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# The performance of Brahman–Shorthorn and Sahiwal–Shorthorn beef cattle in the dry tropics of northern Queensland
# 2. Reproductive rates and liveweights of $F_2$ *et seq.* females

*R. G. Holroyd*[A], *T. A. James*[B], *V. J. Doogan*[C], *G. Fordyce*[D], *R. Tyler*[E] *and P. K. O'Rourke*[C]

[A] Queensland Department of Primary Industries, Box 6014, Rockhampton Mail Centre, Qld 4702, Australia.
[B] Queensland Department of Primary Industries, M.S. 586, Theodore, Qld 4719, Australia.
[C] Queensland Department of Primary Industries, G.P.O. Box 46, Brisbane, Qld 4001, Australia.
[D] Queensland Department of Primary Industries, Swan's Lagoon Beef Cattle Research Station, Millaroo, Qld 4807, Australia.
[E] Queensland Department of Primary Industries, P.O. Box 48, Gayndah, Qld 4625, Australia.

**Summary.** The female reproductive rates and liveweight performance of $F_2$ *et seq.* generations of 1/2 Brahman (1/2 B), 1/2 Sahiwal (1/2 Sah), 3/4 Brahman (3/4 B) and 3/4 Sahiwal (3/4 Sah) were evaluated in the dry tropics of northern Queensland from 1978 to 1986. The balance of the breed composition was predominantly Shorthorn. A preliminary comparative analysis of $F_2$ and $F_3$ data showed no differences between the filial generations and data were subsequently pooled.

Crossbreed differences between groups had a small effect on pregnancy rate and were not a major determinant of fertility compared with age and year effects. Any crossbreed differences were counteracted by inconsistent cross x year effects. For mature cows, 3/4 Sah had significantly ($P$<0.05) lower weaning rates than other crosses. The percentage unit difference between pregnancy rate and weaning rate was higher in Sahiwal cross than Brahman cross cows (19 *v.* 9%). In lactating cows, calving dates were an average 10 days later in 3/4 than 1/2 *Bos indicus* cows.

Generally Brahman crosses were heavier than Sahiwal crosses. In the dry season, Brahman crosses were 16, 30, 36 and 43 kg heavier than Sahiwal crosses for 2-year-old heifers and 3-, 4- and 5–9-year-old cows, respectively. There was little difference between 1/2 and 3/4 *B. indicus*, except in mature cows, where 1/2 Sah were 27 kg heavier ($P$<0.05) than 3/4 Sah at start of mating.

There were pronounced year effects on all of the reproductive and growth parameters of both heifers and lactating cows. Pregnancy rate and mating liveweight were negatively correlated with date of seasonal break of the dry season ($r$ = −0.71 to −0.88, $r$ = −0.84 to −0.98, respectively). Cross x year interactions for pregnancy rate, calving date and mating liveweight were attributed to factors other than the type of year.

## Introduction

The introduction of *Bos indicus* cattle into the tropical areas of northern Australia has been through the mating of Brahman bulls and, to a lesser extent, Sahiwal and Africander bulls to *B. taurus* cow herds. However, the optimum level of *B. indicus* is yet to be quantified. After the initial cross, a number of options exist. Rudder (1978) proposed that the *inter se* mating of $F_1$ and sequential generations to stabilise the cross was the most practical approach in the extensive beef herds of northern Australia. The other options of continuous production of $F_1$ cattle, or the use of rotational crossbreeding to capitalise on heterosis, are less practical, either because of the difficulty of obtaining sufficient numbers of the parental breeds, particularly *B. taurus*, or because of the practical difficulties of maintaining several distinct cow herds (Rudder 1978; Frisch and Vercoe 1982). However, research data indicate that *inter se* mating lowers the fertility in $F_2$ and subsequent generations of 1/2 Brahman cross cattle (Seebeck 1973). Cattle producers in Queensland have cited poor fertility as one disadvantage of *B. indicus* cattle (Elder *et al.* 1979).

A previous paper (Holroyd *et al.* 1990) described the reproductive and liveweight performance of $F_1$ 1/2 Brahman and $F_1$ 1/2 Sahiwal cows and the first backcross of 3/4 Brahman and 3/4 Sahiwal. Clear cut effects of different crosses on fertility were infrequent, and where differences did occur, they were inconsistent due to cross x year interactions. However, Brahman cross cows were generally heavier than their Sahiwal counterparts. This paper compares the reproductive and liveweight performances of the $F_2$ *et seq.* generations of these same 4 crosses: 1/2 Brahman (1/2 B), 1/2 Sahiwal (1/2 Sah), 3/4 Brahman (3/4 B), 3/4 Sahiwal (3/4 Sah).

