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Effects of Bull Exposure on Postpartum Interval and Reproductive Performance in Beef Cows

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EFFECTS OF BULL EXPOSURE ON POSTPARTUM INTERVAL AND REPRODUCTIVE PERFORMANCE IN BEEF COWS

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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PREFACE

The postpartum interval is the period of time from parturition until the first postpartum estrus that is accompanied by ovulation. The postpartum interval of the suckled beef cow ranges from 46 to 168 days (Dunn and Kaltenbach, 1980). A prolonged postpartum interval in the beef cow is of major economic importance in terms of cow productivity. The achievement of a 365 day calving interval requires a calving to conception interval of 80 to 85 days. Since average calving rates to a given service or insemination are only 50 to 60% (Diskin and Sreenan, 1980), the earlier a cow begins to cycle postpartum, the greater the chance of successful conception by this time.

There are many factors which influence the length of the postpartum interval. Breed of the dam, heterosis, age of the dam, dystocia, season of calving and photoperiod are a few of the factors contributing to the variation in postpartum interval. Numerous researchers have linked the nutritional state of beef cows to the duration of the postpartum interval. Cows in an adequate nutritional state which results in good body condition prior to parturition, have shorter intervals to first estrus after calving than cows in thin body condition at time of calving. There is increasing information that manipulation of suckling can influence duration of the postpartum anestrous period. In addition, the presence of bulls during the postpartum interval influences the time when cows resume estrous cycles following parturition.

The successful management of these factors could result in cows returning to estrus sooner following parturition. Early induction of postpartum estrous cycles in late calving cows or in cows that have long postpartum intervals would be advantageous to the producer. However, evidence that conception rates are higher in cows that have had a postpartum estrous cycle preceeding the time of breeding is conflicting.

The purpose of the following literature review will be to examine the various factors that influence the postpartum interval in beef cattle, specifically bull exposure.

Review of Literature

Knowledge of progesterone, estrogen and luteinizing hormone (LH) patterns in the anestrous beef cow is helpful in understanding how some of the various factors influence the postpartum interval.

Postpartum Endocrine Function

The early postpartum period is characterized by ovarian inactivity. Plasma progesterone concentrations are low after calving and remain low until just prior to estrus (Arije et al., 1974; Rawlings et al., 1980; Humphrey et al., 1983). Arije et al. (1974) reported that serum progestins increased steadily from 0.3 ng/ml at seven days before estrus to 2.0 ng/ml at three days before estrus and then fell to 0.2 ng/ml at estrus. Humphrey et al. (1983) also noted a progesterone peak with a mean level of $1.3 \pm .1$ ng/ml between 4.6 and .6 days before the first postpartum estrus. The source of this progesterone peak is not known. Blood concentrations of progesterone are reliable indicators of luteal function during the postpartum period since progesterone is the major steroid synthesized by the corpus luteum.

Estrogen levels decline after parturition and remain low until just before estrus (Arije et al., 1974; Humphrey et al., 1983). Preceding the first postpartum estrus there is a rise in estrogen levels for two to three days (Ecternkamp and Hansel, 1973; Arije et al., 1974; Humphrey et al., 1983).

Plasma LH concentrations are low before parturition and increase over the postpartum period (Rawlings et al., 1980; Peters et al., 1981). Humphrey et al. (1983) noted that the increased mean values for LH were the result of an increased frequency and magnitude of LH peaks during episodes of LH secretion. Development of a frequent pulsatile pattern of LH secretion seems to be a prerequisite for occurrence of the first postpartum estrus and/or ovulation (Peters et al., 1981; Humphrey et al., 1983).

Postpartum anestrus may be caused by suppression of gonadotropin releasing hormone (GnRH) release from the hypothalmus, suppression of LH secretion from the pituitary or a combination of these two factors (Humphrey et al., 1983). GnRH treatment of postpartum cows resulted in LH release (Fernandes et al., 1978). In addition, intermittent administration of GnRH resulted in ovulation and the completion of one full ovarian cycle in acyclic beef cows (Riley et al., 1981). Endogenous opioid peptides are thought to play a role in regulating pulsatile LH secretion in postpartum cows (Malven, 1986; Whisnant et al., 1986). A review by Malven (1986) suggests that endogenous opioid peptides inhibit the release of GnRH as part of the mechanism to inhibit release of pituitary LH. Endogenous opioid peptides inhibit pulsatile secretion of LH in the postpartum cow and therefore may play a role in regulation of the postpartum interval.

Breeds and Heterosis

There are differences between breeds in the number of days after parturition to the first estrous cycle. In general, cattle of European breeds have shorter postpartum intervals and higher reproductive rates than Zebu cattle. The average interval from calving to estrus for Angus was 64 days, Brahman 71.2 days, Brangus 68.1 days, and Africander - Angus 72.8 days (Reynolds et al., 1979). These data indicate a seven day difference between Angus and Brahman. Warnick (1955) reported an average interval from calving to estrus of 59.2 days for Angus cows and 62.7 days for Hereford cows. Wiltbank et al. (1962) determined the average interval from calving to estrus for Hereford cows varied from 43 to 65 days, depending upon nutritional treatment. Mean duration of postpartum anestrus was 61.4 ± 2.3 days in Mashonas and 84.5 ± 3.5 days in Africanders (Holness et al., 1978).

Cundiff et al. (1974) compared straightbred Hereford, Angus and Shorthorn females to reciprocal cross females to determine the effects of heterosis on reproduction. Over all breeds, ages, and systems of management the effects of heterosis significantly reduced the interval from parturition to first estrus. The postpartum interval was 2.7 days shorter on the average for crossbred cows than straightbred cows. The effect of heterosis on postpartum interval was greater in Angus-Shorthorn reciprocal crosses than in Hereford-Angus reciprocal crosses due to the relatively long interval for straightbred Shorthorn cows of 63.2±1.9 days compared to 50.6±1.7 days and 55.1±1.7 days for straightbred Hereford and Angus cows, respectively.

Variation in the length of the postpartum interval exists within breeds as well as between breeds.

Age

Young cows have a longer postpartum interval than older cows (Herman and Edmondson, 1950; Wiltbank and Cook, 1958; Wiltbank, 1970; Bellows et al., 1982; Doornbos et al., 1984). Wiltbank (1970) reported that in one breeding season the average interval from calving to first estrus was 53.4 days in cows which were five years or older, 60.2 days in four year old cows, 66.8 days in three year old cows and 91.6 days in two year old cows. Herman and Edmondson (1950) determined that the interval from parturition to first estrus in dairy cows was longest for primipara cows (60-75 days), shortest for middle aged cows (50-60 days), and increased for cows over seven years of age (60-90 days). Wiltbank and Cook (1958) reported that the postpartum interval for Milking Shorthorns decreased with increasing age.

Dystocia

In situations where dystocia occurs, cows have longer postpartum periods of anestrus compared to cows that did not have calving difficulty (Laster et al., 1973a; Bellows et al., 1982; Doornbos et al., 1984). Doornbos et al. (1984) reported that the postpartum interval in cows which experienced prolonged labor was two days longer than cows with short duration of labor (54.4 vs 52.4 days).

Age of dam (Laster et al., 1973a; Bellows et al., 1982; Doornbos et al., 1984) and breed of dam (Laster et al., 1973a) are two significant sources of variation associated with dystocia. Doornbos et al. (1984) reported that calving difficulty scores and duration of labor were greater in heifers than in cows. Laster et al. (1973a) noted that dystocia in two year old cows was $36.03 \pm 2.96\%$ higher than in two year olds and $44.62 \pm 2.99\%$ higher than in four and five year olds. The heifers in these studies had a longer postpartum interval than cows. Laster et al. (1973a) also reported that Hereford cows had more calving difficulty than Angus cows, $34.78 \pm 3.19\%$ compared to $27.02 \pm 3.13\%$. Age of dam x breed of dam had significant effects on percent calving difficulty (Laster et al., 1973a). The difference in percent calving difficulty was greater between Hereford and Angus two year olds than between Hereford and Angus three year olds or four and five year olds. A lower rate of estrus detection during a restricted artificial insemination period in these cows experiencing dystocia indicates that the interval from calving to first estrus is longer in cows having calving difficulty.

Breed of dam and age of dam are two sources of variation associated with dystocia. Dystocia results in a lengthened postpartum interval and depressed reproductive performance. However, little information is available as to how dystocia causes these effects.

