Proceedings, Applied Reproductive Strategies in Beef Cattle
November 12 and 13, 2005, Texas A&M University, College Station

REPRODUCTION OF *BOS INDICUS* BREEDS AND CROSSES

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Introduction

The most numerous *Bos indicus* breed in the United States is the Brahman. The Brahman breed was developed in the Gulf Coast States by upgrading native United States cattle with various breeds of *Bos indicus* cattle from India (Phillips, 1963; Yturria, 1973). Breeders did not control the proportions of different *Bos indicus* breeds used in developing the Brahman. Even with this genetically diverse beginning, the adaptation of this new *Bos indicus* breed to the Gulf Coastal environment has led to its use in crossbreeding and development of other Brahman-influenced breeds. The adaptive traits of the Brahman and its crosses that account for their use in beef production systems include: tolerance of internal and external parasites; tolerance of high solar energy, high ambient temperature and humidity; and the ability to utilize high fiber forages (Koger, 1963). The positive influence of *Bos indicus* breeding on beef production is well documented (Rhoad, 1955; Cartwright and Fitzhugh, 1972; Koger, 1973). Reproduction has generally been reported to be lower in *Bos indicus* compared with *Bos taurus* breeds (Kincaid, 1957; Warnick, 1963; Reynolds, 1967; Temple, 1967; Plasse, 1973). Research results explaining some of the reasons for these results will be presented in this manuscript.

Age at Puberty: Heifers

Emphasis on heifers calving at 2 years of age has made early maturity an important economic trait. *Bos indicus* heifers reach puberty at older ages than *Bos taurus* heifers (Table 1). *Bos indicus* and *Bos indicus* composite breeds mature later than *Bos taurus* breeds (Warnick et al., 1956; Luktuke and Subramanian, 1961; Temple et al., 1961; Reynolds et al., 1963; Reynolds, 1967; Plasse et al., 1968a). *Bos indicus*, but not *Bos indicus* x European, heifers reach puberty at too old of an age to calve at 2 years of age.

Table 1. Age at puberty in heifers

Breed	Age (days)	Source
British breeds	436	Reynolds (1967)
Angus	459	Chase et al. (1997b)
Hereford	413	Chase et al. (1997b)
Hereford x *Bos taurus*	358	Lammoglia et al. (2000)
Limousin x *Bos taurus*	379	Lammoglia et al. (2000)
Piedmontese x *Bos taurus*	338	Lammoglia et al. (2000)
Romosinuano	427	Chase et al. (1977b)
Senepol	481	Chase et al. (1997b)
Hereford x Senepol	384	Chase et al. (1997b)
Senepol x Hereford	427	Chase et al. (1997b)
Senepol x Angus	475	Chase et al. (1997b)
Tuli x Angus	466	Chase et al. (1997b)
Brangus	528	Reynolds (1967)
Brahman x *Bos taurus*	438	Reynolds (1967)
Brahman x Angus	478	Chase et al. (1997b)
Brahman	690	Reynolds (1967)
Brahman	592	Chase et al. (1997b)

Gestation Length

Cows of different breeds have different gestation lengths. There is a disadvantage for breeds with longer gestation periods when they are expected to maintain a 365 day calving interval. The *Bos indicus* breeds derived from India have gestation lengths about 10 days longer than *Bos taurus* breeds (Table 2). To maintain a yearly calving interval, the *Bos indicus* cow must rebreed within 73 days after calving whereas the *Bos taurus* cow must rebreed within 83 days after calving. Composite breeds that include *Bos indicus* breeding are intermediate between *Bos taurus* and *Bos indicus* with regard to gestation length. The only *Bos indicus* cattle with gestation lengths similar to *Bos taurus* (Table 2) are the small African Zebu breeds which lack the productivity of the Indian breeds.

Table 2. Gestation length

Breed	Gestation length (days)	Source
Bos taurus	282	Lush (1945)
Brahman	293	Plasse et al. (1968b)
Brangus	286	Reynolds (1967)
Nelore	291	Veiga et al. (1946)
Nelore and Guzerat	293	Haines (1961)
Nelore, Gir and Guzerat	292	Briquet and DeAbrea (1949)
Afrikander	295	Joubert and Bonsma (1959)
Afrikander	295	VanGraan and Joubert (1961)
African Zebu	283	Hutchison and Macfarlane (1958)
Ethiopian Zebu	283	Mukasa-Mugerwa and Tegegne (1989)

Postcalving Fertility

The principal reason that *Bos indicus* or *Bos indicus* crossbred cows are not pregnant at the end of the breeding season is that they do not come into estrus during the breeding season (Reynolds, 1967). Reynolds (1967) found that average intervals from calving to estrus were shortest in Angus, intermediate in Brangus and longest in Brahman cows (Table 3).

More recent reports (Stahringer et al., 1999; Webb et al., 2001; Strauch et al., 2003) indicate that the interval from calving to estrus is similar in the Brahman compared with *Bos taurus* breeds. With intervals less than 60 days there does not appear to be a longer interval from calving to estrus in the *Bos indicus* cow compared with *Bos taurus* cows. The greatest proportion of *Bos indicus* cows can return to estrus after calving quickly enough to rebreed to calve on an annual basis. Reports in the literature spanning over 30 years show that Brahman cows can have between 61 and 65 day intervals from calving to conception (Plasse et al., 1968c; Stahringer et al., 1999). First service conception rates in postpartum Brahman cows were from 50 to 73% in one report (Webb et al., 2001) and from 40 to 68% in another report (Strauch et al., 2003). From these results there seems to be little evidence of reduced postcalving fertility, at least in current Brahman genetics.

