SYNCHRONIZATION OF ESTRUS IN BEEF CATTLE: VARIOUS USES OF SYNCRO-MATE-B® AND A COMPARISON OF SYNCHRONIZATION AND ARTIFICIAL INSEMINATION WITH NATURAL SERVICE

by

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Since the advent of artificial insemination, several attempts have been made to reduce or eliminate estrus detection in beef cattle. Wishart and Young (1974) reported that farmers involved with herds used in their research were able to detect estrus in only 59-80% of heifers that were actually in heat or had ovulated. Broadway et al. (1975) reported that 25% more females were found in estrus when checks were made for estrus four times daily than twice daily. That indicates how labor intensive good heat detection is for effective use of artificial insemination. Artificial insemination in beef cattle is practiced less than 10% of that in the dairy industry and in less than 5% of all beef cattle primarily due to estrus detection problems.

Steroid hormones, through feedback mechanisms, control the estrous cycle. The use of steroid hormones and synthetic steroid hormones has been researched by many in efforts to control the estrous cycle. The use of exogenous progestagens to block estrus and ovulation was first used in an attempt to synchronize estrus (Christian and Casida, 1948). Later the use of estrogenic compounds, which can be luteolytic early in the estrous cycle of the cow came on the scene (Hansel and Convey, 1984). The idea soon developed that a combination of a progestagen and an estrogen could theoretically synchronize all cycling females. If a corpus luteum is forming early in the cycle the combination of estrogen and progesterone should alter its formation so that removal of the progesterone should result in the female showing estrus. If the female is later in the cycle, a prolonged period of progestagen treatment should block estrus after the corpus luteum naturally regresses until the progestagen is removed. Mimicing hormonal patterns and altering the females natural hormonal secretions should allow control of estrus and ovulation. By controlling when the cow ovulates one could inseminate her without estrus detection. Since the hypothalmic regulation is relatively sensitive to hormone levels, dosages and duration of treatment were investigated extensively so that acceptable fertility could result from a controlled estrus and subsequent ovulation.

Since Christian and Casida (1948) first reported synchronization of estrus with progesterone , many attempts to synchronize estrus have been made using different forms of progesterone or progesterone in combination with estrogens. Nellor and Cole (1956) reported synchronization of 6 of 7 heifers to a 3 d period, 17-19 d after the injection, using progesterone in a starch suspension. Foote and Hunter in (1964) reported that treatment with progesterone alone had no effect on conception rates but tended to lower fertility when used with estradiol, but that progesterone plus estrogen shortened the interval from parturition to conception. Wiltbank et al. (1965) gave various levels of progesterone in combination with estradiol in daily injections starting on different days of the cycle. The combination of progesterone and estrogen regressed the corpus luteum regardless of when treatment started, and stage of the estrous cycle had little or no effect on resulting synchrony. Woody et al. (1967) showed that 100 mg progesterone daily for 10 d started on the day of estrus gave a significant reduction in estrous cycle length. Ray et al. (1961) using repositol found corpora lutea were smaller than control heifers and resulting FSH and LH releases were lower, they used this as a partial explanation of lowered fertility subsequent to extended progesterone treatment. Liang and Fosgate (1971) using 17-alpha-ethynyl-19-nortestosterone (SC4640) and Nilevar for 17 d found a high degree of synchronization in cows and heifers but low pregnancy rates in cows. Smith and Vincent (1973) found somewhat contradictory results using the progestagen Nilevar. They gave 1 to 3 injections with or without estradiol valerate and found a significant reduction in first service conception rates in heifers. Anderson et al. (1962) used a combination of norethynodrel and Enovid in heifers. That combination successfully blocked estrus and estrus occurred over a 4 d period after the end of treatment. With this combination, higher conception rates were achieved when the hormones were fed (orally active) versus injection in suspension. Anderson et al. (1962) fed MAP and all heifers came in estrus in a 3 d period and had conception rates equal to control heifers. Other investigators (Hansel et al., 1961; Zimbelman 1963; and Dhindsa et al., 1967) found similar results although heifers seemed to respond better than cows. Dhindsa et al. (1967) reported that feeding MAP once or twice daily, as long as the total daily intake was the same, had no effect on the response. Hansel et al. (1961) also reported that some females had ovulated but had not been observed in estrus. Further work by Hansel et al. (1975) with MAP in drinking water gave acceptable estrus synchrony although some females had ovulation without estrus. The hormonal pattern suggested that premature or greatly delayed LH surges were the main cause of reduced fertility. Work by Hansel et al. (1966) using MAP and CAP, orally, for 18 d also resulted in synchronization but first and second service conceptions rates were lower with CAP compared to MAP. MAP in this case resulted in significantly more cows pregnant at first service than controls and also greater pregnancy rates after a second breeding. MAP in combination with an injection of estradiol benzoate on the second day of feeding (Randel et al., 1973) resulted in 100% estrus response 27 to 60 h after the last feeding of MAP. Randel et al. (1973) also reported that in these cows, cervical stimulation by artificial insemination hastened the LH surge while not affecting the level of release and that clitoral stimulation shortened the interval from onset of estrus to ovulation. The use of 16-alpha-17- dihydroxyprogesterone acetophenide (DHPA) by Wiltbank et al. (1967) and Wiltbank and Kasson (1968) for 7, 9, or 20 d resulted in synchronization with conception rates similar to controls.