Season and Photoperiod

Season also influences the postpartum interval. Various authors have reported that duration of the postpartum anestrus is shorter for cows calving in the spring and summer than for cows calving in the fall and winter (King and Hurnik, 1980; Peters and Riley, 1982a; Hansen and Hauser, 1983). In contrast, others reported longest intervals from calving to first ovulation for cows calving in the spring (Bulman and Lamming, 1978; Peters and Riley, 1982b). Several authors have suggested that seasonal effects on postpartum interval may be related purely to differences in nutrition and management (Boyd, 1977; DeKruif, 1978). However, these conflicting results may be due to confounding of seasonal changes in environment with those of management. Hansen and Hauser (1983) reported that season interacted with suckling in that winter calving cows suckling calves had a much longer postpartum interval than nonsuckled winter calving cows. The influence of suckling was not as great among cows calving in summer. Spring or summer season of calving was not effective in shortening the already short postpartum interval in nonsuckled cows. A similar interaction was observed between season or calving date and high and low levels of energy. The influence of season of calving was greater for cows fed a low energy diet. The influences of season and level of nutrition tended to diminish as age or number of calvings increased.

Hansen and Hauser (1984) examined the influence of one aspect of season, photoperiod, on the postpartum interval. Supplemental light was provided to autumn and winter calving cows for 18 hours per day beginning at parturition. Supplemental lighting shortened the interval from calving to estrus in some cases. Interactions were present between photoperiod and diet and photoperiod and parity. Lengthening the photoperiod shortened the interval to estrus for multiparous cows fed a diet of hay, but did not affect interval to first estrus among multiparous cows, which were fed hay supplemented with grain. Supplemental lighting shortened the postpartum interval in primiparous cows, but not in multiparous cows under the same management scheme.

In certain situations increasing day length can hasten the onset of estrous cycles after calving. The effect of photoperiod and season does interact with other conditions, such as suckling, parity and nutrition.

How photoperiod influences the postpartum interval is not clear. Hansen and Hauser (1984) reported that supplemental lighting had no effect on serum levels of LH or estradiol.

Nutrition

Extensive evidence links nutrition to the duration of the postpartum interval. Dietary energy levels in both the pre- and postpartum periods influence subsequent reproductive performance in cattle (Wiltbank et al., 1964; Dunn et al., 1969; Bellows and Short, 1978; Holness et al., 1978; Dunn and Kaltenbach, 1980; Bellows et al., 1982; Bartle et al., 1984). Dunn et al. (1969) reported that precalving energy level exerted the greatest influence in the early postpartum period. By 40 days after calving, 25% of the cows fed the high precalving energy level had exhibited estrus compared to only 6% of those fed the low level. Bellows et al. (1982) noted that dams fed a high (6.8 Kg TDN) feed level during gestation returned to estrus

11 days earlier than dams fed a low (3.6 Kg TDN) feed level during gestation. He also observed that low feed levels during gestation were more detrimental to heifers than cows.

Feeding low levels of energy after calving in cows that were restricted prepartum delayed the onset of estrus (Wiltbank et al., 1964). Feeding high energy levels postpartum resulted in cows regaining body condition and shortened the postpartum interval compared to cows fed low levels postpartum. However, the detrimental effects of feeding low levels of energy in late gestation are not completely overcome by feeding high levels postpartum (Dunn et al., 1969).

Many researchers agree that body condition at calving is an important factor influencing postpartum interval. Energy restriction during the late prepartum period results in thin body condition at calving and extends the postpartum interval (Dziuk and Bellows, 1983). Corah et al. (1975) concluded that prepartum nutrition did not significantly influence the interval to first estrus in either heifers or cows. But this may be explained by the fact that they were in excellent condition at the start of the trial. A review by Dunn and Kaltenbach (1980) reported that a high percentage of cows in good body condition at parturition had shown estrus by 60 days postpartum regardless of weight changes either before or after parturition. Richards et al. (1986) indicated that if multiparous cows calve with a body condition score $\geq$ 5 (based on 1 to 9 system) postpartum nutrient intake had little or no influence on postpartum interval to estrus. In contrast, Rutter and Randel (1984) observed that mature cows and heifers that calved with good body condition and were fed low energy diets postpartum had a longer postpartum interval than those fed a high energy diet. The results of Richards et al. (1986) agree with those of Dunn et al. (1969). Richards et al. (1986) concluded that increasing the postpartum energy level of cows calving with a body condition score of $\leq$ 4 increased the cumulative percentage of those exhibiting estrus in a limited breeding season. But cows on a low prepartum energy diet, thus calving with a low body condition score have a longer postpartum interval regardless of level of energy offered postpartum. These studies indicate that body condition at calving is the determining factor related to reestablishment of cyclic ovarian activity in the beef cow.

The mechanism by which energy influences return to estrus is not clear. In cycling cows energy restriction results in an increase in plasma LH levels (Dunn et al., 1974; Beal et al., 1978). Researchers disagree on how energy restriction affects progesterone levels. Dunn et al. (1974) reported that cows on energy restricted diets had higher peripheral progesterone concentrations. While

Gombe and Hansel (1973) and Beal et al. (1978) reported decreased progesterone concentrations in low energy cows. Gombe and Hansel (1973) suggested that restricting energy intake reduces the corpus luteum responsiveness to LH stimulation resulting in the corpus luteum synthesizing and releasing less progesterone. The negative feedback progesterone exerts on LH secretion is decreased resulting in increased systemic levels of LH. Gauthier et al. (1983) reported that delayed resumption of cyclic ovarian activity in underfed acyclic cows was associated with lower concentrations of both LH and follicle stimulating hormone (FSH). Rutter and Randel (1984) observed that cows that maintained body condition had a shorter postpartum interval and higher basal levels of endogenous LH. Therefore, the low LH and FSH levels associated with energy restriction and poor body condition may be responsible for the delay of the first postpartum estrus.

Suckling

Mastectomized cows in which the udder was removed at 150 days of gestation had much shorter postpartum intervals than cows which were allowed to suckle calves ad libitum following parturition (Short et al., 1972). This occurred even though all cows were fed to maintain their body weight for the first seven weeks postpartum. The mastectomized cows lost more body weight than the suckled cows, yet the mastectomized cows returned to estrus sooner than suckled cows. Removing calves from cows at birth also shortened the postpartum interval. This data indicates that suckling and/or lactation inhibits estrous activity in beef cows.

Wiltbank and Cook (1958) compared the reproductive performance of nursed and milked cows. They observed that the interval from calving to first estrus was approximately 30 days longer in the suckled cows. The nursed cows were also less fertile.

Nonsuckled cows have a shorter postpartum interval and evidence indicates that early weaning will also shorten the postpartum interval. Bellows et al. (1974) reported that early weaning of calves, at or prior to 10 days of age, resulted in a shortened postpartum interval (20.5 vs 43.2 days). The fertility of these cows exhibiting estrus early postpartum was low.

Weaning calves eight days prior to the start of a 42 day breeding season increased the percentage of fall calving cows detected in estrus during the first 21 days of breeding by about 30% in two and three year old cows (Laster et al., 1973b). Early weaning had no effect on occurrence of estrus in mature cows during this time. Weaning eight days before the breeding season did not affect the interval from calving to first estrus. The postpartum interval was influenced by calving date and breed of cow.

Holness et al. (1978) reported that temporary weaning of calves for eight days (50 to 58 days after calving) reduced the postpartum interval in cows on a high plane of nutrition and had no effect on cows on a low plane of nutrition.

The effects of limited suckling on duration of the postpartum interval have also been examined. In a study with Brahman x Hereford first calf heifers, Randel (1981) observed that once daily nursing beginning 30 days postpartum decreased the postpartum interval by an average of 99 days. Once daily suckling did not decrease cow-calf performance. Allowing once daily nursing in mature Angus cows also resulted in earlier initiation of estrous cycles after calving than in cows nursed normally (Reeves and Gaskins, 1981). In this study there was no difference in postpartum interval to conception between cows nursed once a day and normally nursed cows.

Suckling intensity is also thought to influence the postpartum interval. Wetteman et al. (1978) observed that the first postpartum estrus occurred earlier in cows suckling one calf than in cows suckling two calves (natural plus foster calf).

As stated earlier weaning calves prior to the breeding season results in an increased incidence of estrous cycles. Smith et al. (1979) reported that 48 hour calf removal also increased the percentage of cows detected in estrus the first 21 days of the breeding season. Also, calf removal in combination with Synchro-Mate B treatment dramatically increased the number of cows exhibiting estrous cycles within 36 hours following removal of the Synchro-Mate B implant.

It has been suggested that suckling might inhibit ovarian activity via an effect on gonadotropin release (Carruthers and Hafs, 1980). Short et al. (1972) reported that plasma LH levels were higher in nonsuckled cows. Peters et al. (1981) also reported increased LH concentrations in milked cows compared to suckled cows. A distinct pulsatile pattern of LH secretion was present in the profiles of milked, but not suckled cows. Humphrey et al. (1983) suggested that the pulsatile LH pattern is a prerequisite for the onset of ovarian cycles. Suckling also decreased plasma progesterone concentrations in postpartum cows (LaVoie et al., 1981).

Suckling and energy restriction both result in decreased LH levels in the postpartum anestrous cow and a longer postpartum interval. But the mechanism governing LH release and the role of other hormones is not clear.