Table 3. Interval from calving to estrus

Breed	Interval (days)	Source
Hereford	59	Warnick (1955)
Angus	63	Reynolds (1967)
Brangus	74	Reynolds (1967)
Brahman	79	Reynolds (1967)
Brahman	45	DeFries et al. (1998)
Brahman	48	Stahringer et al. (1999)
Brahman	54	Webb (2001)
Brahman	59	Strauch et al. (2003)

Endocrine Controlled Reproductive Traits: Cows and Heifers

Estrogen induces estrus behavior in cattle (Short et al., 1973) and is the primary stimulus for the preovulatory LH surge (Henricks et al., 1971; Christensen et al., 1974). The duration of standing estrus is shorter in *Bos indicus* cattle compared with *Bos taurus* cattle (Anderson, 1936; De Alba et al., 1961; Plasse et al., 1970; Rhodes and Randel, 1978).

Ovariectomized Brahman cows have been reported to be less responsive to exogenous estrogen than ovariectomized Brahman x Hereford or Hereford cows (Rhodes and Randel, 1978). Ovariectomized Brahman cows did not accept heterosexual mounting at any estrogen dose and a lower proportion of Brahman x Hereford cows accepted heterosexual mount at the 1 mg dose than did the ovariectomized Hereford cows (Table

4). When homosexual behavior was used as the measurement for behavioral estrus a lower response was reported for the ovariectomized Brahman compared with the ovariectomized Brahman x Hereford or Hereford cows (Table 5). Duration of estrogen induced estrus was shorter in the ovariectomized Brahman and Brahman x Hereford cows than in the ovariectomized Hereford cows (Table 6). The differential response to estrogen may be clearer when the time from estrogen stimulus to behavioral estrus is compared between breedtypes. The time from estrogen to estrus was longest in the ovariectomized Brahman, intermediate in Brahman x Hereford and shortest in Hereford cows (Table 6).

Table 4. Proportion of ovariectomized cows accepting heterosexual mount after injection of estrogen

Breed	Cows showing estrus (%)			
	Estradiol-17ß dose			
	1 mg	2 mg	4 mg	8 mg
Brahman	0**	0**	0**	0**
Brahman x Hereford	33†	100	100	100
Hereford	83	100	100	100

From: Rhodes and Randel (1978)
†P < 0.10.
**P < 0.005.

Table 5. Proportion of ovariectomized cows accepting homosexual mount after injection of estrogen

Breed	Cows showing estrus (%)			
	Estradiol-17ß dose			
	1 mg	2 mg	4 mg	8 mg
Brahman	66*	83*	66*	83*
Brahman x Hereford	83	100	100	100
Hereford	83	100	100	100

From: Rhodes and Randel (1978).
*P < 0.05.

Table 6. Response of ovariectomized cows to estrogen injection

Breed	Duration of estrus (hours)	Time to estrus (hours)
Brahman	8.2	20.6
Brahman x Hereford	8.4	12.9
Hereford	12.3	9.9

From: Rhodes and Randel (1978).

The greatest concentrations of circulating estrogen before estrus (Randel, 1980) in estrous cycling heifers occur nearest estrus in Hereford, intermediate in Brahman x Hereford and furthest from estrus in Brahman (Table 7). The elapsed time between endogenous estrogen and onset of estrus in estrous cycling heifers is remarkably similar to the elapsed times from estrogen stimulus to behavioral estrus in ovariectomized cows

(Tables 6 and 7). These results show that *Bos indicus* and *Bos taurus* cows have different responses to estrogen. *Bos indicus* cows have a shorter, less intense estrus which occurs later after the estrogen stimulus than in *Bos taurus* cows. *Bos indicus* x *Bos taurus* crosses are intermediate to the parent breeds for these physiological parameters.

Luteinizing hormone (LH) is responsible for ovulation in cattle and the preovulatory LH surge occurs 20 to 22 hours before ovulation (Schams and Karg, 1969) or 3 to 6 hours after the onset of estrus (Henricks et al., 1970) in *Bos taurus* cattle. Gonadotropin releasing hormone (GnRH) is the hormone responsible for pituitary release of LH in cattle (Convey, 1973).

Griffin and Randel (1978) challenged ovariectomized Brahman and Hereford cows with 500 µg injections of GnRH and all cows responded by increasing circulating concentrations of LH within 15 minutes (Figure 1). Mean concentrations of LH were lower ($P < 0.005$) in ovariectomized Brahman (34 ± 4 ng/ml) than in ovariectomized Hereford (67 ± 20 ng/ml) cows. Peak LH concentrations were lower ($P < 0.005$) in ovariectomized Brahman (95 ± 7 ng/ml) than in ovariectomized Hereford (185 ± 68 ng/ml) cows. These results, that *Bos indicus* females show a smaller pituitary response than *Bos taurus* females, are similar to those reported (Godfrey et al., 1990b) for *Bos indicus* and *Bos taurus* bulls. From these results it seems appropriate to assume that the *Bos indicus* pituitary gland secretes less LH when given a measured dose of GnRH than does the *Bos taurus* pituitary gland, regardless of sex.