## Materials and methods

*Location, climate and vegetation*

The experiment was conducted at the Swan's Lagoon Beef Cattle Research Station (20°05'S., 147°14'E.) in the subcoastal spear grass region of northern Queensland. The climate is warm and subhumid, having a distinct hot, wet, summer period (wet season) and a warm, dry, winter period (dry season). A more complete description of climate, soils and vegetation is given by Holroyd *et al.* (1990).

*Animals and their management*

In 1967, a program was commenced to develop 1/2 and 3/4 Brahman herds and a highgrade Sahiwal herd, in order to examine productivity indices in these crosses (see Holroyd *et al.* 1990). The objectives were expanded in 1978 to the development of 5 herds: 1/2 B, 1/2 Sah, 3/4 B, 3/4 Sah, high grade Sahiwal. Two-year-old 1/2 B and 3/4 B heifers were first available for mating in 1978, 1/2 Sah in 1979 and 3/4 Sah in 1981. Numbers of 3/4 Sah heifers were lower than for the other groups in all years.

The herds were run predominantly on native pasture with stocking rates of 1 adult equivalent to 4–6 ha. Except during the mating periods, all cows and offspring were run together to minimise paddock differences. The same management practices were applied to all cows.

The management cycle included mating from January to April, branding in March–April and weaning of calves in April–June (age range of 5–7 months). Unfasted liveweights were taken at the start and end of mating and several times during the dry season. Each year, the initial pregnancy diagnosis was in March–April, 2–3 months after the start of mating. Pregnancy diagnosis was repeated 2–6 times during the ensuing gestation.

Mating ranged from 86 to 100 days. Cows were initially multiple sire mated at a ratio of 4–6 bulls/100 cows, but there was a gradual change to single sire groups, so that by 1982 all cows were mated in single sire groups of 6 sires per crossbreed group with up to 40 cows per mating paddock. Allocation of cows to single sire mating groups depended on lactation status, non-lactating cows being allocated on liveweight within age groups and lactating cows on calving date within age groups.

Each year cows were culled on the basis of poor reproductive performance, physical defects and poor temperament.

*Statistical analyses*

An initial analysis compared the reproductive rates and liveweights, within crosses, of $F_2$ and $F_3$ cows. As there were no differences, these filial generations were pooled and called $F_2$ *et seq.* generation.

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 interactions that were not significant ($P$>0.05).

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, 3, 4 and 5–9 (mature) years old. There were very few cows older than 9 years, and so they were not included in the analyses.

Unless otherwise stated, significant differences were at the $P$=0.05 level.

## Results

*Pregnancy rates*

In 2-year-old heifers, there were large variations between years, with mean pregnancy rates ranging from 96% in 1979 to 29% in 1981 (Table 1). Across all years, Sahiwal cross heifers had higher pregnancy rates than Brahman cross heifers, and within each, 1/2 *B. indicus* were similar to 3/4 *B. indicus* (Table 1). However, there were significant G x Y effects. In 1980, the pregnancy rate in 1/2 Sah was significantly higher than in 1/2 B or 3/4 B. In 1981 and 1986, the pregnancy rate was significantly higher in 1/2 Sah than 1/2 B but not significantly different from 3/4 B or 3/4 Sah. There were no significant differences in other years.

Mean pregnancy rates of lactating cows were highest in 5–9-year-olds, with the other 2 age groups similar (Table 1). There were large variations in pregnancy rates of lactating cows between years and age groups: 3-year-olds, 8% in 1981 to 71% in 1982; 4-year-olds, 10% in 1980 to 69% in 1986; 5–9-year-olds, 15% in 1981 to 91% in 1982 (Table 1).