Bull exposure

There is limited information available on the influence the presence of a bull has on the initiation of cyclicity and subsequent fertility in postpartum anestrous cows. It has been reported that the presence of a ram before the normal breeding season hastens the onset of estrous cycles in seasonally anestrous ewes (Schinckel, 1954; Watson and Radford, 1960). Shelton (1960) reported a similar effect in goats. Additionally, it has been shown that exposure of weaned sows to boars immediately after weaning ensured a rapid return to estrus (Walton, 1986). Boar presence during lactation may also reduce the interval from weaning to estrus in older sows.

Early Russian experiments indicated that the presence of a teaser bull after calving stimulated uterine involution and sexual activity in cows (Nersesjan, 1962; Sipilov, 1967). The percent detected in estrus was increased and the interval to conception by artificial insemination was reduced. Ebert et al. (1972) and Foote (1975) also reported higher percentages of cows detected in estrus when run in groups containing vasectomized bulls compared with groups observed for estrous activity by herdsmen. The reported differences in these studies may be due to more reliable detection of estrus by the bulls.

Skinner and Bonsma (1964) reported that exposing cows to vasectomized bulls prior to the breeding season hastened the onset of estrus in heifers and cows. All heifers in the teased group had mated within 21 days after the start of the breeding season. In the control group matings were spread over 52 days and not all heifers mated. Teasing also resulted in an increase in the percentages of calves born. Symington and Hale (1967) reported that teasing with bulls stimulated ovulation in two of eight and full heat in three of eight sexually inactive cows. Macmillan et al. (1979) also noted a stimulatory effect of bulls on suckling cows. Suckling cows and heifers were exposed to vasectomized bulls 18 to 21 days before the start of an artificial insemination program. Vasectomized bulls were utilized in both the control and treated group to detect estrus during the breeding season. The presence of a vasectomized bull during the premating period increased the percentage of spring calving cows detected in estrus during the 19 day artificial insemination program (69 vs 40%). The presence of bulls during the premating period had no effect on fall calving cows and heifers. In contrast to the results obtained by Macmillan et al. (1979), Blaschke et al. (1981) observed no increased advantage for a higher percent cyclicity in cows exposed to teaser bulls for 30 days prior to the onset of the breeding season when compared with controls exposed to neutered animals.

Zalesky et al. (1984) compared the effects of exposing cows to intact bulls from 3 to 85 days postpartum or from 53 to 85 days postpartum. Cows exposed to bulls soon after calving initiated estrous cycles 21 days earlier than the control cows, as determined by progesterone values. By 53 days postpartum a greater percent of the bull exposed cows had initiated estrous cycles (85 vs 23%).

Fulkerson (1984) utilized steers treated with estradiol benzoate to provide a male effect. These animals have been proven successful at detecting estrus in dairy cattle (Fulkerson et al., 1982). Estrous activity in milked cows was unaffected by exposure to hormone treated steers.

Androgenized cows can also be utilized for heat detection. Kiser et al. (1977) reported that testosterone treated cows detected cows in estrus that were not observed by the herdsman. Their behavior and actions are similar to a bull. Anderson (1984) reported that the introduction of an androgenized cow soon after calving increased the percent detected in heat and bred during the normal artificial insemination period. A gomer cow was used to detect heat in both the control and exposed group during the breeding period. Bruel et al. (1985) observed no difference in the interval to first estrus when cows were exposed to deviated penized bulls or testosterone treated cows beginning 24 to 72 hours after calving.

These studies indicate that the presence of a bull or bull-like behavior shortens the postpartum interval in cows, at least under certain conditions. The response to bull exposure seems to be affected by season, parity and perhaps suckling. Exposure to hormone treated steers did not reduce the postpartum interval in milked cows (Fulkerson et al., 1984).

No studies reviewed examined how bull exposure affects hormone levels in the anestrous cow.

Materials and Methods

Seventy-two purebred beef cows were randomly allotted to one of two treatments after calving in the spring of 1985. The experiment was repeated with 41 cows in the spring of 1986. Cows were culled in 1985 due to the management scheme to phase out two of the purebred breeds maintained at the beef unit. Other cows were culled due to age or because they were open at the end of the breeding season. Additional cows were added to the 1986 trial in conjunction with the expansion of the Simmental herd. Several cows each year were not bred and were maintained as recipients for embryo transfer. Treatments consisted of cows exposed to epididectomized teaser bulls (BE) beginning 3 to 7 d after calving until implantation with Synchro-Mate B (Ceva Lavoratories, Inc., Overland Park,KS) or cows not exposed to bulls (NE). There were no bulls in close proximity to the nonexposed cows prior to the breeding season. One cow was removed from the BE group in 1986 to treat her calf. Cows were maintained on pasture and provided corn silage and alfalfa haylage until pasture was sufficient to meet nutritional requirements. A trace mineral salt was also available throughout the experimental periods.

Cows were observed for estrus twice daily beginning approximately 4 wk after the beginning of calving until synchronization to determine resumption of estrus. In 1986, blood samples were collected weekly by jugular venepuncture. Blood samples were collected in labeled vacutainer tubes. The blood was centrifuged for 35 min at 2500 rpm. The serum was decanted in duplicate labeled tubes and stored at -24 C. Serum progesterone values were determined by radioimmunoassay to confirm cycling status. Resumption of estrous cycles of normal length was determined based on either of the two following criteria: progesterone concentrations of above 1 ng/ml for two consecutive weeks or progesterone concentrations $\geq$ 2 ng/ml in a single weekly sample.

All cows retained for breeding were synchronized with Synchro-Mate B. All cows received an ear implant containing 6 mg of 17α-acetoxy-11β-methyl-19-nor-preg-4-ene-3, 20-dione (Norgestomet) on May 27, 1985 and May 17, 1986. At the time of implant insertion an intramuscular injection of 5 mg of estradiol valerate and 3 mg of Norgestomet was also given. The implant was removed 9 d later. Calves were removed from the cows for 48 h after Norgestomet implant removal. Cows were artificially inseminated without regard for estrus approximately 48 h after implant removal. Epididectomized bulls were utilized for estrous detection in both groups of cows during a 30 d artificial insemination (AI) period. An intact bull was turned in for the last 30 d of a 60 d breeding season.

Each year a group of cows were randomly selected from the BE group (n=8, 1985; n=7, 1986) and the NE group (n=8, 1985; n=7,1986) and observed for estrus beginning 24 h after implant removal in 1985 and 18 h after implant removal in 1986. The cows were fitted with a jugular cannula upon observation of estrus. Not all cows were detected in estrus. These cows were cannulated regardless of heat by 34 h following implant removal. Blood samples were collected at 15 min intervals for two hours and every 2 h for 46 h after cannulation. The blood was allowed to clot for 6 h at 4 C and centrifuged for 35 min at 2500 rpm. The serum was decanted in duplicate labeled tubes and stored at -24 C. Blood samples were assayed for serum levels of luteinizing hormone (LH) in 1985 and 1986 and estradiol in 1986. Some of the cows in these groups were retained as embryo transfer recipients and not bred.

Progesterone Assay

A solid-phase radioimmunoassay technique was used for all progesterone measurements. The antibody was immmobilized on the wall of a polypropylene tube as prepared by Diagnostics Products Corporation (Los Angeles, CA). Progesterone was labeled with sodium iodide (^{125}I) with a high specific activity and total counts of approximately 75,000 cpm at time of iodination. The maximum binding was approximately 40%. The antiserum was specific for progesterone, with a low cross reactivity to other steroids of less than 2.4%. Sensitivity of the assay was determined to be .05 ng/ml. The standard curve was linear between 0.1 ng/ml and 40 ng/ml. Increasing volumes of steer serum were found to be parallel to the standard curve. Recovery was 101%. Intra- and interassay coefficients were determined with the use of pooled steer serum and spiked steer serum. Intra- and interassay coefficients of variation were 12.8% and 13.95%, respectively.

A sample quantity of 200 μl was used and samples were assayed in duplicate. After 3 h of incubation at 37 C, the separation of the bound and free fraction and termination of the assay was accomplished by decanting the supernatant. The remaining bound fraction was counted in a gamma counter for 1 min.

Estradiol Assay

A no extraction, solid phase radioimmunoassay was used for measurement of estradiol. The antibody was obtained from Diagnostic Products Corporation in the form of antibody coated polypropylene tubes. Estradiol was labeled with sodium iodide (^{125}I) with a high specific activity of about 50,000 cpm at iodination. The antiserum was specific for estradiol with low cross reactivity to other steroids. The maximum binding ranged from 34 to 40%.

Increasing volumes of pooled heifer serum and spiked heifer serum paralleled the standard curve. Standards were prepared in the lab using estradiol obtained from Sigma (St. Louis, MO). The standard curve ranged from 5 pg/ml to 50,000 pg/ml. Recovery was determined to be 100%. The intra- and interassay coefficients of variation were 12% and 16.94%, respectively.

All samples were assayed in duplicate. From each sample 100 μl of serum was added to antibody coated tubes. The samples were allowed to incubate overnight at 37 C. After incubation the samples were decanted to separate the bound and free fractions. The bound fraction was counted in a gamma counter for 1 min.