Implants containing a progestagen came into use in the early seventies, that mode of administration tended to reduce feed mixing requirements and offered a more uniform dosage rate. Wiltbank et al. (1971) compared Nilevar implants with the hormone either in the lumen of the implant or divided between the wall and the lumen. The implants with the Nilevar only in the lumen did not block heat in a large number of the animals treated. Acceptable synchrony and fertility resulted when the implants were effective in blocking estrus. The use of progesterone impregnated silastic coils by Roche (1975,1976) for 12 d in combination with an injection of estradiol benzoate and progesterone at the start of treatment synchronized over 60 percent of those treated to a 1 day period. Fertility was no different for females inseminated after estrus or at 56 h after removal of the coil. Use of vaginal pessaries, with an injection of estradiol benzoate and progesterone at insertion, (Screenan and Mulvehill, 1975) for a 10 d period gave slightly higher calving rates than controls inseminated by estrus for the same period. Roche (1974) investigated the effect of estradiol benzoate in various stages of the estrous cycle with a 9 d implant of progesterone. The highest degree of synchrony (100% in 3 d) occurred when females were between day 6 and 14 when implanted. Further research by Roche (1974) indicated that increasing the surface area of the implant increased the effectiveness of synchronization. Woody and Pierce (1974) used an implant containing 250 mg norethandrolone with an injection of estradiol valerate. When implanted after day 10 of the estrous cycle they found the interval to estrus was shorter than if heifers had been earlier in the cycle when treatment was initiated. Sixteen day implants gave reduced fertility if started late in the cycle while the 9 d norethandrolone implant plus estradiol valerate failed to hasten corpus luteum regression early in the cycle. Whitman et al. (1972) and Burrell et al. (1972) reported on the use of a norgestomet (SC21009) implant plus 5 to 7.5 mg of estradiol valerate at implant. Synchrony was improved with 7.5 mg estradiol valerate versus 5 mg but first service conception was lowered with the increased estradiol valerate level. Chupin et al. (1975) reported that injecting norgestomet and estradiol valerate in combination with implanting norgestomet gave results comparable to longer implant periods without injection of norgestomet. Work by Gonzalez-Padilla et al. (1975) compared norgestomet implants plus injections of estradiol valerate and norgestomet to four daily injections of progesterone with estradiol on the first day and 17B-estradiol 2 d after the last progesterone injection. With noncycling heifers the norgestomet estradiol valerate combination resulted in significantly more heifers pregnant 4, 21, and 45 d after the treatment along with higher first service conception rates than the other treatment or in controls inseminated at their first detected estrus. Lemon (1975) compared norgestomet implants plus estradiol valerate or estradiol benzoate to injections of Nilevar plus estradiol valerate or estradiol benzoate. When used alone, estradiol benzoate was a more effective luteolytic agent than estradiol valerate but the best combination for shortening the estrous cycle by decreasing progesterone levels and regressing the corpus luteum was norgestomet plus estradiol valerate. Woody and Abenes (1975) worked with varying levels of norgestomet in the implant, with or without estradiol valerate at implantation. They reported lower fertility when treatment was started on day 14 versus day 2 of the estrous cycle. With a 9 d implant, 12 mg SC21009 gave closer synchrony and in combination with 5 mg estradiol valerate gave the highest fertility. Reports by Spitzer et al. (1976), a 6 mg SC21009 implant plus 3 mg SC21009 and

5 or 6 mg estradiol valerate injected, show that 6 mg estradiol valerate gave a higher degree of synchrony than 5 mg estradiol valerate with resulting higher first service conception rates. Zaied et al. (1976) further reported that cows with a corpus luteum at start of treatment had a higher pregnancy rate and that lactating cows had lower pregnancy rates than non-lactating cows with similar postpartum intervals. Spitzer et al. (1976) found that the treatment was more effective in cows further postpartum. Work reported by Spitzer et al. (1978) and Miksch et al. (1978) agreed with previous reports in which heifers treated either early or late in the cycle failed to respond to the treatment. An injection of 17B-estradiol near the time of implant removal failed to decrease variation associated with onset of estrus or ovulation. Spitzer et al. (1978) reported that implanting in the middle portion of the ear resulted in fewer lost implants and thus was more effective than implanting near the tip or base of the ear.