There were no significant differences between crossbreed groups for pregnancy rates of lactating cows. However, significant G x Y effects occurred in both 3- and 4-year-olds. With 3-year-olds in 1979, pregnancy rate in 1/2 Sah was significantly higher than in 1/2 B, which in turn was significantly higher than 3/4 B (100%

**Table 1. Effect of year and crossbreed group on pregnancy rate (PR, %), weaning rate (WR, %) and calving date (CD, days) for 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 |
| Mean | 1014 | 76 | 996 | 61 | 684 | 315 | 515 | 42 | 495 | 34 | 182 | 321 | 188 | 39 | 186 | 37 | 73 | 326 | 582 | 69 | 534 | 45 | 373 | 323 |
| s.d. | | 37.4 | | 44.0 | | 20.6 | | 43.3 | | 43.5 | | 18.8 | | 43.6 | | 43.9 | | 19.6 | | 36.0 | | 44.1 | | 19.1 |
| *Year of mating* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1978 | 69 | 81ac | 69 | 73a | 53 | 310ab | | | | | | | | | | | | | | | | | | |
| 1979 | 98 | 96b | 91 | 71a | 77 | 306a | 58 | 54a | 57 | 48a | 22 | 318ab | | | | | | | | | | | | |
| 1980 | 108 | 58d | 105 | 44b | 49 | 322cd | 64 | 12b | 64 | 9b | 8 | 322abc | 24 | 10a | 24 | 12a | | | | | | | | |
| 1981 | 135 | 29e | 135 | 20c | 29 | 332d | 40 | 8b | 40 | 7b | | | 18 | 16ab | 18 | 17a | | | 30 | 15a | 30 | 0a | | |
| 1982 | 103 | 86ab | 101 | 68a | 85 | 313b | 18 | 71a | 17 | 59a | | | | | | | | | 60 | 91b | 55 | 71b | 50 | 316a |
| 1983 | 96 | 69cd | 96 | 52b | 57 | 314bc | 73 | 18b | 73 | 18b | 12 | 332c | 66 | 35b | 66 | 27a | 19 | 332a | 101 | 52c | 101 | 28c | 46 | 340b |
| 1984 | 104 | 85a | 102 | 69a | 84 | 314bc | 48 | 49a | 47 | 37a | 23 | 319ac | | | | | | | 67 | 81b | 58 | 47d | 42 | 319a |
| 1985 | 208 | 90ab | 207 | 75a | 174 | 314b | 70 | 67a | 68 | 52a | 49 | 327c | 42 | 65c | 42 | 63b | 29 | 331a | 164 | 88b | 145 | 63b | 121 | 328c |
| 1986 | 93 | 86ab | 90 | 77a | 76 | 309ab | 144 | 59a | 129 | 45a | 68 | 310b | 38 | 69c | 36 | 66b | 25 | 315b | 160 | 85b | 145 | 62b | 114 | 315a |
| *Crossbreed group* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/2 B | 294 | 70a | 292 | 58 | 187 | 312a | 145 | 38 | 144 | 32 | 47 | 317a | 52 | 41 | 52 | 38 | 15 | 321 | 223 | 72 | 209 | 61a | 140 | 320 |
| 1/2 Sah | 222 | 79b | 218 | 64 | 155 | 314a | 119 | 48 | 111 | 43 | 43 | 316a | 52 | 53 | 50 | 47 | 23 | 320 | 134 | 74 | 117 | 55a | 90 | 319 |
| 3/4 B | 386 | 72ac | 376 | 63 | 258 | 319b | 201 | 40 | 200 | 32 | 80 | 325b | 75 | 40 | 75 | 37 | 32 | 328 | 207 | 69 | 195 | 57a | 134 | 324 |
| 3/4 Sah | 112 | 81bc | 110 | 60 | 84 | 314ab | 50 | 44 | 40 | 31 | 12 | 326ab | 9 | 22 | 9 | 25 | 3 | 337 | 18 | 60 | 13 | 8b | 9 | 331 |