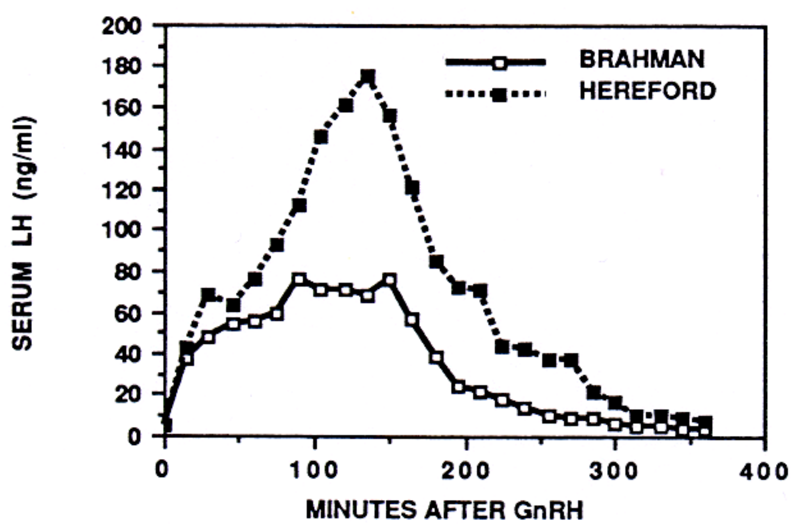

Figure 1. Response of ovariectomized cows to GnRH.

Comparative data evaluating the preovulatory LH surge in Brahman, Brahman x Hereford and Hereford heifers have been reported for estrous synchronized heifers (Randel, 1976) and normal estrous cycling heifers (Randel and Moseley, 1977). In estrous synchronized heifers (Figure 2) and normal estrous cycling heifers (Figure 3), the Brahman heifers had the smallest preovulatory LH surge with the Brahman x Hereford heifers and Hereford heifers having the larger LH surges. In both experiments, the time from estrus to the preovulatory LH peak was shorter in the Brahman heifers than in the Hereford heifers (Table 8).

Table 7. Time of peak circulating estrogen before estrous in estrous cycling heifers

Breed	Time (hours)
Brahman	24[a]
Brahman x Hereford	16[b]
Hereford	8[c]

From: Randel (1980).
[a,b,c]Different superscript differ $P < 0.05$.

Table 8. Timing of the preovulatory LH surge

	Time from estrus to peak LH (mean hours ± SE)	
Breed	Randel (1976)	Randel and Moseley (1977)
Brahman	0.4 ± 3.4	2.0 ± 1.3
Brahman x Hereford	6.8 ± 2.1	3.0 ± 1.3
Hereford	5.3 ± 1.3	6.5 ± 1.8

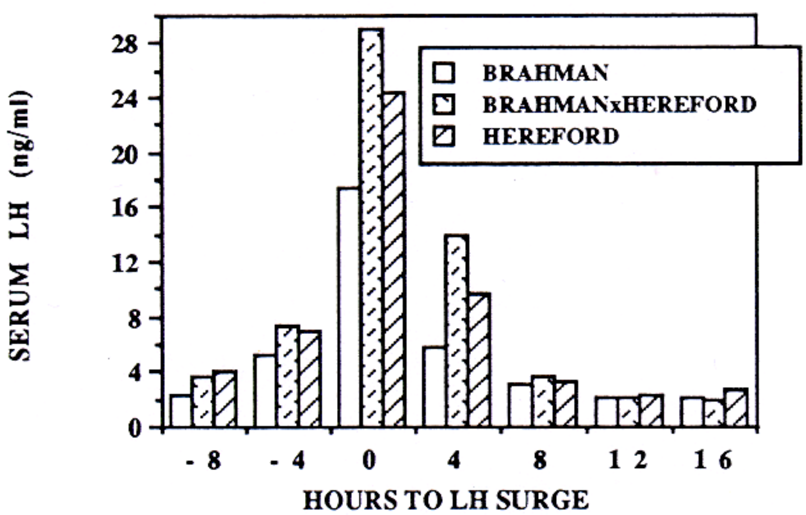

Figure 2. The preovulatory LH surge in estrous synchronized heifers.

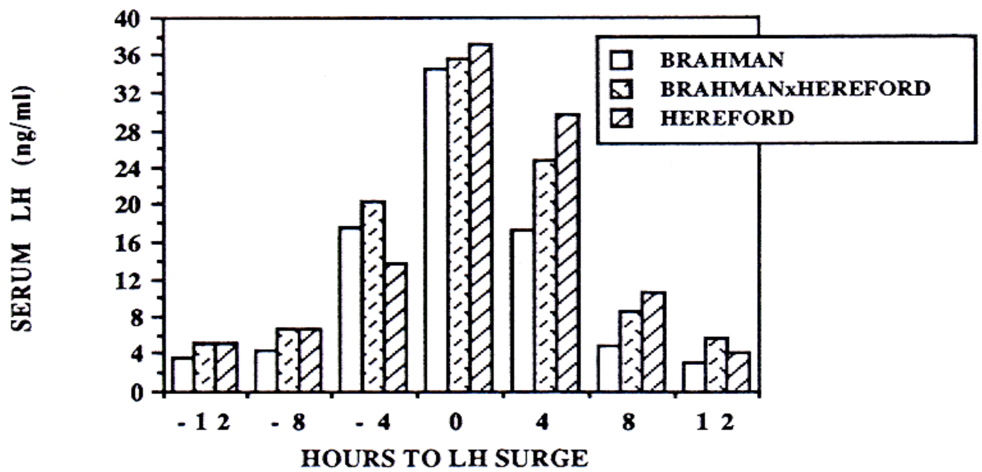

Figure 3. The preovulatory LH surge in estrous cycling heifers.