Davenport et al. (1979,1980), working in product research and development for G.D. Searle and Company, did extensive field trials using a product they named Syncro-Mate-B® (SMB). This treatment consisted of a 6 mg implant of SC21009 (norgestomet, a synthetic progestagen) in combination with an injection containing 3 mg SC21009 and 5 mg estradiol valerate at the time of implant. The implant was placed subcutaneously on the outer surface of the ear and left in situ for 9 d. CEVA Laboratories Inc. later purchased the rights to this product and received FDA approval for it use in beef and dairy heifers in 1982.

Further work on cows 40 to 60 d postpartum receiving a 6 mg SC21009 implant with 3 mg SC21009 plus 6 or 7 mg estradiol valerate by Smith et al. (1979a) showed that calf removal decreased variation in time of estrus as all cows that responded to the treatment had shown estrus by 42 h following implant removal. Calves were removed at the time of implant removal. Results for synchrony and pregnancy rates were equal for calf removal anytime 24 h before to 24 h after implant removal. Removing calves from lactating beef cows for 48 h seems to have no detrimental effects on milk production, calf growth rate, and weaning weights as shown by Beck et al. (1979).

Mares et al. (1977) used a 6 mg norgestomet implant with an injection of 3 mg norgestomet plus 6 mg estradiol at implant to test timed insemination against imsemination by estrus. In herds with less than 50 percent of the cows cycling, inseminating by appointment resulted in higher 5, 25, and 45 d pregnancy rates than inseminating by estrus and in significantly higher pregnancy rates than in controls inseminated by estrus with out synchronization. In herds with greater than 50 percent of the cows cycling, 5 d pregnancy rates were significantly higher in cows inseminated by appointment than in cows inseminated by estrus or controls, with 25 and 45 d pregnancy rates also showing an advantage. Work with dairy heifers by Anderson et al. (1982) indicated inseminating by estrus resulted in higher conception rates in cycling dairy heifers. In non-cycling dairy heifers, varying results have been reported. More reports on timing of insemination by Wishart and Young (1974), Henderson (1978), Davenport et al. (1979), Kiser et al. (1980), Spitzer et al. (1981) and Kazmer et al. (1981) all show that insemination by appointment results in satisfactory conception rates following SMB treatment. Although these researchers used a variety of times to inseminate, a range of 45 to 55 h after implant removal gave no large differences in conception rates especially when calf removal was practiced in lactating cows. Synchronized heifers have been bred by natural service, Farin et al. (1982) showed pregnancy rates somewhat lower than those inseminated by appointment. These results suggest that insemination by appointment can be a viable alternative.

Smith et al. (1979b) reported that heifers weighing over 250 kg had increased reproductive performance following treatment with SMB. In a large number of Brahman cross heifers not observed in estrus in the previous 36 d, over 91 percent showed estrus and over 50 percent conceived to first service. Spitzer later reported (1982) that while most heifers reach puberty at 13 to 16 months, weight is the determining factor influencing the onset of puberty. Spitzer also reported inducing estrus in light weight heifers but pregnancy rates were very low and few continued cycling. Reasons for reduced conception rates in heifers induced to cycle are not clear. Hixon et al. (1981) reported that short luteal phases which occur in about 20 percent of the anestrous animals reduced first service conception rate in heifers but that cyclicity did not affect first service conception rate in cows.

Guidelines for the SMB treatment reported by Davenport et al. (1980) include adequate nutrition, 30 d or more postpartum before initiation of treatment, and 48 h calf removal in lactating cows. Although treatment at 30 d postpartum will induce some non-cycling cows to exhibit estrus, Henderson (1978) reported that cows less than 42 d postpartum have twice as many noncycling than cows greater than 42 d postpartum. This agrees with Perkins and Kidder (1963) as they reported an average uterine involution time of 37 d , and Warnick (1955) who had reported an interval of return to first estrus of 47 to 77 d. Holtz et al. (1979) separated cows less than 50 d postpartum from cows greater than 50 d postpartum and found a three fold increase in the number of cows calving at the expected time when SMB treatment was started after 50 d postpartum.

The use of synchronization to decrease the interval from calving to conception is a valuable management tool. Reports by Burris and Priode (1958), Davenport et al. (1965), and Lesmeister et al. (1973) indicate that heritability for selection of early calving cows is low but that if a heifer calves early her first time she will tend to calve earlier throughout her life. Heifers that calved early also had a higher average lifetime calf production by weaning heavier calves at a set weaning date. Further information by Burris and Priode (1958) indicates that for each 20 d delay in calving there was a 6 percent decrease in the number of cows calving the following year.