**Table 2. Effect of year and crossbreed group on liveweight (kg) at start of mating (SOM), average daily gain (ADG, kg/day) over mating and dry season weight (DS, kg) for 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* | 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] |
| Mean | 1012 | 276 | 1009 | 0.76 | 687 | 306 | 500 | 307 | 498 | 0.40 | 488 | 358 | 184 | 332 | 184 | 0.56 | 297 | 393 | 570 | 374 | 570 | 0.48 | 700 | 421 |
| s.d. | | 28.6 | | 0.157 | | 33.6 | | 32.1 | | 0.193 | | 38.3 | | 38.2 | | 0.256 | | 39.5 | | 40.0 | | 0.271 | | 42.4 |
| *Year of mating* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1978 | 69 | 252a | 68 | 0.83a | 54 | 291a | | | | | | | | | | | | | | | | | | |
| 1979 | 98 | 340b | 98 | 0.35b | 87 | 298b | 56 | 330a | 56 | 0.26a | 62 | 326a | | | | | | | | | | | | |
| 1980 | 107 | 227c | 106 | 1.00c | 52 | 270b | 62 | 284b | 62 | 0.59b | 24 | 322ab | 23 | 313a | 23 | 0.65a | | | | | | | | |
| 1981 | 135 | 213d | 135 | 0.74d | | | 38 | 253c | 37 | 0.51c | | | 18 | 312a | 18 | 0.57a | | | 30 | 310a | 30 | 0.51a | | |
| 1982 | 103 | 277e | 103 | 0.80a | 88 | 275b | 17 | 299b | 17 | 0.35a | 100 | 309b | | | | | 36 | 337a | 60 | 380b | 60 | 0.55a | 90 | 368a |
| 1983 | 96 | 224c | 95 | 1.21e | 64 | 343c | 71 | 238d | 71 | 1.05d | 79 | 414c | 65 | 275b | 65 | 1.10b | 82 | 431b | 100 | 290c | 100 | 1.29b | 117 | 465b |
| 1984 | 104 | 315f | 104 | 0.65f | 86 | 323d | 47 | 348e | 46 | 0.10e | 80 | 370d | | | | | 70 | 401c | 65 | 434d | 65 | 0.13c | 144 | 425c |
| 1985 | 207 | 329g | 207 | 0.61g | 181 | 339c | 69 | 349e | 69 | 0.26a | 69 | 400e | 42 | 380c | 42 | 0.32c | 65 | 401c | 164 | 414e | 164 | 0.32d | 196 | 443d |
| 1986 | 93 | 305h | 93 | 0.69f | 75 | 312e | 140 | 357e | 140 | 0.05e | 74 | 369d | 36 | 380c | 36 | 0.17d | 44 | 395c | 151 | 418e | 151 | 0.08c | 153 | 404e |
| *Crossbreed group* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/2 B | 293 | 282a | 292 | 0.79a | 199 | 315a | 141 | 323a | 141 | 0.42 | 135 | 371a | 51 | 345a | 51 | 0.54 | 80 | 407a | 220 | 397a | 220 | 0.56a | 289 | 447a |
| 1/2 Sah | 222 | 274b | 221 | 0.76ab | 155 | 298b | 117 | 307b | 117 | 0.41 | 105 | 348b | 51 | 326b | 51 | 0.54 | 64 | 377b | 132 | 367b | 132 | 0.45b | 151 | 403b |
| 3/4 B | 385 | 279a | 384 | 0.78a | 250 | 314a | 193 | 316a | 191 | 0.40 | 199 | 377a | 73 | 345a | 73 | 0.59 | 125 | 414a | 201 | 394a | 201 | 0.48b | 247 | 443a |
| 3/4 Sah | 112 | 269b | 112 | 0.73b | 83 | 299b | 49 | 284c | 49 | 0.36 | 49 | 339b | 9 | 312b | 9 | 0.58 | 28 | 373b | 17 | 340c | 17 | 0.44ab | 13 | 392b |

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

*v.* 48% *v.* 14%), but there were no significant differences in other years. With 4-year-olds, there were inconsistent effects of crossbreed group, with significant differences occurring in 1983 and 1985.

*Weaning rates*

There were no significant differences between crossbreed groups in heifer weaning rates (Table 1). Year variations in weaning rates of heifers ranged from 20% in 1981 to 77% in 1986. There was a significant G x Y interaction. In 1979, weaning rate in 3/4 B was significantly higher than in 1/2 B, with 1/2 Sah being intermediate; in 1980, the weaning rate was significantly higher in 1/2 Sah than the other crosses; and in 1984, it was lower in 3/4 Sah than 1/2 B and 1/2 Sah but not 3/4 B. There were no differences in the other years.

The general means reflected an increasing level in weaning rates of lactating cows with age (Table 1). There was no significant difference between cross groups for 3- and 4-year-olds. In 5–9-year-olds, 3/4 Sah had significantly lower weaning rates than the other crosses (Table 1) but numbers of 3/4 Sah were low. Marked year variations were apparent in weaning rates in all age groups, for example, 5–9-year-olds ranged from 0% in 1981 to 71% in 1982. In 3-year-olds, there was a G x Y interaction which mirrored the trend of pregnancy rate.