Estrogen has been reported to be the primary stimulus for hypothalamic release of GnRH which in turn stimulates pituitary release of LH in cattle (Henricks et al., 1971; Hobson and Hansel, 1972; Short et al., 1973; Christensen et al., 1974). Rhodes et al. (1978) found that elapsed time from estrogen injection to peak LH concentration was longest in ovariectomized Brahman, intermediate in Brahman x Hereford and shortest in Hereford cows (Table 9). Ovariectomized Brahman cows had the smallest area under the LH release curve, Brahman x Hereford were intermediate and Hereford cows released the greatest amount of LH (Table 9).

Bos indicus cows have a smaller preovulatory LH surge, a smaller estrogen or GnRH releasable pool of pituitary LH and are slower to respond to an estrogen stimulus with GnRH secretion from the hypothalamus compared with *Bos taurus* cattle.

The timing of physiological events leading to ovulation has been reported for Brahman, Brahman x Hereford and Hereford heifers (Randel, 1976). Brahman heifers ovulated earlier after the onset of estrus than did the Brahman x Hereford or Hereford heifers (Table 10). The interval from the LH surge to ovulation did not differ between the breeds. Ovulation times following the onset of estrus have been reported for grade Brahman heifers in Florida (25.6 hours; Plasse et al., 1970), for Brahman heifers in Venezuela (20.6 hours; Troconiz, 1976) and for *Bos taurus* heifers in Montana (33.2 hours; Randel et al., 1973). *Bos indicus* females ovulate 8-10 hours earlier after the onset of estrus than *Bos taurus* females. The primary difference between *Bos indicus* and *Bos taurus* females is that the *Bos indicus* female takes longer from the peak in estrogen to onset of behavioral estrus and then a shorter time from estrus onset to ovulation than the *Bos taurus* female.

Detection of corpora lutea (CL) by rectal palpation is more difficult in *Bos indicus* females than in *Bos taurus* females (Plasse et al., 1968a). Brahman heifers have smaller CL than Brahman x Hereford or Hereford heifers (Irvin et al., 1978) and CL from Brahman cows are smaller than in Angus cows (Segerson et al., 1984; Table 11). Progesterone content of CL from Brahman heifers, Brahman x Hereford heifers and

Brahman cows has been reported to be lower than Hereford heifers (Irvin et al., 1978) or Angus cows (Segerson et al., 1984; Table 12). Conversely, Segerson et al. (1984) found that Brahman cows had greater ovarian and stromal weights on day 17 after estrus compared with Angus cows (Table 13). Brahman cows also had greater numbers of small (< 5 mm) follicles and more follicular fluid but smaller numbers of large (> 5 mm) compared to Angus cows (Table 14).

As *Bos indicus* cows have smaller CL and both *Bos indicus* and *Bos indicus* x *Bos taurus* cows have less progesterone in the CL than *Bos taurus* cows, it is not surprising that both have lower circulating concentrations of progesterone from day 2 through 11 after estrus than *Bos taurus* (Randel, 1977; Figure 4). Segerson et al. (1984) also reported that Brahman cows had lower serum progesterone from day 7 through 17 after estrus than Angus cows (Figure 5).

Table 9. LH response to estrogen injection in ovariectomized cows

Breed	Time to peak LH (mean hours ± SE)	Area under the LH curve (mean ± SE)
Brahman	27.8 ± 2.0[a]	6.0 ± 2.8[a]
Brahman x Hereford	23.8 ± 0.9[b]	11.1 ± 2.1[b]
Hereford	22.1 ± 1.0[c]	25.1 ± 7.4[c]

From: Rhodes et al. (1978).
[a,b,c]Means in columns with different superscripts differ $P < 0.05$.

Table 10. Timing of physiological events leading to ovulation (mean hours ± SE)

Breed	Estrus to LH surge	LH surge to ovulation	Estrus to ovulation
Brahman	0.4 ± 3.4	18.5 ± 3.1	18.9 ± 2.2[a]
Brahman x Hereford	6.8 ± 2.1	22.2 ± 2.6	29.0 ± 1.3[b]
Hereford	5.3 ± 1.3	23.3 ± 2.1	28.6 ± 1.5[c]

From: Randel (1976).
[a,b,c]Means in columns with different superscripts differ $P < 0.05$.

Table 11. Corpus luteum weight (mean g ± SE)

	Day of the estrous cycle		
Group	8	13	17
Brahman heifers[a]	2.5 ± 0.1[c]	2.7 ± 0.1[c]	--
Brahman x Hereford heifers[a]	4.6 ± 0.4[d]	3.8 ± 0.3[d]	--
Hereford heifers[a]	4.0 ± 0.4[d]	3.6 ± 0.3[d]	--
Brahman cows[b]	--	--	2.4 ± 0.1[c]
Angus cows[b]	--	--	4.1 ± 0.3[d]

[a]From: Irvin et al. (1978).
[b]From: Segerson et al. (1984).
[c,d]Means in columns with different superscripts differ $P < 0.05$.