Luteinizing Hormone Assay

Concentrations of LH were determined by double antibody radioimmunoassay procedure described by Niswender et al. (1969) with modifications. Purified antigen labeled with sodium iodide (^{125}I) was obtained from Diagnostics Products Corporation. Dr. G. D. Niswender (Colorado State University) provided a primary antibody (No. 15). Cross reactivity existed between ovine and bovine LH. The maximum binding ranged from 37 to 60%. Increasing volumes of steer serum and spiked steer serum paralleled the standard curve which ranged from 0.063 to 25 ng/ml. Recovery was determined by adding 1 ng/ml of LH (DPC) to steer serum and was 104%. The intra- and interassay coefficients of variation were 13.9% and 21.3%, respectively.

All samples were assayed in duplicate. From each sample 200 μl of serum was added to properly labeled tubes containing LH antibody and labeled antigen. After 3 d incubation at 4 C, the second antibody was added and incubated an additional 2 d. After incubation, the tubes were centrifuged for 20 min. The supernatant was decanted and the precipitate counted for 1 min in a gamma counter.

Statistical Analysis

Estrus detection data were utilized to determine days to first estrus and percentage cycling for 1985. For 1986, progesterone values were used. Any cows that had calved less than 30 d before synchronization were not included in these calculations. For cows greater than 30 d postpartum that had not been in estrus prior to synchronization, date of first estrus was calculated as 2 d after Synchro-Mate B implant removal. Calving records were used to estimate percentage conceiving to the timed insemination and pregnancy rates. For cows sold, palpation for pregnancy approximately 77 d after the end of the breeding season was used to calculate conception data. A 283 d gestation period was used to determine when conception occurred.

Statistical analyses were performed on continuous data by analysis of variance using General Linear Models (GLM) procedure of Statistical Analysis Systems (SAS, 1982). The model for days to first estrus also included a covariate for age of dam. Categorical data were analyzed using Chi-square analysis (Steele and Torrie, 1980). Analysis of variance and Chi-square values are shown in the appendix.

Results and Discussion

Return to Estrus

Initiation of estrous cycles occurred at 47±3.13 d for BE cows compared with 71.4±3.04 d for NE cows in 1985 ($P<.01$; table 1). The mean days, in 1986, from calving to first estrus for BE cows was 45.8±4.14 d postpartum compared with 52.2±4.02 d in NE cows ($P>.05$). Initiation of estrous cycles occurred 24 d earlier for BE cows than NE cows in 1985 and 6 d earlier for BE cows in 1986. Analysis of variance with adjustment for the covariate age of dam was carried out for days to first estrus. Age of dam did not influence ($P>.05$) days to first estrus in 1985 and 1986.

The data for return to estrus were not combined because of the two different methods to determine resumption of estrous cycles in each year. In 1985, visual observation for estrus was utilized to determine cyclicity and progesterone values in 1986.

The proportion of cows exhibiting estrous cycles as time progressed is depicted in figures 1 and 2. A greater ($P<.01$) percentage of BE cows were in estrus between 5 and 12 wk postpartum compared to NE cows in 1985. By 15 wk postpartum all cows in both groups had exhibited estrus. Cows that were greater than 30 d postpartum and had not been in estrus prior to synchronization were considered to

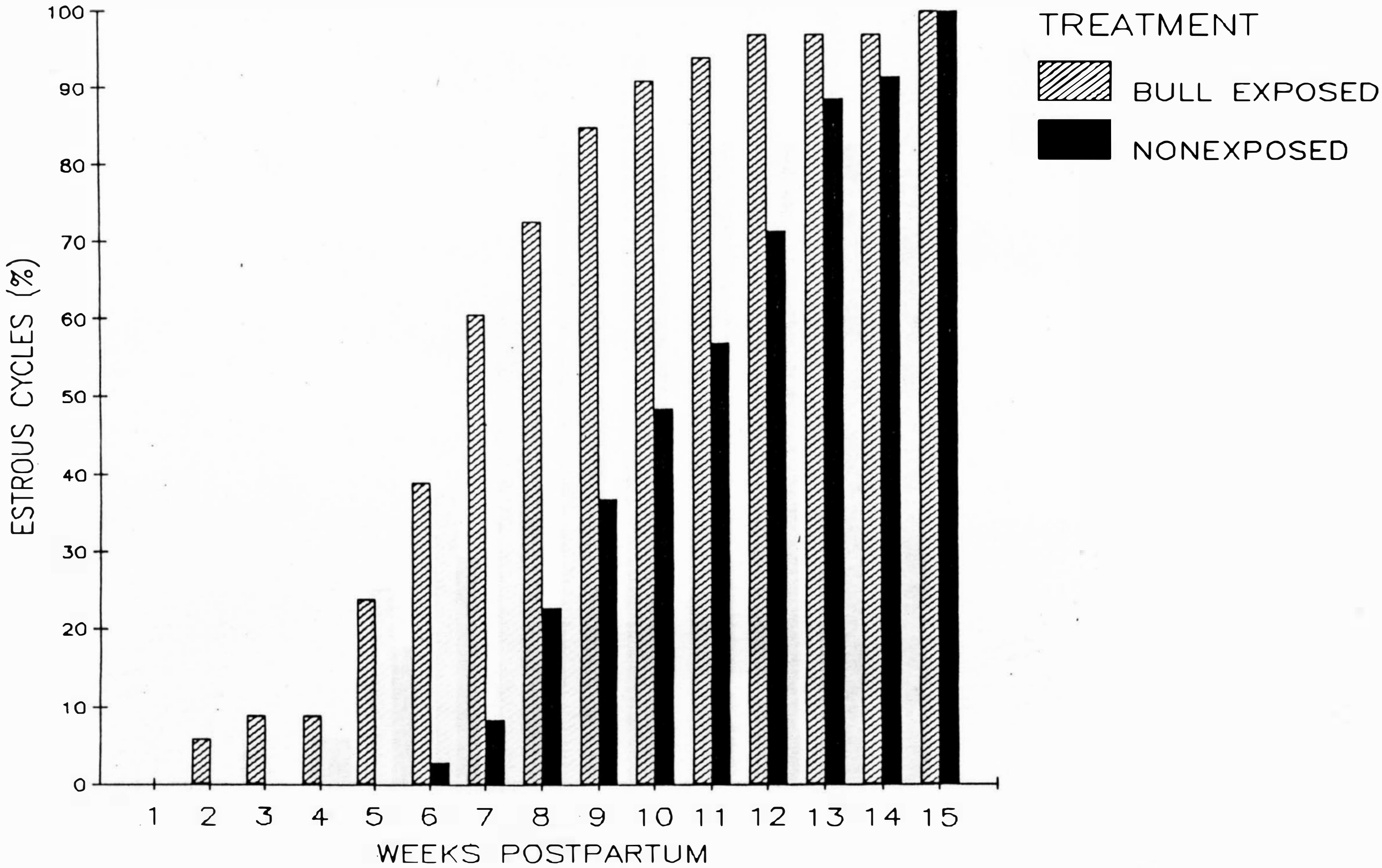
Table 1. LEAST-SQUARES MEANS FOR CALVING DATES, DATES OF FIRST ESTRUS, AND DAYS FROM CALVING TO FIRST ESTRUS[a]

	1985		1986	
	BE	NE	BE	NE
No. of cows	35	37	20	20
No. of cows >30 d postpartum	33	35	16	17
No. of cows culled	22	28	6	5
Avg calving date[bc]	83.5 ± 3.31	84.1 ± 3.22	89.1 ± 4.38	85.8 ± 4.38
Avg date of first estrus[bde]	128.4 ± 2.92	153.3 ± 2.84**	126.7 ± 3.29	132.2 ± 3.19
Avg days from calving to first estrus[de]	47.2 ± 3.13	71.4 ± 3.04**	45.8 ± 4.14	52.2 ± 4.02

[a]Values are means ± SE.
[b]Gregorian days.
[c]For all cows in the trial.
[d]Determined from visual detection in 1985 and from serum progesterone in 1986.
[e]For cows > 30 d postpartum.