*Calving date*

There was annual variation in calving date of heifers ranging from 306 days in 1979 to 332 days in 1981 (Table 1). The main effects showed that, for heifers, 3/4 B had significantly later calving dates than 1/2 B and 1/2 Sah but not 3/4 Sah (Table 1). However, there was a G x Y interaction; 3/4 B calved significantly later than other crosses in 1981; 1/2 Sah calved later than other crosses in 1982; 3/4 Sah calved significantly earlier than 1/2 B and 3/4 B in 1983 and significantly later than all other crosses in 1984.

In each of the 3 age groups of lactating cows there were significant year effects with later calving dates occurring in 1983, particularly in 5–9-year-old cows, than in other years (Table 1). Across age groups, there was a trend for later calving dates in 3/4 *B. indicus* crosses than in 1/2 *B. indicus* crosses. However, significant differences occurred only in 3-year-olds, where 3/4 B were significantly later than 1/2 B and 1/2 Sah, but not 3/4 Sah.

*Start of mating weight*

In heifers there were large year variations for start of mating weight ranging from 213 kg in 1981 to 340 kg in 1979 (Table 2). The main effects showed that the Brahman crosses were significantly heavier than the Sahiwal crosses. However, there was a G x Y interaction with significant differences occurring between crosses in every year except 1978. Apart from 1979 and 1980 when 1/2 B were significantly heavier than 3/4 B with 1/2 Sah intermediate, there was no consistent trend amongst the crosses for start of mating weight of heifers.

Lactating cow liveweight increased with age (Table 2). Within each age group, there were large variations in start of mating liveweight, with a range of 119 kg in 3-year-olds, 105 kg in 4-year-olds and 144 kg in 5–9-year-olds. In 1983 cows were lightest. Main effects showed that in each age group of lactating cows, Brahman crosses were significantly heavier than Sahiwal crosses (Table 2). There was no significant difference between 1/2 B and 3/4 B; however 1/2 Sah were heavier than 3/4 Sah, these differences being significant in 3-year-olds and 5–9-year-olds (Table 2). In 3-year-olds, there was a significant G x Y effect with significant differences occurring between crosses in every year except 1981. The trend between 1979 and 1981 was for 1/2 Sah to be either intermediate to or heavier than Brahman crosses, but in later years Sahiwal crosses were lighter than Brahman crosses.

*Average daily gain (ADG) over mating*

There were wide between year variations in all of the age classes, for example, gains by 3-year-olds ranged from 0.05 kg/day in 1986 to 1.05 kg/day in 1983. As a general rule, low ADG corresponded to years with high start of mating weights and vice versa (Table 2).

There was a significant G x Y effect in heifers, with significant differences occurring between crosses in years 1979–83, with no consistent trend. Main effects showed no significant differences between crosses for 3- and 4-year-old lactating cows but 5–9-year-old 1/2 B had significantly higher ADG than 3/4 B and 1/2 Sah but not 3/4 Sah (Table 2). Significant G x Y effects occurred in both 3- and 5–9-year-olds. For 3-year-olds, significant differences between crosses occurred in all years except 1981 and 1982, however, these differences were inconsistent. In 5–9-year-olds, 1/2 B gained more weight than 3/4 B in 1982, 1983 and 1986.

*Dry season weight*

The Brahman crosses were significantly heavier than the Sahiwal crosses in all age groups. However, across all age groups, there were no significant differences between 1/2 B and 3/4 B, or between 1/2 Sah and 3/4 Sah (Table 2). The mean differences between the Brahman and Sahiwal crosses were 16 kg as 2-year-olds; 29 kg as 3-year-olds; 35 kg as 4-year-olds and 43 kg as 5–9-year-olds. Within each age group, there were large year differences in dry season weight.

## Discussion

Effects of crossbreed groups on pregnancy rate were small and overall were not a major determinant of fertility compared with age and year effects. Any crossbreed group effects tended to be counteracted by

**Table 3. Percentage unit difference between pregnancy rate and weaning rate for the crossbreed groups of $F_1$, backcross and $F_2$ *et seq.* generations**

| | 2-year-old | 3-year-old | 4-year-old | 5–9-year-old |
|---|---|---|---|---|
| $F_1$[A] | | | | |
| 1/2 B | 10 | 5 | 7 | 9 |
| 1/2 Sah | 12 | 14 | 13 | 17 |
| Backcross[A] | | | | |
| 3/4 B | 11 | 5 | 9 | 10 |
| 3/4 Sah | 15 | 9 | 12 | 11 |
| $F_2$ *et seq.* | | | | |
| 1/2 B | 12 | 6 | 3 | 11 |
| 1/2 Sah | 15 | 5 | 6 | 19 |
| 3/4 B | 9 | 8 | 3 | 12 |
| 3/4 Sah | 21 | 13 | 0 | 52 |

[A] Data from Holroyd *et al.* (1990).

inconsistent G x Y effects. Similar trends were recorded in the $F_1$ generation, where there were no clear cut differences in pregnancy rates between crosses (Holroyd *et al.* 1990).

