Reproductive Characteristics of the Brahman and Brahman Based Bull

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GENERAL REPRODUCTIVE TRAITS

The Brahman is a Bos indicus breed which was developed in the Gulf Coast states of the United States (Phillips, 1963; Yturria, 1973). The adaptive traits which specifically suit the Brahman and Brahman based breeds for production in temperate, subtropical or tropical areas include: tolerance of internal and external parasites; tolerance of high solar energy, ambient temperature and humidity; and the ability to utilize high fiber forages (Koger, 1963). Crosses between the Brahman and European breeds exhibit more heterosis than crosses among the European breeds and therefore have increased fertility (Kincaid, 1962; Cartwright et al., 1964; Koger et al., 1973; Peacock et al., 1977). Brahman and Brahman based bulls have shown preferential breeding patterns by preferring to breed Brahman or Brahman based females over European females (Reynolds, 1967). Brahman and Brahman based bulls have been reported to have lower calving rates compared with European bulls (Reynolds, 1960; Koger et al., 1962; Chapman and England, 1965; Reynolds et al., 1965; Reynolds, 1967). Data reported in these studies have been compiled to create the calving percentages by breeds presented in table 1. Brahman and Brahman based bulls sired lower percentages of calves within each breed of cow compared with European bulls.

AGE AT PUBERTY

Brahman and Brahman based bulls reach puberty at older ages than do European breeds of bulls (Lunstra et al., 1978; Fields et al., 1982; Neuendorff et al., 1985). Puberty in bulls has been defined as the age at which a bull produces an ejaculate containing a minimum of 50 x 10^6 spermatozoa with at least 10% progressive motility (Wolf et al., 1965; Killian and Amann, 1972; Barber and Almquist, 1975). Puberty is a developmental process that can be thought of as a continuing process from the presence of the first sperm in an ejaculate through 50 x 10^6 spermatozoa with at least 10% progressive motility in the ejaculate. Bulls of European breeds (Lunstra et al., 1978) have the first sperm in the ejaculate earlier than Brahman bulls (Neuendorff et al., 1985; Chase et al., 1989; Nolan et al., 1990) and reach 50 x 10^6 spermatozoa with at least 10% progressive motility earlier (Lunstra et al., 1978) than Brahman bulls (Fields et al., 1982; Neuendorff et al., 1985; Table 2). Brahman and Brahman based bulls must reach an older age than European breeds of bulls to achieve the reproductive maturity required to impregnate a cow.

TESTICULAR DEVELOPMENT

Scrotal circumference is an important measurement which makes up 40% of the possible points in the Breeding Soundness Evaluation (Society for Theriogenology, 1976). Scrotal circumference is a growth trait that may be affected by genetic, environmental or individual bull differences. Various reports in the literature show that Brahman and Brahman based bulls have smaller scrotal circumferences at a given age and that allowances should be made for breed in the Breeding Soundness Evaluation (Morris et al., 1978; Chenoweth and Ball, 1980; Morris et al., 1987; Morris et al., 1989). In contrast, Fields et al. (1982) found that Brahman and Angus bulls had similar scrotal circumference measurements following puberty. Comparison at similar stages

of development show that Brahman bulls have smaller scrotal circumferences at first sperm than European bulls; one report (Fields et al., 1982) found larger and one report (Neuendorff et al., 1985) found smaller scrotal circumferences at 50 x 10^6 spermatozoa in the ejaculate (Table 3). Most of the reports in the literature show that Brahman bulls have smaller scrotal circumferences than European bulls at similar ages or at similar stages of sexual maturity.

Scrotal circumference differs between Brahman and Hereford bulls following puberty. Godfrey et al. (1990) reported that Hereford bulls from two genetic origins (Origin A, 15.6 mo of age, scrotal circumference of 32.2 cm; Origin B, 14.1 mo of age, scrotal circumference of 33.0 cm) had larger scrotal circumferences than Brahman bulls (20 mo of age, scrotal circumference of 30.8 cm). The different growth curve of the Brahman bulls required the bulls to be about 35 mo of age by the time they reached scrotal circumferences similar to the Hereford bulls (Figure 1). These findings support the reports by Morris et al. (1978), Chenoweth and Ball (1980) and Morris et al. (1987). Most young Brahman and Brahman based bulls are penalized when using the Breeding Soundness Evaluation scoring system which was developed using data collected from European bulls. The Breeding Soundness Evaluation of scrotal circumference in Brahman and Brahman based bulls should use a modified scoring chart as suggested by Morris et al. (1987). Morris et al. (1989) reported the effect of age on scrotal circumference of 921 American Brahman bulls. Comparison of these measurements with the Breeding Soundness Evaluation (Society for Theriogenology, 1976) requirements for scrotal circumference shows that average Brahman bulls do not reach the requirement of the Breeding Soundness Evaluation to receive the maximum points for scrotal circumference until they are over 36 mo of age (Figure 2).