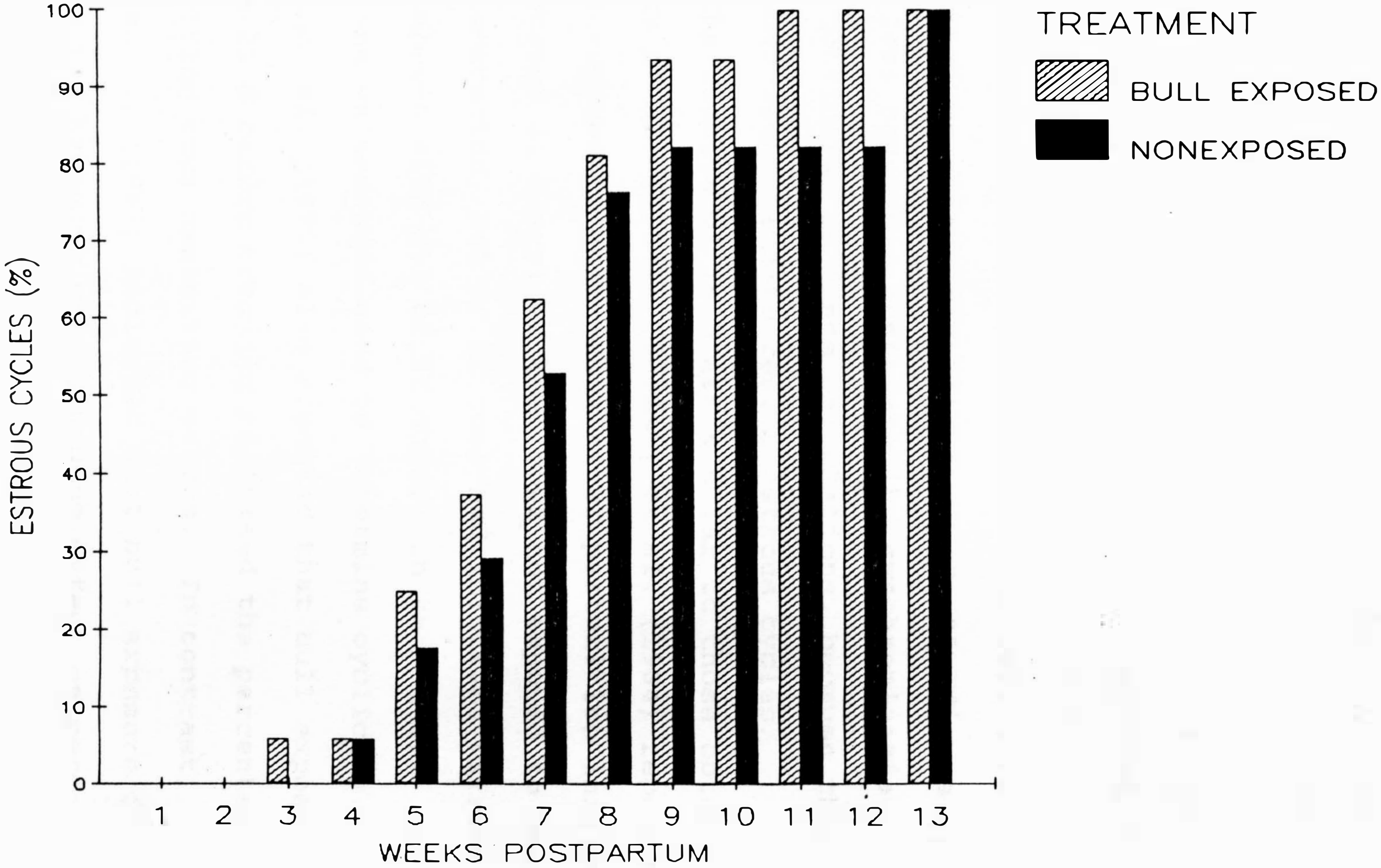
**P<.01

FIGURE 1: CUMULATIVE PERCENTAGE OF BULL EXPOSED AND NONEXPOSED COWS EXHIBITING ESTRUS AS TIME POSTPARTUM PROGRESSED, 1985.



Determined by visual observation.

FIGURE 2: CUMULATIVE PERCENTAGE OF BULL EXPOSED AND NONEXPOSED COWS IN ESTRUS AS TIME POSTPARTUM PROGRESSED, 1986.



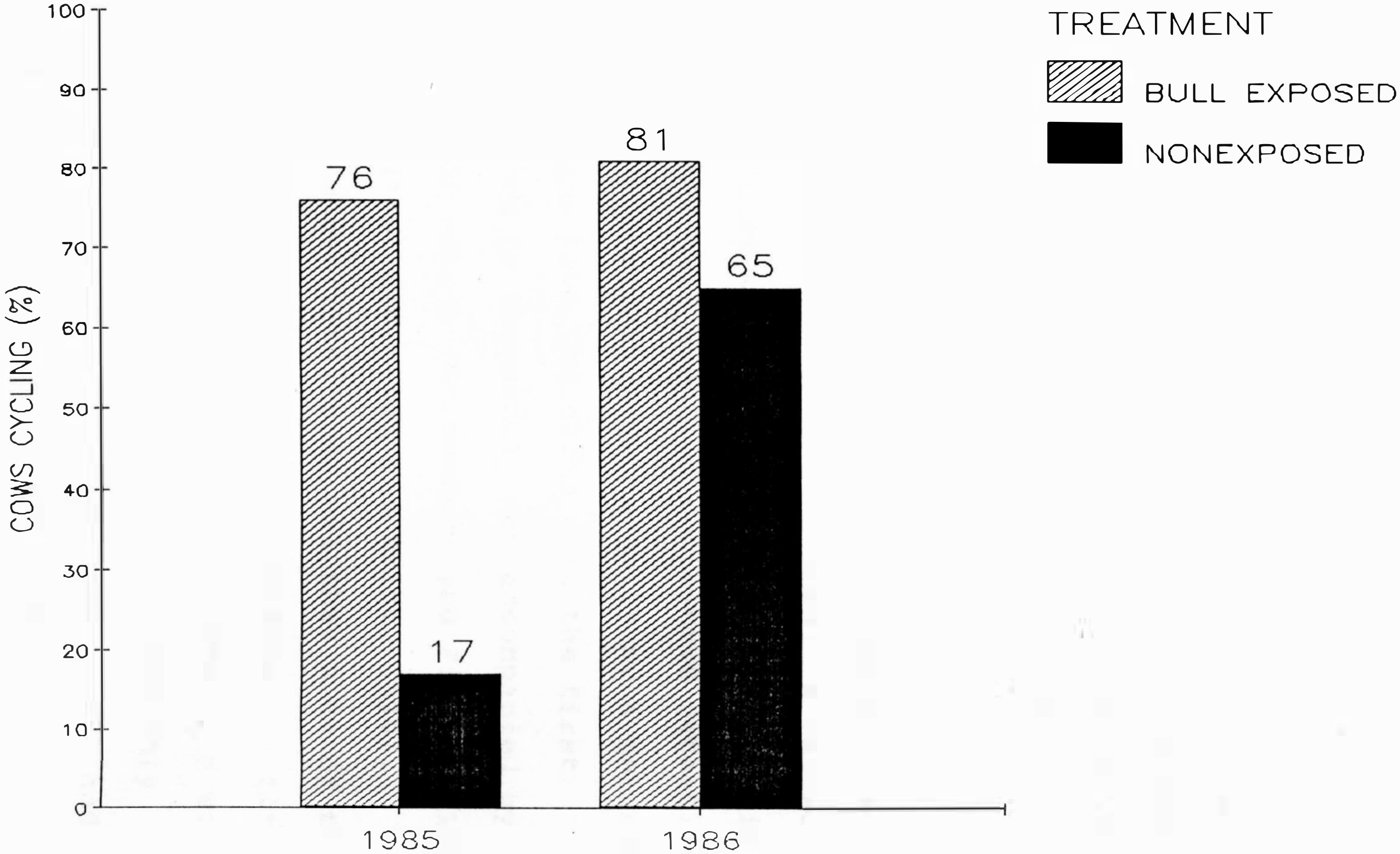
Determined by progesterone levels.

be in estrus 2 d after Synchro-Mate B implant removal. In 1986, there was no difference (P>.05) in the cumulative number of cows in estrus as time postpartum progressed. All cows were considered to be in estrus by 13 wk postpartum. By synchronization time in 1985, 76% (25/33) of the BE cows had initiated estrous cycles compared with 17% (6/35) of the NE cows (P<.01). In 1986, 81% (13/16) of the BE cows and 65% (11/17) of the NE cows were determined to be estrual by synchronization time (P>.05; figure 3). Any cows less than 30 d postpartum by synchronization time were not considered in these calculations, because they had not had sufficient time to resume estrous cycles.

The results of 1985 are similar to those obtained by Zalesky et al. (1984). Zalesky et al. (1984) reported that cows exposed to bulls soon after parturition initiated estrous cycles 21 d earlier than cows not exposed to bulls. By 53 d postpartum, 86% of BE cows had initiated estrous cycles compared with 23% of NE cows. In this study progesterone values were used to determine cyclicity. Macmillan et al. (1979) also reported that bull exposure for 18 to 21 d before breeding increased the percentage of spring calving cows exhibiting estrus. In contrast, Blaschke et al. (1981) indicated that bull exposure for 30 d prior to the breeding season had no effect on percent cyclicity.

The results of 1986 show no advantage (P>.05) for

FIGURE 3: PERCENTAGE OF BULL EXPOSED AND NONEXPOSED COWS IN ESTRUS PRIOR TO SYNCHRONIZATION FOR EACH OF THE TWO RESPECTIVE YEARS.