Table 12. Progesterone content of corpora lutea (mean ± SE)

Group	μg/CL	Source
Brahman heifers	216.9 ± 45.0	Irvin et al. (1978)
Brahman x Hereford heifers	217.7 ± 35.3	Irvin et al. (1978)
Hereford heifers	334.6 ± 87.8	Irvin et al. (1978)
Brahman cows	190.8 ± 28.9	Segerson et al. (1984)
Angus cows	266.3 ± 23.9	Segerson et al. (1984)

Table 13. Ovarian and stromal weights on day 17 after estrus (mean ± SE)

	Ovarian weight (g)		Stromal weight (g)	
Breed	Active[a]	Inactive[b]	Active	Inactive
Angus	9.2 ± 0.4	4.6 ± 0.3[c]	3.9 ± 0.3[c]	3.6 ± 0.3[c]
Brahman	11.0 ± 1.1	7.9 ± 0.9[d]	6.8 ± 0.9[d]	6.2 ± 0.7[d]

From: Segerson et al. (1984)
[a]Active ovary contains CL.
[b]Inactive ovary does not contain CL.
[c,d]Means in columns with different superscripts differ $P < 0.01$.

Table 14. Ovarian follicular characteristics on day 17 after estrus (mean ± SE)

	Number of follicles			
Breed	Small (< 5 mm)		Large (> 5 mm)	
	Active[a]	Inactive[b]	Active	Inactive
Angus	22.3 ± 3.4	20.2 ± 0.3	2.3 ± 0.5	1.8 ± 0.5
Brahman	40.8 ± 5.6	37.1 ± 5.3	1.2 ± 0.3	0.9 ± 0.2

From: Segerson et al. (1984).
[a]Active ovary contains CL.
[b]Inactive ovary does not contain CL.

Influence of Season

The *Bos indicus* and *Bos indicus* crossbred cows are long day breeders. There are numerous reports in the literature that as day length decreases reproductive function decreases in *Bos indicus* cattle (Anderson, 1944; Tomar, 1966; Jochle, 1972; Randel, 1984). *Bos indicus* tend to become anestrus during unfavorable seasons (Dale et al., 1959; Tomar, 1966; Plasse et al., 1968a). The frequency of estrus without ovulation also increased in *Bos indicus* females during unfavorable seasons (Luktuke and Subramanian, 1961; Plasse et al., 1970).

Research from our laboratory (Stahringer et al., 1990) supports the literature. Brahman heifers which were experiencing normal estrous cycles in October experienced a relatively high proportion (88%) of either anestrus or abnormal estrus cycles in November, December, January and February before returning to normal estrous cyclicity in March (Figure 6). Serum progesterone concentrations were lower ($P < 0.001$) in heifers during the months of November, December, January and February than in either October or March

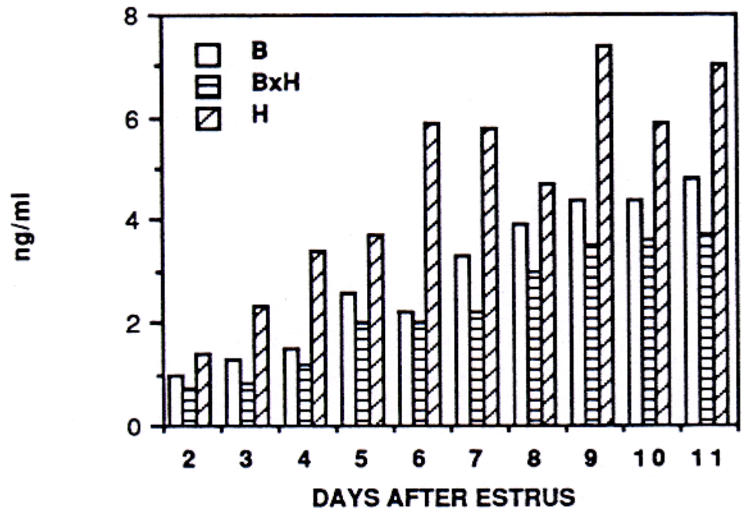

Figure 4. Serum progesterone.

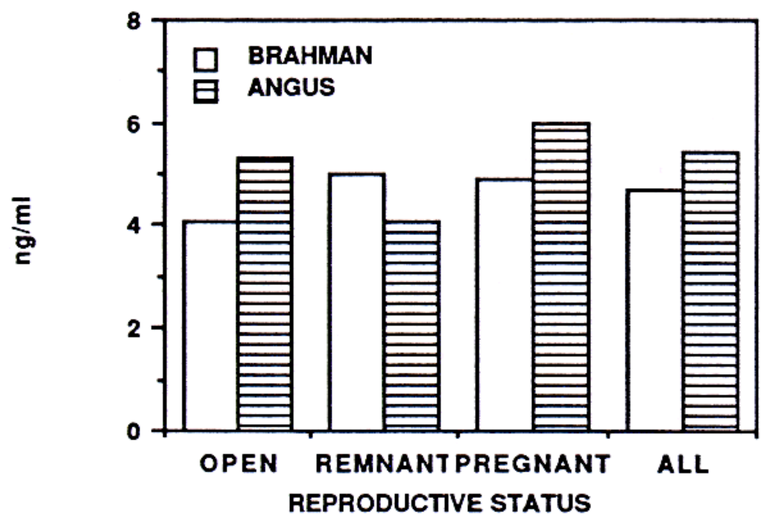

Figure 5. Serum progesterone in mature cows 7-17 days after breeding.