The importance of proper nutrition during the time of treatment and rebreeding was shown by Wiltbank et al. (1964). Cows that were fed 150% of NRC TDN 4 wk postpartum had higher conception rates than cows fed only NRC TDN levels from calving to breeding. Feeding the higher levels of energy immediately post calving also gave higher conception rates than feeding extra energy preceding calving.

EXPERIMENT 1. TIMED ARTIFICIAL INSEMINATION AFTER SYNCRO-MATE-B® (SMB) TREATMENT COMPARED TO NATURAL SERVICE

SUMMARY

In two trials, a total of 167 crossbred cows and heifers were assigned to two groups by age, postpartum interval, and cycling status (determined by blood progesterone levels). Cows in the treatment group were synchronized with Syncro-Mate-B® and inseminated by appointment 48-54 h after implant removal, then exposed to bulls 3 d later. Cows in the control group were not synchronized and were allowed to mate naturally beginning the same day that the synchronized cows were inseminated.

TRIAL 1

At the time of insemination, 82.8% of cycling females and 67% of non-cycling treated females had been in estrus since implant removal as indicated by KAMAR® heatmount detectors. The percentage of females conceiving to the timed insemination was 53.6 (15/28) for cycling and 50 (3/6) for non-cycling females. The percentage pregnant for treated and control cows at 10 d and 20 d from the start of the breeding season were 52.9 and 21.2, 64.7 and 51.5, respectively. The average interval from the start of breeding to conception was longer (P=.1) for control cows (31 d) than for treated cows (24 d) and the average calving interval was also longer (P=.05) for controls (367 vs 358 d). Average calf weights 169 d from the start of the calving season were higher for calves from treated cows (P=.15) than for those from control cows (167.6 vs 157.6 kg).

TRIAL 2

The percentage of females conceiving to the timed insemination was 42% overall with 45.2% of the cycling cows and 25% of the noncycling cows conceiving. Pregnancy rates at 10 d and 20 d from the start of the breeding season were 42% and 56% for synchronized cows, 20% and 60% for unsynchronized cows. The use of synchronization and timed insemination in this trial resulted in a tight grouping of calves from artificial insemination early in the calving season. In the overall calving season, however, much of the advantage noted in Trial 1 had been negated.

INTRODUCTION

Syncro-Mate-B® (CEVA Laboratories Inc., Overland Park, KS) is the trade name for an estrous synchronization treatment approved for use in beef and dairy heifers but as yet unapproved by the FDA for use in cows. The treatment consists of a hydron implant containing 6 mg SC21009 (norgestomet) placed subcutaneously in the back middle one third of the ear for 9 d. An injection containing 5 mg estradiol valerate and 3 mg norgestomet in sesame oil is given at the time of implantation.

Heifers that calve earlier in the calving season will calve earlier in subsequent years and calves born earlier grow significantly faster from birth to weaning and will weigh more at weaning than calves born later in the calving season (Lesmeister et al. 1973). It has further been reported that heritability and repeatiblity of such parameters as calving date, interval from calving to first estrus, and interval to subsequent pregnancy is low with little progress to be made from selection (Davenport et al., 1965).

There is evidence to indicate that Syncro-Mate-B® can be successfully used in beef cows with timed insemination. Best results have occurred when calves are separated from cows from the time of the norgestomet implant removal until insemination 48 h later (Wishart and Young, 1974; Henderson, 1978; Davenport et al., 1979; Kiser et al., 1980; and Kazmer et al., 1981). Much work has shown that pregnancy rates at various stages early in the breeding season give an advantage to synchronization when compared to unsynchronized cows (Mares et al., 1977).

This experiment was conducted to determine if timed insemination following synchronization with Syncro-Mate-B® would be feasible to the cow-calf producer who does not practice synchronization or artificial insemination.

MATERIALS AND METHODS

TRIAL 1

Sixty-seven fall calving cows at the Ft. Hays Branch Experiment Station were divided into two groups by cow age, postpartum interval, and cycling status. Cows in Group 1 had estrus synchronized, were inseminated by appointment, then placed with bulls. Group 2 (Controls) were not treated and were exposed to bulls for natural mating. Average age and postpartum interval for Group 1 and 2, respectively, were 5.0 yr and 63.48 d , 4.94 yr and 64.08 d. Cycling status was determined by radioimmunoassay of blood serum progesterone as described by Stevenson et al. (1984). All cows were bled twice by jugular venipuncture, 7 d apart before the experiment was started. Blood was collected in 16 x 127 mm sterile evacuated blood collection tubes. Blood was transported from the site of collection to the laboratory in an ice chest. Serum was collected by centrifugation (20 min at 2400 rpm) within 24 h of collection. Serum was then frozen and stored at -8^{o} C until the radioimmunoassay was performed.