Determined by visual observation in 1985 and progesterone levels in 1986.

BE cows compared to NE cows regarding return to estrus. This is in contrast to the results obtained in 1985. This difference could be due to a number of reasons. The small number of cows available in 1986 limited the degrees of freedom. The greater the degrees of freedom, the greater is the chance of finding significance. A trend was noted that resulted in a slight advantage for BE cows in terms of date of first estrus and percentage cycling prior to synchronization.

The advantage for BE cows in 1985 may be due to failure to detect estrus in the NE cows. A review by Foote (1975) indicated that more cows were detected in estrus when a teaser bull was used for estrus detection compared to visual observation twice daily by a herdsman.

Many studies have indicated that the first postpartum ovulation is frequently not accompanied by observable signs of estrus (Trimberger and Fincher, 1956; Kiracofe et al., 1969; Stevenson and Britt, 1979). Trimberger and Fincher (1956) observed that 9.8% of the cows studied had a quiet ovulation preceeding the first observable estrus following parturition. The cows would not stand to be mounted by a teaser bull. The only observable sign of estrus was a mucous discharge, and a follicle palpated on the ovary. Odde et al. (1980) reported that the life of the corpus luteum associated with silent ovulation is shorter than corpora lutea produced at subsequent ovulations. Stevenson and Britt (1979) reported that for cows having estrous cycles of short duration, progesterone levels exceeded 1 ng/ml during only two sampling days of that cycle.

The criteria to determine onset of estrous cycles in 1986 were utilized to eliminate short luteal phases that occur prior to the onset of normal length cycles during the postpartum period (Humphrey et al., 1983). In the present study, progesterone concentrations between 1 and 2 ng/ml followed the next week by concentrations of < 1 ng/ml were considered indicative of short luteal phases.

A comparison of visual observation and progesterone values to determine return to estrus is presented in table 2. The percentage of cows cycling in the BE group is similar for both methods of estrus detection. This would indicate that the criteria used to evaluate progesterone values eliminated silent estrus and subsequent short

Table 2: COMPARISON OF VISUAL OBSERVATION (VO) FOR SEXUAL BEHAVIOR AND SERUM PROGESTERONE (P4) FOR DETERMINATION OF ESTRUS - 1986[a]

Trt	No. of cows	% in estrus determined by P4	% in estrus determined by VO
Bull exposed	16	81%	87.5%
Nonexposed	17	65%	23.5%

[a]Cows > 30 d postpartum.

cycles. In the NE group 41.5% more cows were determined to be in estrus utilizing progesterone values than by visual observation for signs of heat. This indicates that estrus detection with teaser bulls is more reliable than observation for homosexual behavior among cows. As discussed previously cows exhibit more definite signs of estrus in the presence of bulls.

The small number of cattle used in 1986 and the different methods of estrus detection used each year contribute to the of lack of conclusive results on the effects of bull exposure on the postpartum interval.

Synchro-Mate B Treatment and LH levels

Each year a group of cows from each treatment were bled to determine LH levels. Based on estrus detection data in 1985, 62.5% (5/8) of the BE cows and 21% (3/7) of the NE cows were in estrus prior to synchronization. One cow in the NE group was dropped due to inadequate sampling. In 1986, 100% (7/7) of BE cows and 28.6% (2/7) of NE cows were cyclic prior to synchronization based on progesterone levels. The number of cows exhibiting an LH peak corresponding to ovulation did not differ (P>.05) between treatment or year. In 1985, 87.5% (7/8) of BE cows and 71.4% (5/7) of NE cows exhibited an LH peak. In 1986, 71.4% (5/7) of BE cows and 71.4% (5/7) of NE cows had an LH peak.

Researchers do not agree on the effects of Synchro-Mate B on induction of estrus. Miksch et al. (1978) reported that synchronization with Synchro-Mate B may accelerate ovarian activity in anestrous cows. Conception rate after a single service was 60% for anestrous cows. In contrast, Smith et al. (1979) indicated that Synchro-Mate B treatment is not effective in inducing estrus in anestrus beef cows suckling calves. Miksch et al. (1978) described the cows used in their trial as being in good body condition and maintained on an adequate nutritional level. Conversely, the cows used in the study by Smith et al. (1979) were in thin body condition and were maintained on a restricted plane of nutrition prior to and after parturition. Smith et al. (1979) theorized that cow condition or energy intake at the time of treatment may be a factor determining whether an anestrous cow will respond to Synchro-Mate B treatment. The cows in the present study were in good condition each year.

Cows not exhibiting a LH peak did not conceive to the timed insemination. For both years, of the cows having an LH peak 52.6% (10/19) conceived to the timed insemination. Some of the cows in the 1986 trial were kept as embryo transfer recipients and not bred.

Rahe et al. (1980) reported that the preovulatory surge of LH fluctuated in a pulsatile manner and that duration of the surge is approximately 6 to 8 h in cows.

Peak LH levels did not differ between treatment (P>.05) but were different (P<.05) between years (table 3). Mean peak LH levels in 1985 were 7.25±5.78 and 7.65±6.84 ng/ml for BE and NE cows, respectively. In 1986, peak LH levels were 21.53±6.84 ng/ml for BE cows and 21.99±6.84 ng/ml for NE cows. The reason for this difference is not known. Time to the LH peak following Synchro-Mate B implant removal and calf removal did not differ (P>.05) between treatment and year. The LH surge corresponding to estrus occurred between 20 and 55 h after implant removal. The LH surge in 1985 occurred 31.28±3.10 and 30.20±3.67 h following Synchro-Mate B implant and calf removal in BE and NE cows, respectively. In 1986, the LH surge occurred 25.05±3.67 and 34.35± 3.67 h in BE and NE cows, respectively. Smith et al. (1977) reported that the LH surge corresponding to estrus occurred 24 to 40 h after implant and calf removal and levels varied from 2.4 to 15.5 ng/ml. The LH peak levels in this study ranged from 2.4 to 72.8 ng/ml. Schams et al. (1977) reported a maximum LH peak value of 50 ng/ml.

Estradiol levels were determined for the 1985 trial. An estradiol peak occurs on day 18 to 21 of the estrous cycle (estrus = day 0) that stimulates the preovulatory surge of LH (Schams et al., 1977; Bearden and Fuguay, 1984). Ecternkamp (1978) reported that estradiol levels decrease rapidly after a LH surge caused by injection of pregnant mare serum. Ecternkamp (1978)

Table 3. LEAST-SQUARES MEANS FOR TIME FROM SYNCHRO-MATE B (SMB) IMPLANT REMOVAL TO LH PEAK, PEAK LH LEVELS, AND ESTRADIOL LEVELS AT PEAK LH LEVELS[a]

	1985		1986	
	BE	NE	BE	NE
No. of cows	8	7[b]	7	7
No. exhibiting LH peak	7	5	5	5
Hours from SMB implant removal to LH peak	31.28 ± 3.10	30.20 ± 3.67	25.05 ± 3.67	34.35 ± 3.67
Peak LH levels (ng/ml)[c]	7.25 ± 5.78	7.65 ± 6.84	21.53 ± 6.84	21.99 ± 6.84
Estradiol levels (pg/ml) at LH peak[d]	4.89 ± 1.32	8.39 ± 1.56		

[a]Values are means ± SE.
[b]1 cow dropped due to inadequate sampling.
[c]Year effect (P<.05).
[d]Determined for 1985 only.

reported maximal estradiol levels of 8.4±1.0 pg/ml. Estradiol levels at the time of the LH peak in the present study ranged from 2.42 to 11.9 pg/ml and did not differ (P>.05) between treatment (table 3). Estradiol levels averaged 4.89±1.32 and 8.39±1.56 pg/ml for BE and NE cows, respectively.

Conception and Pregnancy Rates

Effects of bull exposure on conception and overall pregnancy rates are presented in table 4. The percentage of cows conceiving to the timed insemination was not affected (P>.05) by bull exposure or year. Conception to the timed insemination in 1985 was 63.3 (19/30) and 45.2% (14/31) for BE and NE cows, respectively. In 1986, conception rates for the timed insemination were 43.8% (7/16) for BE cows and 50% (8/16) for NE cows. The conception rates for first service in the present study are similar to those obtained by Smith et al. (1979) and Kiser et al. (1980) when cows were inseminated 48 h after Norgestomet implant and calf removal.