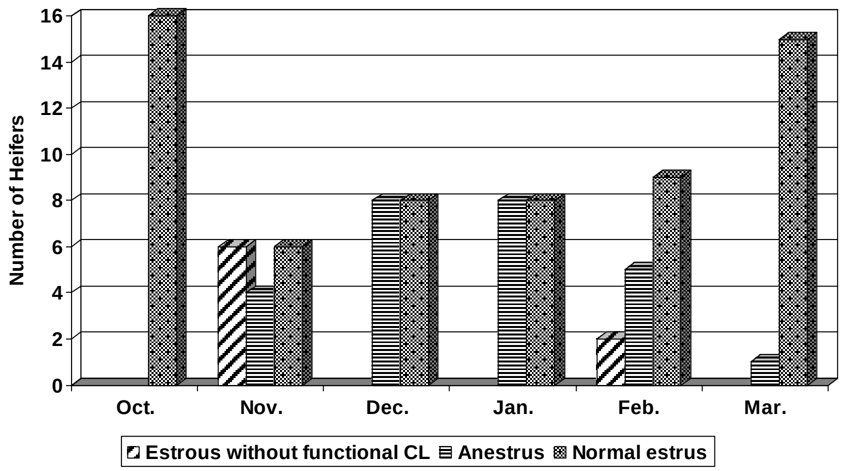

Figure 6. Distribution of the occurrence of normal estrus, estrus without formation of functional CL and anestrus by month in Brahman heifers.

Jochle (1972) reported that conception rates in Brahman cattle were higher during the summer months. Data from our laboratory (Neuendorff et al., 1984) show that Brahman females have higher ($P < 0.005$) first service conception rates in the summer (61%) compared with the late fall (36%). This experiment reported results from artificial insemination so that there were no seasonal influences due to the males involved.

Production of gametes is also affected by season in the female. Bastidas and Randel (1987) reported that the number of transferable embryos produced per Brahman donor cow was greatest in the fall and lowest in the winter (Figure 7). *Bos taurus* breeds have not been reported to be affected by season in production of transferable embryos (Massey and Oden, 1984) yet in this report the authors found that Brahman cows produced the greatest number of embryos in the spring season. Bastidas and Randel (1987) found that pregnancy rates per Brahman donor cow were lower in the winter months (Figure 8). The combination of reduced production of transferable embryos and lower pregnancy rates in the winter months resulted in fewer pregnant recipient cows per Brahman donor cow (Figure 9).

Not all of the fertility data are negative for the *Bos indicus* cattle. High ambient environmental temperatures decrease pregnancy rates in *Bos taurus* cattle (Biggers et al., 1987; Dunlap and Vincent, 1971; Ingraham et al., 1974; Putney et al., 1988; Putney et al., 1989a; Ryan et al., 1992). *Bos taurus* heifers subjected to heat stress during the later stages of oocyte maturation produced fewer embryos to superovulation and had a greater proportion of embryos with retarded development (Putney et al., 1989b).

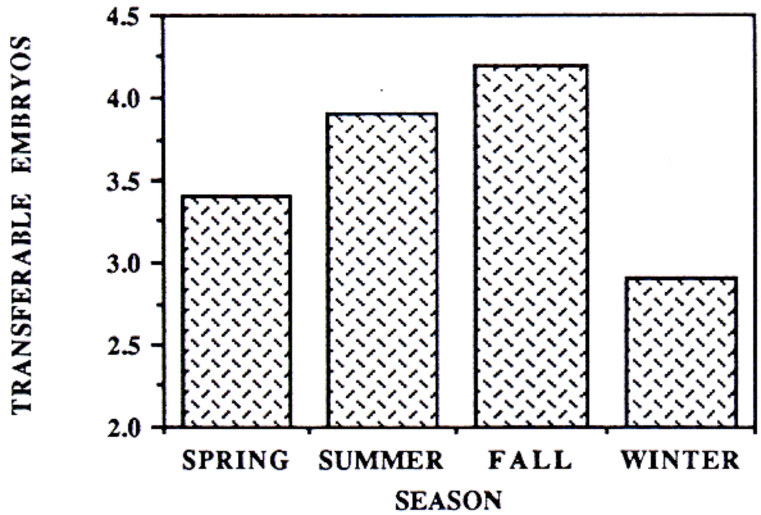

Figure 7. Transferable embryos per Brahman donor cow.

