than in 1972. Three-year-old 1/2 Sah grew significantly faster than 1/2 B (Table 3). In 4-year-old cows, there were no such differences; however, a significant G x Y interaction occurred in 5–9-year-old cows, with 1/2 Sah gaining significantly more weight in 1975 and 1977, and less in 1979 than 1/2 B and having comparable weight to 1/2 B in 1978.

Dry season weight. Dry season weight increased with increasing cow age up to 4 years (Table 3). Significant year effects occurred across all age groups. 1/2 B were heavier than 1/2 Sah in all cow age groups, although the difference was not significant for 4-year-olds (Table 3). However, significant G x Y effects occurred in 2-year-old cows with 1/2 B being significantly heavier than 1/2 Sah in 1972 and 1973 but not in 1974.

Backcross 3/4 Brahman v. *backcross 3/4 Sahiwal*

Pregnancy rates. In 2-year-old heifers, although there were significant year effects, there were no significant differences between crosses (Table 2). With lactating cows, mean pregnancy rates were highest in 4-year-olds and lowest in 3-year-olds, with 5–9-year-old cows being intermediate (Table 2). Significant G x Y interactions occurred in all lactating cow age groups. In 3-year-old cows, cross effects were not significant in 4 of the 5 years, the exception being 1979, when 3/4 B were significantly lower than 3/4 Sah (11 *v.* 65%). Pregnancy rates for 4-year-old 3/4 B and 3/4 Sah cows were comparable in all years except 1977 when 3/4 B had considerably higher rates than 3/4 Sah (94 *v.* 20%). This interaction was attributed to impaired fertility of 1 bull. In 5–9-year-old-cows, 3/4 B had significantly higher pregnancy rates than 3/4 Sah in 1978 and 1980 but not in other years.

Weaning rates. There were no significant differences between 3/4 B and 3/4 Sah in weaning rates in 2-year-old heifers, although there were significant year effects (Table 2). With lactating cows, mean weaning rates of age groups parallelled the trend in pregnancy rates. There were no significant differences between crosses in 3-year-olds, but 4-year-old 3/4 B had significantly greater weaning rates than 3/4 Sah cows. However a significant G x Y interaction occurred in 5–9-year-olds, where weaning rates were significantly higher in 3/4 B than 3/4 Sah in 1980 and 1982 but not in other years.

Calving date. Mean calving date tended to increase with increasing cow age (Table 2). Year effects were significant only with the 4- and 5–9-year-old age groups. Differences between crosses were only apparent in the 5–9-year-old age group, when 3/4 B calved significantly earlier than 3/4 Sah in 2 of the 5 years.

Liveweight at start of mating. Although there were significant year effects of liveweight at mating there were no significant crossbreed effects in 2-year-old heifers (Table 3). For lactating cows, weight increased with cow age, with year differences occurring in all age groups. In both 3- and 4-year-olds, 3/4 B were significantly heavier than 3/4 Sah. A significant G x Y interaction occurred in 5–9-year-old cows, with 3/4 B being heavier than 3/4 Sah. These differences were significant in 4 of the 6 years.

Average daily gain over mating period. Within each age group, 3/4 B grew faster than 3/4 Sah and these differences were significant for 2- and 4-year-olds (Table 3). With 3- and 5–9-year-olds, there was a G x Y interaction due to the magnitude of difference between the crosses. With 3-year-olds, the differences were significant in 3 of the 4 years, and in 5–9-year-olds, 5 of the 6 years.

Dry season weight. Dry season cow weight increased with increasing cow age. In each age group there were significant year effects, and in all age groups, 3/4 B were significantly heavier than 3/4 Sah (Table 3).

Discussion

Clear-cut differences in fertility (pregnancy rate, weaning rate and calving date) between crosses were infrequent, and where differences did occur, they were often inconsistent due to cross x year interactions, many of which could not be explained. Mean values for pregnancy rates of lactating F_1 cows were 80.3% for 1/2 B, 83.8% for 1/2 Sah, 60.6% for 3/4 B and 50.4% for 3/4 Sah. In contrast, data from elsewhere would suggest that the Sahiwal has a genetic potential for higher fertility than other *B. indicus* breeds. Harricharan (1971) recorded higher calving rates and shorter calving intervals in Sahiwals than in Brahmans in Guyana. Similarly, Hardjosubroto (1984) reported higher calving rates in Sahiwal cross cows than in other *B. indicus* crosses, including the Brahman cross, in Indonesia. Under Australian conditions, this potential for higher fertility may be masked by the high level of inbreeding which has occurred in the Sahiwal (Herron 1978) because of the small number of original importations.