The percentage of cows conceiving during the 30 d AI period was not different (P>.05) between treatments or years. In 1985, 54.5% (6/11) of BE cows and 64.7% (11/17) of NE cows conceived during the AI period. In 1986, conception rates during the AI period were 33.3% (3/9) and 75% (6/8) for BE and NE cows, respectively. The total

Table 4. PREGNANCY RATES IN COWS EXPOSED (BE) AND NOT EXPOSED (NE) TO BULLS DURING THE EARLY POSTPARTUM PERIOD

	1985		1986	
	BE	NE	BE	NE
No. of cows bred	30	31	16	16
No. conceiving to timed insemination	19 (63.3)[a]	14 (45.2)	7 (43.8)	8 (50)
No. conceiving during 30 d AI period	6 (54.5)	11 (64.7)	3 (33.3)	6 (75)
Total no. pregnant[b]	28 (93.3)	30 (96.7)	14 (87.5)	16 (100)

[a]Percentages are given in parenthesis.
[b]Breeding season of 60 d, 30 d AI period and 30 d clean up.

percentage pregnant at the end of the breeding was similar (P>.05) between treatments and years (table 4). Pregnancy rates at the end of the breeding season in 1985 were 93.3 (28/30) and 96.7% (30/31) for BE and NE cows, respectively. In 1986, the total percentage pregnant was 87.5% (14/16) for BE cows and 100% (16/16) for NE cows.

These results indicate that bull exposure soon after parturition had no effect on pregnancy rates to a timed insemination, during the first 30 d of breeding or during the breeding season. Findings by Blaschke et al. (1981) also indicate no increased advantage in pregnancy rates for cows exposed to teaser bulls for 30 d prior to the breeding season.

The average interval to conception was not influenced (P>.05) by bull exposure, but was affected (P<.01) by year (table 5). The breeding season in 1986 was started 10 d earlier than in 1985. The average days from calving to conception in 1985 were 84.7±3.76 and 89.3±3.63 d for BE and NE cows, respectively. In 1986, the interval from calving to conception was 66.9±5.32 and 77.7±4.97 d for BE and NE cows, respectively. Average date of conception was not different (P>.05) between treatments, but was different (P<.01) between years (table 5). The average conception date in 1985 was day 167.2±2.85 and 174.0±2.75 for BE and NE cows, respectively. In 1986, the average date of conception was day 162.2±4.03 for BE cows

Table 5. LEAST-SQUARES MEANS FOR DAYS POSTPARTUM BY BREEDING, DATES OF CONCEPTION, DAYS FROM CALVING TO CONCEPTION, AND CALVING DATE FOLLOWING TREATMENT[a]

	1985		1986	
	BE	NE	BE	NE
Avg date calved[bc]	83.5 ± 3.31	84.1 ± 3.22	89.1 ± 4.38	85.8 ± 4.38
Avg days postpartum by breeding[cd]	74.5 ± 3.31	73.9 ± 3.22	58.9 ± 4.38	62.3 ± 4.38
Avg date of conception[bd]	167.2 ± 2.85	174.0 ± 2.75	162.2 ± 4.03	160.4 ± 3.77
Avg days from calving to conception[d]	84.7 ± 3.76	89.3 ± 3.63	66.0 ± 5.32	77.7 ± 4.97
Avg calving date following treatment[be]	83.8 ± 3.04	91.5 ± 2.94	79.6 ± 4.31	78.1 ± 4.03

[a]Values are means ± SE.
[b]Gregorian days.
[c]Includes all cows in the trial.
[d]Year effect (P<.01).
[e]Year effect (P<.05).

and day 160.4±3.77 for NE cows. The apparent advantage for BE cows in 1986 regarding days from calving to conception is not seen in average conception date. Some of the late calving cows in the BE group conceived early in the breeding season, whereas some late calving cows in the NE group were maintained as embryo transfer recipients and not bred. Therefore, the interval from calving to conception is shorter for BE cows, but average conception date is not different from NE cows.

A review by Wiltbank (1970) indicated that in beef cows conception rate at first service increases until approximately 90 d after calving. Conceptions rates prior to 60 d after calving will be low. Reeves and Gaskin (1981) reported that reducing the postpartum interval to first estrus by once daily suckling did not shorten the postpartum interval to conception. Short et al. (1972) also observed that the very early postpartum estrus is infertile. In contrast, Zalesky et al. (1984) reported that a significant number of cows conceived at the estrus associated with the first postpartum estrous cycle. The cows in the present study were not bred at first estrus and were approximately 60 d postpartum by breeding time (table 5). Therefore, bull exposure would not be expected to affect interval to conception or average date of conception in the present study.

The average calving date the spring following bull exposure was also not affected (P>.05) by treatment, but was affected (P<.05) by year (table 5). Bull exposed cows in 1985 calved at day 83.8±3.04 and NE cows calved at day 91.5±2.94 in 1986. Cows in the 1986 trial calved at day 79.6±4.31 and 78.1±4.03 in 1987 for BE and NE groups, respectively.

SUMMARY

This study was conducted to determine the effects of bull exposure during the early postpartum period on return to estrus and fertility in spring calving beef cows. The effects of bull exposure on LH release following Synchro-Mate B implant removal was also examined. In the spring of 1985, 72 purebred beef cows were exposed to epididectomized bulls 3 to 7 d after calving until synchronization with Synchro-Mate B or not exposed to bulls. Cows were observed for estrus twice daily beginning approximately 4 wk after the start of calving. The trial was repeated with 41 cows in the spring of 1986. Blood samples were collected weekly by jugular venepuncture and assayed for progesterone to determine resumption of estrous cycles. Cows in the 1986 trial were also observed for estrus.

All cows were synchronized with Synchro-Mate B and inseminated 48 h after implant removal without regard for estrus. Calves were removed for 48 h following implant removal. Each year a group of cows were randomly selected from the BE group (n=8, 1985; n=7, 1986) and NE group (n=8, 1985; n=7, 1986) and cannulated at estrus or within 34 h following Synchro-Mate B implant removal. Blood samples were collected at 15 min intervals for 2 h and every 2 h for 46 h for determination of serum LH levels. In 1985,

blood samples were also assayed for estradiol.

Bull exposed cows returned to estrus 24 d earlier (P<.01) than NE cows in 1985 (47.2±3.13 vs 71.4±3.04 d). No difference (P>.05) was observed between BE and NE cows for days from calving to resumption of estrous cycles in 1986 (45.8±4.14 vs 52.2±4.02 d). The percentage of cows exhibiting estrus prior to synchronization was greater (P<.01) for BE than NE cows in 1985 (76 vs 17%). In 1986, no difference (P>.05) between BE and NE cows was observed in the percentage of cows cycling by synchronization (81 vs 65%).

A small number of cows were randomly selected for determination of LH release. The number of cows exhibiting an LH peak following synchronization with Synchro-Mate B did not differ between BE and NE cows for either year. In 1985, 87.5% of BE cows and 71.4% of NE cows exhibited an LH peak. In 1986, 71.4% of BE and 71.4% of NE cows exhibited an LH peak. Peak LH levels did not differ between treatment (P>.05), but were different (P<.05) between years. Mean peak LH levels in 1985 were 7.25±5.78 and 7.65±6.84 ng/ml for BE and NE cows, respectively. In 1986, peak LH levels were 21.53±6.84 ng/ml for BE cows and 21.99±6.84 ng/ml for NE cows. Time to the LH peak following Synchro-Mate B implant removal and calf removal did not differ (P>.05) between treatment and year. The LH peak, in 1985, occurred 31.28±3.10 and 30.20±3.67 h following Synchro-Mate B implant and calf removal in BE and NE cows, respectively. In 1986, the LH surge occurred 25.05±3.67 and 34.35±3.67 h following implant and calf removal in BE and NE cows, respectively. Estradiol levels were determined for the 1985 trial and did not differ (P>.05) between treatment. Estradiol levels corresponding to the LH peak averaged 4.89±1.32 pg/ml for BE cows and 8.39±1.56 pg/ml NE cows.

The percentage of cows conceiving to the timed insemination was not affected (P>.05) by bull exposure or year. Conception to the timed insemination in 1985 was 63.3% for BE cows and 45.2% for NE cows. In 1986, conception rates for the timed insemination were 43.8 and 50% for BE and NE cows, respectively. The percentage of cows conceiving during the 30 d AI period was not different (P>.05) between treatments or years. In 1985, 54.5% of BE cows and 64.7% of NE cows conceived during the AI period. In 1986, conception rates during the AI period were 33.3 and 75% for BE and NE cows, respectively. The total percentage pregnant at the end of the breeding season was similar (P>.05) between treatments and years. Pregnancy rates at the end of the breeding season in 1985 were 93.3 and 96.7% for BE and NE cows, respectively. In 1986, the total percentage pregnant was 87.5% for BE cows and 100% for NE cows.

Days from calving to conception and average date of conception were not influenced (P>.05) by bull exposure, but were affected (P<.01) by year. The average calving date the spring following bull exposure was also not affected (P>.05) by treatment, but was influenced (P<.05) by year. The year effect is explained by the fact that the breeding season was started 10 d earlier in 1986 than in 1985.

The results of the two trials are inconclusive. The small number of cattle used in 1986 and the different methods of estrus detection used in each year make it difficult to determine the effects of bull exposure on the postpartum interval. Bull exposure soon after parturition may reduce the postpartum interval and increase the percentage cycling prior to the breeding season. However, if cows are at least 60 d postpartum by breeding, pregnancy rates are not influenced by bull exposure. Bull exposure also does not influence time from Synchro-Mate B implant removal to the LH peak or peak LH levels. Estradiol levels corresponding to the LH peak were not influenced by bull exposure.