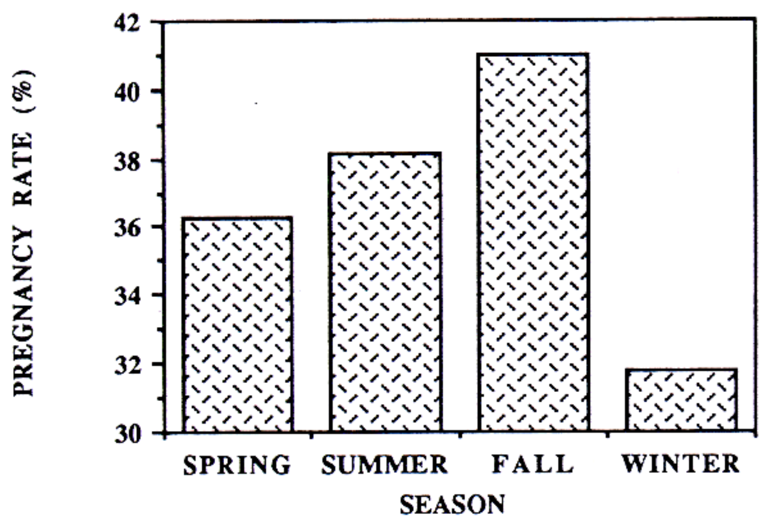

Figure 8. Pregnancy rate per Brahman donor cow.

An experiment was carried out to determine the effects of environmental temperature and humidity on both Brahman and Holstein oocytes (Rocha et al., 1998). Brahman and Holstein donor cows were treated with follicle stimulating hormone and oocytes were harvested in August and in January. When these oocytes collected in August were fertilized in vitro and incubated through developmental stages allowing for transfer to recipient cows, none of the oocytes from Holstein cows (Table 15) resulted in transferable embryos but reasonable proportions of Brahman oocytes developed into transferable embryos (Table 16). Brahman cows responded to super stimulation with production of similar numbers and quality of oocytes as in the summer months. It appears that if a Brahman cow is estrous cycling during the winter she produces high quality oocytes capable of being fertilized and developing into a normal embryo.

In an experiment evaluating the effect of breed and season (Rhodes et al., 1982), Brahman heifers had smaller corpora lutea than *Bos taurus* heifers (Table 17). Both *Bos indicus* and *Bos taurus* corpora lutea that developed in the winter had higher concentrations and content of progesterone than those from the summer. When luteal cells from these corpora lutea were incubated with luteinizing hormone in a culture system, the luteal cells from the Brahman heifers produced less progesterone and were less responsive to luteinizing hormone than cells from *Bos taurus* heifers and luteal cells collected in the winter were less responsive than those collected in the summer (Figure 10).

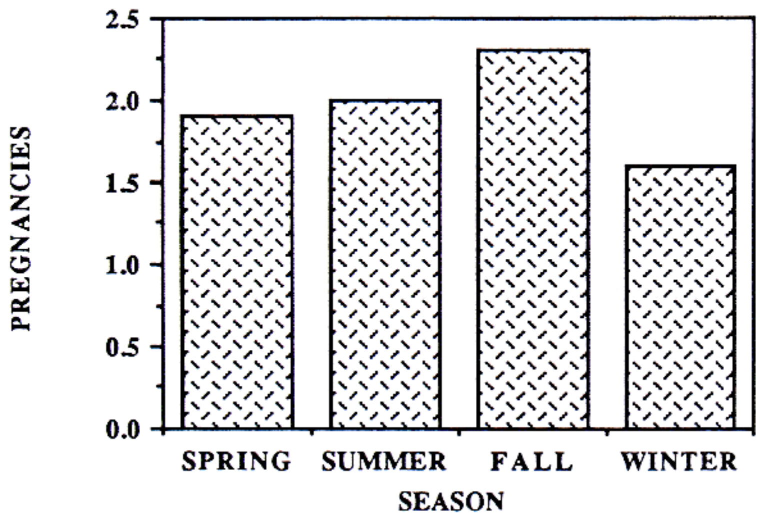

Figure 9. Pregnant recipient cows per Brahman donor cow.

A possible explanation for some of the seasonal influences found in *Bos indicus* cattle may be that pituitary function is altered during the winter. Brahman cows have a lower preovulatory luteinizing hormone surge during the winter compared with the spring or summer periods (Harrison et al., 1982; Figure 11).

It is clear from these experiments that season moderates endocrine function to a greater extent in *Bos indicus* cattle than in *Bos taurus* cattle resulting in suppressed reproductive function in *Bos indicus* cattle during the winter months.

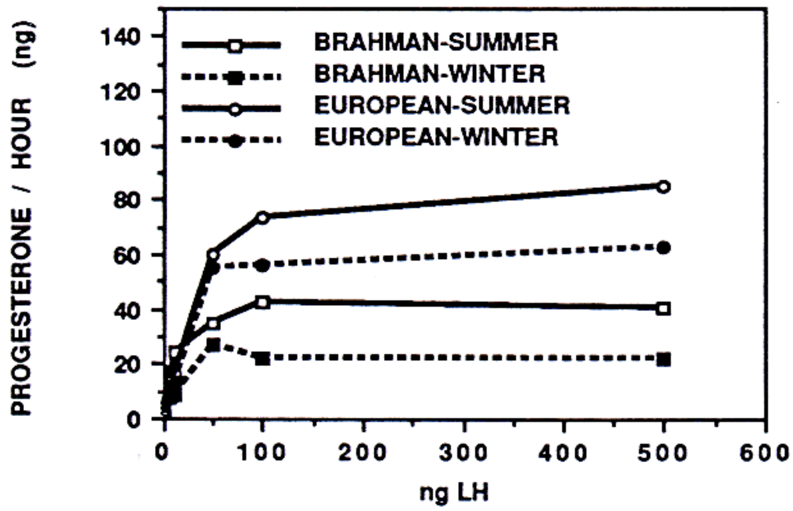

Figure 10. Progesterone secretion by cultured luteal cells.