Females with serum progesterone levels of less than 1 ng/ml for both collections were considered to be non-cycling (Godke et al., 1979; Adeymo and Heath, 1980) at the start of the experiment.

All females in Group 1 received a 6 mg norgestomet implant, placed subcutaneously in the back middle one third of the ear for 9 d and were also given an injection of 3 mg norgestomet and 5 mg estradiol valerate in sesame oil at the time of implantation (standard Syncro-Mate-B® treatment). Treatment was initiated immediately after collection of the second blood sample. Implants were removed 9 d later and all calves were separated from the cows from the time of implant removal until after insemination which was 48-52 h after implant removal. Calves were retained so that they could be seen and heard by the cows but no direct physical contact could occur. KAMAR® heatmount detectors were placed on the rump of all cows in Group 1 to determine if estrus had occurred in the interval from implant removal to insemination. Females in Group 1 were inseminated with semen collected by a reputable bull stud. All semen was packaged in .5 cc straws which were thawed for 20 sec in a 35-37° C water bath. The four inseminators were stratified over cows and heifers, cycling and non-cycling females, and the bulls used for insemination. Cows were inseminated with semen from a Simbrah bull and heifers were inseminated with Hereford semen. A Simmental bull was placed with cows, a Red Angus bull with heifers, from 3 to 60 d after artificial insemination. The cleanup bull being a different breed was used to help in determining sire of calves.

Cows in Group 2 were allowed to mate naturally with a Simmental bull with the breeding season beginning the day that Group 1 was artificially inseminated. The breeding season lasted for 60 d and was the same time period for both groups.

Pregnancy diagnosis 60 d after insemination of Group 1 and calving dates based on a 283 d gestation were used to calculate conception date. Breed of the calf was also used if actual calving date did not match the projected calving date. Calf weights were obtained for all calves approximately 5.5 mo after the start of the calving season.

TRIAL 2

One hundred spring calving crossbred cows of Hereford, Angus, and Simmental origin at the Ft. Hays Branch Experiment Station were divided as in Trial 1. Average age and postpartum interval for Groups 1 and 2, respectively, were 7.3 y and 64.3 d, 7.9 y and 66.4 d. A visual body condition score (Clarke, 1983) was obtained 49 d and 2 d before the breeding season began. Average condition scores for Group 1, 49 and 2 d before the breeding season were 5.08 and 5.05, and for Group 2, 49 and 2 d before the breeding season were 4.93 and 5.15.

Treatments for Groups 1 and 2 were identical to those in Trial 1 except KAMAR® heatmount detectors were not used and calves were not weighed in this trial. Cows were inseminated with semen from one Simmental and one Hereford bull. Bulls were stratified over cycling and non-cycling cows as were the three inseminators to remove inseminator and sire bias. Two Simmental bulls were placed with the cows 3 d after they were artificially inseminated for a period of 57 d.

Statistical analysis was performed by general linear models (SAS, 1979) for the following variables: treatment group, inseminator, sire, postpartum interval, initial and final progesterone levels, age of the female, visual body condition scores, and season between trials.

RESULTS AND DISCUSSION

TRIAL 1

Calves from the treated group were born earlier (P<.05) and were heavier (table 1) than calves from the untreated group. Since postpartum interval for the two groups was nearly equal at the start of the breeding season, calving interval was also shortened (P<.1) in the treated cows (table 1).

Overall pregnancy rates were not different for the 60 d breeding season (table 2). Pregnancy rates at 10 and 20 d after the start of breeding were higher for treated cows (table 2). Pregnancy rate at 10d for the treated group only included pregnancies to the timed insemination following synchronization since all 18 calves were sired by artificial insemination. The 20 d pregnancy rate for the treated group probably includes cows which were synchronized but did not conceive to the timed insemination. Pregnancy rates (table 2) were similar to pregnancy rates reported by Gonzalez-Padilla et al. (1975) in heifers and Mares et al. (1977) in cows in that early pregnancy rates favor synchronization with non-synchronized cows catching up by the end of the breeding season.

The use of KAMAR®'s in the this experiment proved ineffective as an activated or missing KAMAR® was not a good indicator of subsequent conception. In cows considered to have been in estrus in the interval between implant removal and insemination, 43% conceived to the timed insemination while 57% not showing estrus conceived. Although a higher percentage of cows not showing estrus by the time of insemination conceived (57% vs 43%) it should be noted that no non-cycling cows (0/2) conceived without showing estrus while 50% of the non-cycling cows showing estrus conceived. This indicates that in non-cycling cows that it may be advisable to check for estrus before inseminating, especially if expensive semen is being used.

TRIAL 2

For the overall calving season, there was no significant difference in birth date of calves in the two groups (table 3). Pregnancy rates at 10 d of the breeding season gave a two fold advantage to the synchronized cows. This advantage, however, had been negated by 20 d of the breeding season and virtually no difference existed from 20 d to the end of the breeding season (table 4).