The volume of the testes can be obtained by measuring the scrotal circumference and the length of each testis using the formula; paired testes volume = .0396 x average testis length x (scrotal circumference)^2 (Lunstra et al., 1988). Young (13 to 16 mo old) Brahman bulls have been reported to have smaller testes volume than young Angus, Hereford or Santa Gertrudis bulls (Fields et al., 1979). The Brahman bulls experienced a rapid testes growth phase and had a more similar testes volume at 17 to 20 mo of age (Table 4). Godfrey et al. (1990a) reported that Brahman bulls had smaller paired testes volume than Hereford bulls until the Brahman bulls reached approximately 3 yrs of age (Figure 3). Testes growth patterns differ between Brahman and some Brahman based bulls and European bulls. The testes grow more rapidly in European bulls compared with the testes of Brahman bulls.

SEMEN PRODUCTION

The lower calving percentages of Brahman and Brahman based bulls (Table 1) may be due to differences in semen production. The smaller testes of Brahman and some Brahman based bulls may have less spermatogenic tissue; therefore, Brahman and Brahman based bulls may produce fewer spermatozoa. Young Brahman bulls reach sexual maturity at older ages than European bulls (Table 2) and have dramatic differences in the quality of ejaculates until the pubertal process is completed (Fields et al., 1982). Sperm concentrations and motility are lower from 12 to 16 mo of age in Brahman bulls compared with Angus bulls (Figures 4 and 5). The slower rate of development of Brahman and Brahman based bulls (Fields et al., 1979) is reinforced by lower sperm concentrations (Figure 6) and motility (Figure 7) in ejaculates of developing bulls.

Mature Brahman bulls (Hardin et al., 1981) continue to produce ejaculates with lower sperm concentrations (Figure 8) compared to mature Angus bulls. Godfrey et al. (1990b) studied

mature Brahman and Hereford bulls over a longer period of time and in more detail. Sexually mature Brahman and Hereford bulls were studied for a 21 mo period. Sperm concentrations for the Brahman bulls were lower than for the Hereford bulls in six of the seven sampling periods (Figure 9). Mean sperm concentration was 386.1 x 10^6 sperm/ml in the Brahman bulls compared with 492.7 x 10^6 sperm/ml in the ejaculate of Hereford bulls. Sperm concentration was 27.6% higher in Hereford than in Brahman bulls.

Motility of the sperm from the same bulls (Godfrey et al., 1990b) was lower in Brahman than in Hereford bulls (Figure 10). Mean percent motile sperm in the ejaculate was 50.6% for Brahman bulls compared with 68.7% in the Hereford bulls. Progressive motility scores (range of 0 through 5) were also lower in the Brahman than in the Hereford bulls (Figure 11). Mean progressive motility score was 2.5 for the ejaculates from the Brahman bulls compared with 3.4 for ejaculates from the Hereford bulls. Percentages of live sperm were lower in six of the seven sampling periods in Brahman compared with Hereford bulls (Figure 12). Mean numbers of live sperm were lower in Brahman (49.7%) than in Hereford bulls (63.8%). Sperm morphology did not differ as dramatically as concentration or motility between Brahman and Hereford bulls (Figure 13). The percentages of normal sperm were lower in Brahman (78.7%) than in Hereford bulls (86.2%). Acrosomal morphology was better in the Hereford bulls than in the Brahman bulls (Figure 14). Percent normal acrosomes was lower in Brahman (56.9%) than in the Hereford bulls (67.9%). Semen quality score was computed using this formula: Quality = (progressive motility + live sperm score + morphology score + concentration score)/4. The semen from Brahman bulls was of lower quality than semen from the Hereford bulls on each day that the semen was collected (Figure 15). Semen quality scores (range of 0 through 5) were lower in Brahman bulls (2.6) than in Hereford bulls (3.5). Taking these semen quality factors into consideration for samples collected over a 21 mo period shows that Hereford bulls produce ejaculates which are 34.6% better on the average compared with Brahman bulls.

Brahman and Brahman based bulls mature at a slower rate than European bulls and have smaller testes which produce semen with lower concentrations of sperm cells, decreased motility and increased numbers of abnormal sperm. The lower quality of the ejaculate of Brahman bulls may be a factor involved with the lower calving percentages found when Brahman or Brahman based bulls are compared with European bulls (Table 1).

ENDOCRINOLOGY

Reproductive processes are controlled by hormones. Libido is a key factor of male reproduction and is lower in the Brahman (libido score = 2.5) than in Angus (libido score = 4.4) bulls (Hardin et al., 1981). Testosterone, secreted from the Leydig cells of the testes, is responsible for male sexual characteristics. Young Brahman bulls have lower concentrations of testosterone in their circulation than young Angus bulls (Fields et al., 1982; Figure 16).

Sexually mature, Brahman bulls and Angus bulls secrete luteinizing hormone (LH) from the pituitary gland in a pulsatile fashion and at a similar frequency of pulses (Godfrey et al., 1990b). The Brahman bulls have lower basal concentrations of LH with a smaller pulse amplitude compared with Angus bulls (Figure 17). The mature Brahman bulls respond to pulsatile LH with a pulsatile release of testosterone at the same frequency but at a greater amplitude compared with Angus bulls (Figure 18).