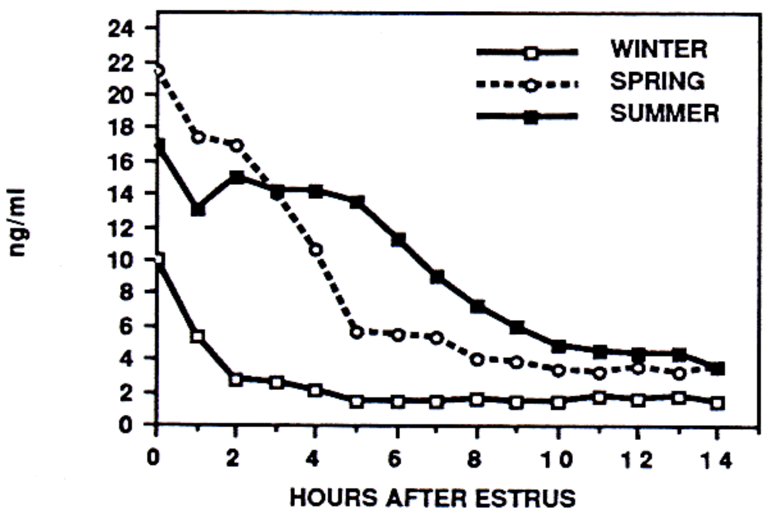

Figure 11. Serum LH in Brahman cows.

Table 15. Percentage of normal oocytes collected from Holstein cows and embryo development from the 2 cell to the blastocyst stage

Season	Total Number of Oocytes	Percentage of Normal Oocytes	Percentage of Oocytes Developing To[a]			
			$\geq$ 2-cell (48 h)	$\geq$ 8-cell (96 h)	Morula (144 h)	Blastocyst (192 h)
Cool	67	80.0±19.1[b]	59.8±11.7	44.4±12.7[d]	34.2±12.7[d]	29.0±14.8[d]
Hot	28	24.6±6.3[c]	52.3±10.6	1.1±4.8[e]	0[e]	0[e]

From: Rocha et al. (1998).

[a]Numbers in parentheses indicate the number of hours post insemination. Normal and abnormal oocytes were fertilized.

Means in the same column with different superscripts differ: $^{bc}P = 0.01$; $^{de}P \leq 0.003$.

Table 16. Percentage of normal oocytes collected from Brahman cows and embryo development from the 2 cell to the blastocyst stage

Season	Total Number of Oocytes	Percentage of Normal Oocytes	Percentage of Oocytes Developing to[a]			
			$\geq$ 2-cell (48 h)	$\geq$ 8-cell (96 h)	Morula (144 h)	Blastocyst (192 h)
Cool	83	83.3±17.4	83.1±10.7	71.3±11.6	55.5±12.2	52.3±13.5
Hot	89	77.0±6.3	79.3±10.6	69.9±4.8	58.1±4.8	41.3±7.2

From: Rocha et al. (1998).
[a]Numbers in parentheses indicate the number of hours post insemination. Normal and abnormal oocytes were fertilized.

Table 17. Effect of breed and season on CL weight, Progesterone (P_4) concentration and progesterone content[a]

Measurement	Brahman		Hereford x Holstein	
	Summer	Winter	Summer	Winter
Weight (g)	2.74 ± 0.10[b]	3.01 ± 0.29[b]	4.58 ± 0.44[c]	5.11 ± 0.49[c]
P_4 concentration (µg/g)	30.8 ± 2.8[d]	52.6 ± 7.8[e]	39.0 ± 7.1[f]	40.4 ± 1.9[f]
P_4 content (µg/CL)	104.0 ± 5.3[g]	153.2 ± 35.9[h]	174.1 ± 35.9[i]	201.9 ± 9.5[j]

[a]From Rhodes et al. (1982).
[b,c]Means within a row with different superscripts differ ($P < 0.001$).
[d,e,f]Means within a row with different superscripts differ ($P < 0.10$).
[g,h,i,j,k]Means within a row with different superscripts differ ($P < 0.01$).

SUMMARY

Reproductive performance differs in subtle ways in *Bos indicus* cattle compared with *Bos taurus* cattle. Developmental differences are apparent during the pubertal process in both males and females. Reproductive endocrinology is similar between *Bos indicus* and *Bos taurus* in that the mechanisms are the same yet nuances of timing are different around estrus and ovulation in the female. Reproductive efficiency, as measured by first service conception rates, is similar in *Bos indicus* and *Bos taurus* cattle. In fact, summer reproductive efficiency may be superior in *Bos indicus* compared with *Bos taurus*. During the winter months *Bos indicus* cattle have marked decreases in reproductive efficiency compared with *Bos taurus*. In most reproductive traits *Bos indicus* x *Bos taurus* animals are superior to the mean of the parents or not different from the superior parent breedtype. The subtle differences between *Bos taurus* and *Bos indicus* cattle must be taken into consideration when designing treatments targeting reproductive function.

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