There was a trend in the lactating cows for 1/2 Sah to have the highest pregnancy rates. Mean values for pregnancy rates of lactating cows were 1/2 B 56%, 1/2 Sah 60%, 3/4 B 52% and 3/4 Sah 45%. However, there is a lack of critical comparative reproductive data for Sahiwal and Brahman crosses in Australia. Entwistle and Goddard (1983) reported that pregnancy rates in 3/4 Brahman cross and 3/4 Sahiwal x 3/4 Africander cross cows in North Queensland were similar. Harricharan (1971) reported higher calving rates and shorter calving intervals in Sahiwals than in Brahmans in Guyana. Also, Hardjosubroto (1984) reported higher calving rates in Sahiwal cross cows than in other *B. indicus* breeds, including the Brahman cross, in Indonesia. Other reports indicate that the Sahiwal has a better reproductive performance than other *B. indicus* breeds including the Boran (Trail and Gregory 1981) and the Red Sindhi (Johar and Taylor 1967).

The most noticeable difference between the crossbreed groups in reproductive parameters occurred in the percentage unit difference between pregnancy rate and weaning rate, with significantly lower weaning rates in the older 3/4 Sah than in other crosses. The difference between pregnancy rate and weaning rate represents the cumulative prenatal, perinatal and postnatal losses, with higher losses in Sahiwal crosses in all age groups (Table 3). A similar trend was recorded in the $F_1$ generation and backcross (Holroyd *et al.* 1990). Losses were similar for $F_1$, backcross and $F_2$ *et seq.* generations for each crossbreed group. Most of these losses were in the perinatal and the early postnatal period (within 14 days of birth). Bottle teats and maternal causes such as poor mothering and congenital abnormalities explained most of the loss in the Sahiwal crosses, and the prevalence and cause of this foetal and calf wastage have been described in detail by Holroyd (1987).

The differences in reproductive performance between 1/2 and 3/4 *B. indicus* were minor except in certain parameters. Calving dates for 3-year-old lactating 3/4 *B. indicus* tended to be later than for 1/2 *B. indicus*, whilst the older 3/4 Sah had lower pregnancy rates and, especially, weaning rates than 1/2 Sah. The absence of consistent fertility differences between 1/2 and 3/4 B is at variance with the observations of Barr (1971) of lower fertility in 3/4 Brahman herds than in 1/2 Brahman herds in North Queensland. In contrast, Holmes (1984) reported increasing calving rates with increasing *B. indicus* content of cattle in Papua New Guinea. There are no clear trends from data from the U.S.A. on the relative reproductive performances of cattle with different proportions of a common *B. indicus* breed. Cartwright *et al.* (1964) reported lower weaning rates in 3/4 Brahman than in 1/2 Brahman cows in Texas; conversely, Peacock *et al.* (1971) found comparable weaning rates in 1/2 and 3/4 Brahman cows in Florida.

The data did not allow a contemporary reproductive analysis to compare filial generations. A marked decline in fertility in the $F_2$ generation has been recorded in the filial comparisons within the 1/2 Brahman lines (Seebeck 1973). A comparison of the means for

**Table 4. Effects of filial generation on pregnancy rates (PR, %) and weight at start of mating (SOM, kg) for cows (pooled over crossbreed groups), and correlation with date of seasonal break**

| | 2-year-old heifers | | 3-year-old lactating cows | | 4-year-old lactating cows | | 5–9-year-old lactating cows | |
|---|---|---|---|---|---|---|---|---|
| | PR | SOM | PR | SOM | PR | SOM | PR | SOM |
| $F_1$[A] | 92 | 302 | 73 | 357 | 89 | 413 | 84 | 414 |
| Backcross[A] | 88 | 299 | 46 | 319 | 65 | 337 | 59 | 351 |
| $F_2$ *et seq.* | 76 | 276 | 42 | 307 | 39 | 332 | 69 | 374 |
| Correlation | −0.71* | −0.84** | −0.88** | −0.91** | −0.86 | −0.98** | −0.76 | −0.87** |