When sexually mature Brahman and Hereford bulls were given a large dose (200 µg) of gonadotropin releasing hormone (GnRH), they responded by secreting LH which in turn stimulated secretion of testosterone (Godfrey et

al., 1990b). The Hereford bulls had a greater release of LH compared with Brahman bulls (Figure 19), but release of testosterone was similar (Figure 20). The low concentrations of testosterone in the blood of young Brahman bulls is probably related to smaller testes size and not to a lack of response to GnRH and LH. Patterns of release of the reproductive hormones are similar in mature bulls with Brahman bulls having lower concentrations of LH but similar release of testosterone compared with Hereford bulls.

SELECTION FOR REPRODUCTIVE EFFICIENCY

It is possible to improve the reproductive efficiency of Brahman and Brahman based bulls using selection for scrotal circumference and the Breeding Soundness Evaluation (Godfrey et al., 1988). Scrotal circumference of yearling bulls is a moderate to highly heritable trait (about 50%), which means that selection will be effective in increasing scrotal circumference (Brinks, 1987).

Santa Gertrudis bulls were selected using the results of the Breeding Soundness Evaluation and a minimum scrotal circumference over a 10 yr period (Godfrey et al., 1988). A Breeding Soundness Evaluation score of 60 was considered failing, and bulls were culled at this level. Bulls were required to have a minimum scrotal circumference of $\geq$ 30 cm at 16 mo to be tested. Scrotal circumference increased about 3 cm for bulls tested at 16 and 20 mo as well as for mature bulls (Table 5).

The smaller testes size of Brahman and Brahman based bulls can be corrected through selection. This would increase the quantity of sperm producing tissue and possibly correct the problems seen in sperm concentration, motility, percentage of live sperm and percentage of normal sperm in Brahman and Brahman based bulls.

SUMMARY

Brahman and Brahman based bulls are adapted to adverse environmental conditions of the tropics and subtropics. Reproductive efficiency is lower in regard to percent calving rates compared with European bulls. Testes volume and scrotal circumference are smaller in Brahman and Brahman based bulls, particularly as young developing bulls. The Breeding Soundness Evaluation guidelines developed for European bulls cannot be applied to young Brahman and Brahman based bulls without modification. Semen quality measurements of concentration, motility and morphology are slightly lower in Brahman and Brahman based bulls. Endocrine control of reproduction is similar between Brahman and Brahman based bulls compared with European bulls. As with the female, small differences are found in the circulating concentrations of LH in Brahman and Brahman based bulls. Serum testosterone concentrations are lower in young Brahman and Brahman based bulls than in young Angus bulls. Differences in serum testosterone concentrations are minimal between breeds of mature bulls. Selection for scrotal circumference can improve reproductive efficiency in Brahman and Brahman based bulls.

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Table 1. Calving Percentages			
	Breed of sire		
Breed of Dam	Brahman	Brahman based	European
Brahman	70.0	54.0	74.2
Brahman based	71.5	74.5	80.4
European	61.5	54.0	72.7
All cows	67.4	62.2	75.5

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Table 2. Age at Puberty

Breed	Age at first sperm, d	Age at puberty, d	Source
Brown Swiss	236	264	Lunstra et al. (1978)
Red Poll	252	295	Lunstra et al. (1978)
Angus	265	296	Lunstra et al. (1978)
Angus	--	348	Fields et al. (1982)
Hereford	266	326	Lunstra et al. (1978)
Brahman	--	477	Fields et al. (1982)
Brahman	295	454	Neuendorff et al.(1985)
Brahman	374	--	Chase et al. (1989)
Brahman	397	--	Nolan et al. (1990)

Table 3. Scrotal Circumference Near Puberty			
	Scrotal circumference		
Breed	**First sperm**	**50 x 10^6 sperm**	**Source**
Hereford	23.9	27.9	Lunstra et al. (1978)
Angus	27.4	28.6	Lunstra et al. (1978)
Angus	---	28.8	Fields et al. (1982)
Red Poll	25.6	27.5	Lunstra et al. (1978)
Brown Swiss	26.1	27.2	Lunstra et al. (1978)
Brahman	---	33.4	Fields et al. (1982)
Brahman	23.7	26.6	Neuendorff et al. (1985)
Brahman	25.3	---	Chase et al. (1989)
Brahman	23.6	---	Nolan et al. (1990)

ENDFIELD

Table 4. Paired Testes Volume		
	Paired testes volume (cc)	
Breed	**13 to 16 mo**	**17 to 20 mo**
Brahman	595	742
Angus	746	786
Montana Hereford	819	764
Florida Hereford	847	822
Santa Gertrudis	893	947

Source: Fields et al. (1979)

Table 5. Effect of Selection on Average Scrotal Circumference (cm) of Santa Gertrudis Bulls			
	Age		
Time	16 mo	20 mo	Mature
Before selection	33.1	33.9	37.0
After Selection	36.1	37.9	40.1

Source: Godfrey et al. (1988).