Year had the most pronounced effect on fertility levels, and the variation appeared to reflect the severity of nutritional stress during the previous dry season (Entwistle and Goddard 1984; Rudder *et al.* 1985), which influences liveweight and subsequent fertility. Similar marked year to year variations in reproductive performance have been reported from central Queensland (Rudder *et al.* 1976), North Queensland (Entwistle and Goddard 1984), Brazil (Tundisi *et al.* 1962) and Zambia (Thorpe *et al.* 1980) and reflect the variations which occur in both timing and distribution of rainfall in tropical and subtropical regions of the world.

Although they cannot be strictly compared, there was a trend to higher fertility levels in the F_1 cows than in the backcross cows, particularly among lactating cows. This may be related to differences in start of mating weight for each group. Differences in pregnancy rate were 4, 27, 24 and 25 percentage units in favour of F_1 cows for 2-year-olds and 3-, 4- and 5–9-year-old lactating cows, respectively. Corresponding differences in weight at the start of mating, in favour of F_1 cows, were 3, 38, 76 and 63 kg, respectively. Seasonal conditions may have contributed to the differences in weight and fertility between F_1 and backcross cows as low decile rainfall years occurred in the 1981–83 period. However, the results support the work of Rudder *et al.* (1976), who found lower reproductive rates in 3/4 Brahman backcross cows than in first generation 1/2 Brahman cows in central Queensland.

In northern Australian beef herds fertility is generally highest in heifers, lowest in young lactating cows and intermediate in mature lactating cows (McClure 1973; Holroyd 1977). A similar trend was evident in this study, with pregnancy rates of 2-year-old heifers in excess of 85% and a marked reduction in pregnancy rates of lactating 3-year-old cows (19 percentage units for F_1 and 42 percentage units for backcross). The depression in fertility in the latter group may reflect lower liveweights at mating (38 kg difference), as liveweights in this range (320 kg) have been associated with decreased fertility (Goddard *et al.* 1980) in *B. indicus* cross cows.

The trends in pregnancy rates over crossbreed groups and years also occurred in weaning rates. The percentage unit difference between pregnancy rate and weaning rate represents the amount of foetal and calf loss to weaning. Overall, the Sahiwal cross cows have higher foetal and calf losses as the mean differences between pregnancy rates and weaning rates are 10% and 12% for 2-year-old F_1 1/2 B and F_1 1/2 Sah, respectively; 8% and 15% for lactating F_1 1/2 B and F_1 1/2 Sah; 11% and 15% for 2-year-old backcross 3/4 B and backcross 3/4 Sah; and 8% and 10% for lactating backcross 3/4 B and backcross 3/4 Sah. The causes and prevalence of these losses have been documented (Holroyd 1987).

In both data sets, year had an extremely variable influence on liveweight and liveweight change of cows and this indicates the extent to which variations in seasonal conditions and, hence, nutritional conditions can influence cattle weights in the dry tropics of northern Australia. In central Queensland, Rudder *et al.* (1985) found that year had a larger and more consistent influence on cow mating liveweight than did genotype, and that this variation was partly explained by May–October (dry season) rainfall which was an indication of pasture productivity during the period. A similar pattern was observed here, in that higher mating weights tended to follow years when the seasonal break to the dry season occurred relatively early, or in years following substantial winter rainfall.

As a general rule, Brahman crosses were heavier throughout than their Sahiwal counterparts, the exception being the start of mating weights for the first data set, where in 2 of the 3 years, F_1 1/2 Sah were heavier than F_1 1/2 B. This may be an aberration because of the later start of mating weights recorded in 1972. In lactating cows, start of mating weights were, on average, 21 kg more in 1/2 B than in 1/2 Sah and were 29 kg more in 3/4 B than in 3/4 Sah. Similar magnitudes of difference were found in dry season weights between Brahman and Sahiwal crosses.

Acknowledgments

We wish to thank the many staff of Beef Cattle Husbandry, Technical Services and Biometry Branches of the Queensland Department of Primary Industries who contributed to this project. Financial support from the Australian Meat Research Committee as projects DAQ 10 and DAQ 44 is gratefully acknowledged.

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Received 18 December 1989, accepted 23 July 1990