No significant differences occurred in the interval from the start of the breeding season to calving or in calving interval due to body condition at either of the times the cows were scored or the change in body condition between the two scores. Cows with the highest initial body condition scores tended to calve earlier, but cows with a higher body condition score at the start of the breeding season calved slightly later (table 5).

In combining the results of Trials 1 and 2, we see a significant advantage in calving date and calving interval from synchronization and timed insemination early in the breeding season (table 6). Once again the conception rate for the control group is equal to or slightly better than the treated group by 20 d of the breeding season (table 7).

The following variables were analyzed but no discussion will be included as all had minimal to no effect on the parameters we measured: inseminator, sire, postpartum interval at the start of the breeding season, progesterone level at either blood sample, age of the female, or season of the trial.

From the results of this experiment it would appear that a possible advantage of synchronization and timed insemination would be for the producer who has been unable to utilize artificial insemination due to labor limitations or accessibility of cows. In this case, synchronization and timed insemination shortened the interval from the start of the breeding season to conception, intensified calving early in the calving season, and increased calf weights at a set weaning date. Some of this increased weaning weight may be attributed to a genetic advantage from the AI sire but this is an advantage of utilizing artificial insemination. Further advantages may be realized through sire selection resulting in faster growing calves and superior replacement heifers.

TABLE 1. LEAST SQUARES MEANS FOR CALVING DATE, CALVING INTERVAL, AND CALF WEIGHT (Trial 1)

	SYNCRO-MATE-B[a]	NATURAL SERVICE[b]
CALVING DATE (d)	296.0[c]	302.9[d]
CALVING INTERVAL (d)	358.7[e]	367.5[f]
CALF WEIGHT-165 d (kg)	167.6[g]	157.6[h]

[a] 9 d implant of 6 mg norgestomet plus an injection of 3 mg norgestomet and 5 mg estradiol valerate at implantation. Calves were removed from implant removal until insemination 46-52 h later. Cows were then exposed to the bull 3 d after insemination for 57 d.

[b] Cows were exposed to the bulls for 60 d beginning on the day the other group was inseminated.

[cd] row means differ (P<.1)

[ef] row means differ (P<.05)

[gh] row means differ (P<.15)

TABLE 2. COMPARISON OF COWS SYNCHRONIZED WITH SYNCRO-MATE-B® AND ARTIFICIALLY INSEMINATED TO COWS BRED BY NATURAL SERVICE (Trial 1)

	SYNCHRONIZED[a]		CONTROL[b]	
	NUMBER	PERCENT	NUMBER	PERCENT
FEMALES	34		33	
NON-CYCLING	6[c]	17.6	5	15.2
PREGNANT				
10 d of breeding season[d]	18	52.9	7	21.2
20 d of breeding season	22	64.7	17	51.5
60 d of breeding season	33	97.1	32	96.9
DAYS TO CONCEPTION	24		31	
CALVES FROM AI	18			

[a] Cows received the standard SMB treatment and were inseminated as described in Table 1.

[b] Cows were exposed to bulls for 60 d beginning on the day the synchronized were inseminated.

[c] Three conceived to artificial insemination

[d] Day 0 represents the day control cows were first exposed to bulls and synchronized cows were artificially inseminated.

TABLE 3. LEAST SQUARES MEANS FOR CALVING DATE AND CALVING INTERVAL (Trial 2)

	SYNCRO-MATE-B[a]	NATURAL SERVICE[b]
CALVING DATE (d)	295.74	298.86
CALVING INTERVAL (d)	358.80	365.40

[a] 9 d implant of 6 mg norgestomet plus an injection of 3 mg norgestomet and 5 mg estradiol valerate at implantation. Calves were removed from implant removal until insemination 46-52 h later. Cows were then exposed to the bull 3 d after insemination for 57 d.

[b] Cows were exposed to the bulls for 60 d beginning on the day the other group was inseminated.

TABLE 4. COMPARISON OF COWS SYNCHRONIZED WITH SYNCRO-MATE-B® AND ARTIFICIALLY INSEMINATED TO COWS BRED BY NATURAL SERVICE (Trial 2)

	SYNCHRONIZED[a]		CONTROL[b]	
	NUMBER	PERCENT	NUMBER	PERCENT
FEMALES	50		50	
NON-CYCLING	8[c]	16.0	9	18.0
PREGNANT				
10 d of breeding season[d]	21	42.0	10	20.0
20 d of breeding season	28	56.0	30	60.0
60 d of breeding season	45	90.0	48	96.0
DAYS TO CONCEPTION	13		16	
CALVES FROM AI	22[e]			

[a] Cows received the standard SMB treatment and were inseminated as described in Table 1