* $P$<0.05; ** $P$<0.01. [A] Data from Holroyd *et al.* (1990).

pregnancy rate of age groups across filial generations indicates a reduction in fertility in the $F_2$ *et seq.* generations for heifers and also a reduction in both the backcross and $F_2$ *et seq.* generations for lactating cows (Table 4). This appears to be related to differences in weight at start of mating (Table 4). Trends towards lowered pregnancy rates were much stronger from $F_1$ to $F_2$ *et seq.* for 1/2 B and 1/2 Sah (each 24% units) than from backcross to $F_2$ *et seq.* for 3/4 B (9% units) and 3/4 Sah (5% units). However, the $F_1$ data were collected in the 1970s, and rainfall tended to be higher in those years than the 1980s, when some of the backcross and most the $F_2$ *et seq.* data were collected.

Year was extremely influential on all of the reproductive and growth parameters measured in both heifers and lactating cows. Both pregnancy rate and liveweight at mating (pooled over crossbreed groups) were negatively correlated with date of the seasonal break of the previous dry season (Table 4). Anderson (1990) found that to achieve a reconception rate of at least 80% for mature cows in this environment, July–November (dry season) rainfall needed to be more than 150 mm, which occurred in approximately 1 in every 4 years.

General relationships of cow age and pregnancy rate reported from northern Australian beef herds indicate fertility is highest in heifers and mature cows and lowest in lactating first calf cows (McClure 1973; Holroyd 1977). A similar trend was found in this study, except that pregnancy rates of lactating 3- and 4-year-old cows were depressed considerably compared with the other 2 age groups.

As with the $F_1$ and backcross (Holroyd *et al.* 1990), the $F_2$ *et seq.* Brahman cross females tended to be heavier than Sahiwal cross females, although these differences were only consistently present in the dry season weight. The mean differences between Brahman and Sahiwal $F_2$ *et seq.* crosses in dry season weight were 16 kg as 2-year-olds, 30 kg as 3-year-olds, 36 kg as 4-year-olds and 43 kg as 5–9-year-olds. These data confirm suggestions by Daly (1981) that Sahiwals have lighter mature liveweights than Brahmans.

Relationships between liveweight and fertility have been presented by Anderson (1990) in more detailed studies of this data set to assess the predictive value of liveweight for subsequent fertility. In summary Anderson (1990) reported, after pooling data over crossbreed groups, that mature cows which calved early in the calving season, reared a calf to weaning in the previous year and weighed at least 350 kg in the mid dry season, after adjustment for stage of gestation, were most likely to reconceive in the subsequent mating. Further work by Anderson (1990) found that reconception rates increased linearly and then plateaued above 300 and 350 kg at start of mating for 3-year-old and mature $F_2$ *et seq.* 1/2 and 3/4 *B. indicus*, respectively, indicating that these are target liveweights for lactating cows in this environment. These positive relationships between liveweight and pregnancy rates are in general agreement with previous reports (Goddard *et al.* 1980; Rudder *et al.* 1985).

There was little difference in liveweight performance of 1/2 and 3/4 Brahmans. Rudder *et al.* (1982) reported that there were no consistent differences in growth rates to 3 years of 1/2 and 3/4 Brahman steers on a commercial property in central Queensland. However, Corlis *et al.* (1980) did observe genotype x year interactions in growth rate of 1/2 and 3/4 Brahman steers, suggesting that the relative performance of the genotypes varied according to seasonal conditions. Our data with cows would suggest that G x Y interactions could not be attributed to any known environmental factors. Where G x Y interactions did occur, correlations of date of seasonal break, as the indicator of the type of year, with pregnancy rate, calving date and weight at mating tended to be similar for the different levels of *B. indicus* within each cross. Hence, those interactions could not be explained by type of year.

Although there was little difference in pregnancy rate between Brahman and Sahiwal crosses within generations, we recommend the Brahman as a more suitable *B. indicus* source for the dry tropics of northern Australia because of the higher incidence of losses between pregnancy and weaning in the Sahiwal crosses. However, no recommendations can be made regarding the level of *B. indicus* (1/2 *v.* 3/4) since there was little difference between them for fertility or liveweight parameters.

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