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APPENDIX

TABLE 1. LEAST-SQUARES ANALYSIS OF VARIANCE FOR CALVING DATE

Source of variation	df	SS[a]	F	P
Treatment	1	46.871	.12	.73
Year	1	335.868	.88	.35
Treatment x year	1	102.799	.27	.61
Error	108	41450.617		
Total	111	41904.714		

[a] Sums of squares are SAS GLM Type III.

TABLE 2. LEAST-SQUARES ANALYSIS OF VARIANCE FOR DATE OF FIRST ESTRUS AND DAYS FROM CALVING TO FIRST ESTRUS[ab]

Source of variation	df	SS	F	P
		Date of First Estrus		
1985				
Treatment	1	10498.488	36.47	.0001
Error	66	18997.203		
Total	67	29495.691		
1986				
Treatment	1	259.094	1.50	.23
Error	31	5364.967		
Total	32	5624.061		
		Days From Calving to First Estrus		
1985				
Treatment	1	9938.728	30.73	.0001
Error	66	21343.081		
Total	67	31281.809		
1986				
Treatment	1	346.668	1.26	.27
Error	31	8498.059		
Total	32	8844.727		

[a] Cows >30 d postpartum.

[b] For cows >30 d postpartum not in estrus, date of first estrus was calculated as 11 d after Synchro-Mate B implant removal.

TABLE 3. LEAST-SQUARES ANALYSIS OF VARIANCE FOR DAYS TO FIRST ESTRUS

Source of variation	df	SS[a]	F	P
1985				
Treatment	1	10501.736	33.01	.0001
Age	1	664.517	2.09	.15
Error	65	20678.564		
Total	67	31281.809		
1986				
Treatment	1	311.071	1.10	.30
Age	1	1.648	.01	.94
Error	30	8496.411		
Total	32	8844.727		

[a] Sums of squares are SAS GLM Type III.

TABLE 4. CUMULATIVE NUMBER OF COWS EXHIBITING ESTRUS AS TIME POSTPARTUM PROGRESSED, 1985[ab]

Weeks postpartum	Nonexposed		Bull exposed	
	Cumulative	Percentage	Cumulative	Percentage
1	0	0	0	0
2	0	0	2	6.0
3	0	0	3	9.0
4	0	0	3	9.0
5	0	0	8	24.0
6	1	3.0	13	39.0
7	3	8.6	20	60.6
8	8	22.9	24	72.7
9	13	37.0	28	85.0
10	17	48.6	30	91.0
11	20	57.0	31	94.0
12	25	71.4	32	97.0
13	31	88.6	32	97.0
14	32	91.4	32	97.0
15	35	100.0	33	100.0

[a] Cows >30 d postpartum.
[b] Cows >30 d postpartum not in estrus, first estrus was calculated as 11 d after Synchro-Mate B implant removal.

TABLE 5. CUMULATIVE NUMBER OF COWS IN ESTRUS AS TIME POSTPARTUM PROGRESSED, 1986[ab]

Weeks postpartum	Nonexposed		Bull exposed	
	Cumulative	Percentage	Cumulative	Percentage
1	0	0	0	0
2	0	0	0	0
3	0	0	1	6.0
4	1	6.0	1	6.0
5	3	17.7	4	25.0
6	5	29.4	6	37.5
7	9	53.0	10	62.5
8	13	76.5	13	81.3
9	14	82.4	15	93.8
10	14	82.4	15	93.8
11	14	82.4	16	100.0
12	14	82.4	16	100.0
13	17	100.0	16	100.0

[a] Cows >30 d postpartum.

[b] Cows >30 d postpartum not in estrus, first estrus was calculated as 11 d after Synchro-Mate B implant removal.

TABLE 6. CHI-SQUARE ANALYSIS FOR CUMULATIVE NUMBER OF COWS IN ESTRUS AS TIME POSTPARTUM PROGRESSED, 1985 AND 1986

	χ^2 value, 1 df[a]	
Week	BE vs NE 1985	BE vs NE 1986
2	2.185	--
3	3.329	1.096
4	3.329	.002
5	9.616**	.267
6	13.869**	.243
7	20.546**	.308
8	16.956**	.113
9	16.147**	1.005
10	14.264**	1.005
11	12.266**	3.106
12	8.172**	3.106
13	1.759	.000
14	.942	--
15	.000	--

[a] $\chi^2_{.05}$ value = 3.84 for 1 df.
**$P < .01$, $\chi^2_{.01}$ value = 6.63 for 1 df.

TABLE 7. CHI-SQUARE ANALYSIS OF VARIANCE FOR NUMBER OF COWS IN ESTRUS BY SYNCHRONIZATION

	χ^2 value, 1 df
	Bull exposed vs nonexposed
1985	23.526**
1986	1.137

**$P < .01$, $\chi^2_{.01}$ value = 6.63 for 1 df.

TABLE 8. CHI-SQUARE ANALYSIS FOR NUMBER OF COWS EXHIBITING AN LH PEAK

	χ^2 value, 1 df[a]
Bull exposed vs nonexposed	.291
1985 vs 1986	.291
Year 1985	
Bull exposed vs nonexposed	.603
Year 1986	
Bull exposed vs nonexposed	.000

[a] $\chi^2_{.05}$ value = 3.84 for 1 df.

TABLE 9. LEAST-SQUARES ANALYSIS OF VARIANCE FOR TIME FROM SYNCHRO-MATE B (SMB) IMPLANT REMOVAL TO LH PEAK AND PEAK LH LEVELS

Source of variation	df	SS[a]	F	P
		Time From SMB Implant Removal to LH Peak		
Treatment	1	90.989	1.35	.26
Year	1	5.816	.09	.77
Treatment x year	1	145.001	2.16	.16
Error	18	1210.089		
Total	21	1436.662		
		Peak LH Levels		
Treatment	1	.998	.00	.95
Year	1	1103.323	4.71	.04
Treatment x year	1	.005	.00	.99
Error	18	4212.213		
Total	21	5336.086		

[a] Sums of squares are SAS GLM Type III.

TABLE 10. LEAST-SQUARES ANALYSIS OF VARIANCE FOR ESTRADIOL LEVELS CORRESPONDING TO PEAK LH LEVELS[a]

Source of variation	df	SS	F	P
Treatment	1	35.718	2.92	.12
Error	10	122.398		
Total	11	158.115		

[a] Determined for 1985 only.

TABLE 11. CHI-SQUARE ANALYSIS FOR NUMBER OF COWS CONCEIVING TO TIMED INSEMINATION DURING 30 D AI PERIOD AND DURING BREEDING SEASON

	χ^2 value, 1 df[a]
No. Conceiving to Timed Insemination	
Bull exposed vs nonexposed	.878
1985 vs 1986	.439
Year 1985	
Bull exposed vs nonexposed	2.027
Year 1986	
Bull exposed vs nonexposed	.125
No. Conceiving During 30 D AI Period	
Bull exposed vs nonexposed	2.409
1985 vs 1986	.262
Year 1985	
Bull exposed vs nonexposed	.289
Year 1986	
Bull exposed vs nonexposed	2.951
No. Conceiving During Breeding Season	
Bull exposed vs nonexposed	1.971
1985 vs 1986	.073
Year 1985	
Bull exposed vs nonexposed	.386
Year 1986	
Bull exposed vs nonexposed	2.133

[a] $\chi^2_{.05}$ value = 3.84 for 1 df.

TABLE 12. LEAST-SQUARES ANALYSIS OF VARIANCE FOR DAYS POSTPARTUM BY BREEDING

Source of variation	df	SS[a]	F	P
Treatment	1	47.814	.12	.73
Year	1	4774.464	12.42	.001
Treatment x year	1	101.414	.26	.61
Error	108			
Total	111			

[a] Sums of squares are SAS GLM Type III.

TABLE 13. LEAST-SQUARES ANALYSIS OF VARIANCE FOR DATE OF CONCEPTION, DAYS FROM CALVING TO CONCEPTION AND CALVING DATE FOLLOWING TREATMENT

Source of variation	df	SS[a]	F	P
		Date of Conception		
Treatment	1	127.039	.56	.46
Year	1	1697.135	7.46	.008
Treatment x year	1	367.056	1.61	.21
Error	84	19119.368		
Total	87	21592.000		
		Days From Calving to Conception		
Treatment	1	1181.365	2.98	.09
Year	1	4277.938	10.79	.002
Treatment x year	1	187.894	.47	.49
Error	84	33317.926		
Total	87	38637.773		
		Calving Date Following Treatment		
Treatment	1	183.358	.71	.40
Year	1	1516.917	5.83	.02
Treatment x year	1	422.571	1.63	.21
Error	84			
Total	87			

[a] Sums of squares are SAS GLM Type III.