[b] Cows were exposed to bulls for 60 d beginning on the day the synchronized were inseminated

[c] Two conceived to artificial insemination

[d] Day 0 represents the day control cows were first exposed to bulls and synchronized cows were artificially inseminated

[e] One cow settled to artificial insemination had twin calves

TABLE 5. EFFECT OF BODY CONDITION SCORE AND BODY CONDITION SCORE CHANGE ON SUBSEQUENT CALVING DATE (Trial 2)

Body Condition Score[a]	No.	Calving date[b]
Initial[c]		
4.0 - 4.5	19	296.9
5.0 - 5.5	50	295.8
6.0 - 6.5	5	293.2
Final[d]		
4.0 - 4.5	20	293.3
5.0 - 5.5	45	296.2
6.0 - 6.5	9	299.3
Change[e]		
No Change	30	298.3
Increase .5 - 1.0	24	297.1
Decrease .5 - 1.0	20	290.3

[a] from Clarke, 1983

[b] days from start of the breeding season

[c] 49 d before start of the breeding season

[d] 2 d before start of the breeding season

[e] change between c and d

TABLE 6. LEAST SQUARES MEANS FOR CALVING DATE AND CALVING INTERVAL (Trial 1 + Trial 2)

	SYNCRO-MATE-B[a]	NATURAL SERVICE[b]
CALVING DATE (d)	295.47[c]	300.04[d]
CALVING INTERVAL (d)	357.85[e]	365.44[f]

[a] 9 d implant of 6 mg norgestomet plus an injection of 3 mg norgestomet and 5 mg estradiol valerate at implantation. Calves were removed from implant removal until insemination 46-52 h later. Cows were then exposed to the bull 3 d after insemination for 57 d.

[b] Cows were exposed to the bulls for 60 d beginning on the day the other group was inseminated.

[cd] row means differ (P<.05)

[ef] row means differ (P<.05)

TABLE 7. COMPARISON OF COWS SYNCHRONIZED WITH SYNCRO-MATE-B® AND ARTIFICIALLY INSEMINATED TO COWS BRED BY NATURAL SERVICE (Trial 1 + Trial 2)

	SYNCHRONIZED[a]		CONTROL[b]	
	NUMBER	PERCENT	NUMBER	PERCENT
FEMALES	84		83	
NON-CYCLING	14[c]	16.7	14	16.9
PREGNANT				
10 d of breeding season[d]	39	46.4	17	20.5
20 d of breeding season	50	59.5	47	56.6
60 d of breeding season	78	92.9	80	95.2
DAYS TO CONCEPTION	12		17	
CALVES FROM AI	40[e]			

[a] Cows received the standard SMB treatment and were inseminated as described in Table 1

[b] Cows were exposed to bulls for 60 d beginning on the day the synchronized were inseminated

[c] Five conceived to artificial insemination

[d] Day 0 represents the day control cows were first exposed to bulls and synchronized cows were artificially inseminated

[e] One cow settled to artificial insemination had twin calves

EXPERIMENT 2. EFFECT OF A SECOND NORGESTOMET IMPLANT NINE DAYS AFTER INSEMINATION OF COWS TREATED WITH SYNCRO-MATE-B® (SMB)

SUMMARY

Fourteen mature, non-lactating Simmental and Polled Hereford cows received a 6 mg norgestomet implant 9 d after SMB treatment and timed insemination. The second implant remained in situ for 9d. Cows exhibiting estrus in a 48 h period after implant removal were inseminated at 48 h after implant removal.

The percentage of cows conceiving to the first and second inseminations were 64.3 (9/14) and 75 (3/4), respectively. Of 10 cows not showing estrus in the 48 h period following implant removal, nine were pregnant to the initial insemination. Pregnancy rate after 20 d was 85.7%. Pregnancy rate at 28 d was 100%. The 2 cows not pregnant to either timed insemination conceived after estrus was detected in the next 8 d.

The use of a second norgestomet implant after initial SMB treatment and timed insemination may prove beneficial as the number of calves resulting from artificial insemination was increased with a minimal increase in estrus detection.

INTRODUCTION

To receive maximum benefit from artificial insemination with a minimum amount of estrus detection, a procedure involving repetitive treatment with norgestomet implants was attempted. In theory, cows that are pregnant would not be affected by an exogenous progesterone source and should not exhibit estrus when the progesterone source was removed. Ghallab et al. (1984) showed that repetitive treatment with norgestomet implants had no adverse effects on reproductive performance and that conception rates after the removal of the second implant were higher than after the removal of the first implant in non-cycling heifers.

In cows that did not conceive to a previous insemination, an implant containing progesterone should block estrus after the corpus luteum regresses and then allow estrus after implant removal. Folman et al. (1984), using progestrone releasing intravaginal devices, reported grouping dairy cows so that insemination would occur over a 6 d period every 21 d. The regime was timed so that each cow received her first insemination 59-79 d postpartum and subsequently had an opportunity to exhibit estrus within a 6 d period every 21 d until conceiving to artificial insemination. This regime allowed for artificial insemination with only a 6 d estrus detection period required for each 21 d.

If estrus could be further controlled, the estrus detection period could be further shortened. This experiment was designed to determine the success rate of timed insemination following reimplantation of cows for 9 d starting 9 d after an initial timed insemination in cows synchronized initially with Syncro-Mate-B®.

MATERIALS AND METHODS

Fourteen non-lactating Simmental and Polled Hereford cows located at the KSU Cow-Calf Unit received a 6 mg norgestomet implant 9 d after insemination. All cows had been open for one year. They were treated with Syncro-Mate-B® (see procedure in expt. 1) and inseminated 48 h after implant removal. The norgestomet implant was removed 9 d later. Androgenized cows equipped with chinball marking harnesses were used for estrus detection with twice daily checks for marked cows. Cows detected in estrus in the next 48 h were inseminated at 48 h after implant removal. Cows that did not show estrus during that period were not inseminated. Pregnancy diagnosis by rectal palpation 60 d after the initial synchronization was used to confirm conception date. Calving dates were used to confirm pregnancy diagnosis.

RESULTS AND DISCUSSION

Of the 14 cows given a second implant of norgestomet after an initial treatment with Syncro-Mate-B®, 4 of 14 returned to estrus within 48 h after implant removal. Of these, 3 of 4 conceived to a timed insemination 48 h after implant removal. One of the 10 cows not showing estrus in the 48 h period exhibited estrus and conceived to artificial insemination 6 d after implant removal (26 d after first insemination). The remaining cow not pregnant to the second timed insemination exhibited estrus and conceived to artificial insemination 8 d after the second implant removal. This resulted in all 14 cows being pregnant 28 d after the start of the breeding season with only 2 cows not conceiving to timed insemination (table 8).

Further use of artificial insemination could be achieved with a second norgestomet implant. Folman et al. (1984) decreased estrus detection requirements to 6 d out of every 21 d using progesterone releasing intravaginal devices which resulted in 25 d pregnancy rates of 80% compared to unsynchronized controls pregnancy rate of 52.9%.

In this experiment with a 20 d pregnancy rate of 85.71%, only a 48 h period of estrus detection was required. In our case, testosterone treated cows with chinball marking devices were used for estrus detection, so checks for estrus were made only twice per day. It would be expected that results will vary, but with a 48 h period of estrus detection, with only four actual checks, following 18 d when no estrus detection is required, many more producers may be able to benefit from artificial insemination.

TABLE 8. EFFECT OF A SECOND NORGESTOMET IMPLANT FOLLOWING SMB TREATMENT AND TIMED INSEMINATION

	TOTAL	PERCENT
NUMBER PREGNANT	14[a]	
AFTER FIRST INSEMINATION	9	64.3
AFTER SECOND INSEMINATION	3[b]	75.0
AFTER 2 TIMED INSEMINATIONS	12	85.7
AFTER 28-d BREEDING SEASON	14	100.0

[a] Number of cows on SMB treatment then inseminated and given a norgestomet implant for 9 d beginning 9 d after insemination

[b] Four cows exhibited estrus after second norgestomet implant

EXPERIMENT 3. USE OF $PGF_{2\alpha}$ IN COMBINATION WITH SYNCRO-MATE-B® (SMB)

SUMMARY

The effect of pretreating cows with $PGF_{2\alpha}$ (Lutalyse®) 5 d before SMB treatment in order to have more cows early in the cycle at initiation of SMB treatment was tested in 131 cows and heifers in two trials. Angus and crossbred cows and heifers of Angus, Hereford and Simmental origin were assigned to two groups by age, postpartum interval, and body condition. Each trial consisted of two groups. In group 1, cows received a 30 mg injection of Lutalyse® 5 d before SMB treatment. In group 2, cows received the standard SMB treatment. The SMB treatment began on the same day in both groups within each trial. Calves were removed from all lactating cows for 48 h following implant removal. In Trial 1 cows were inseminated by appointment 48-54 h after implant removal and in Trial 2 were inseminated by estrus.

There were no significant differences in first service conception rates due to treatment, stage of the estrous cycle at initiation of SMB treatment, or breeding by estrus or appointment. A 30 mg im dose of Lutalyse® decreased serum progesterone levels and resulted in estrus response in 86.4% of cows having serum progesterone levels above 1 ng/ml at injection. However, no reproductive parameter measured was enhanced by pretreatment with Lutalyse®

INTRODUCTION

In work at Kansas State University (Brink et al., 1985) in beef heifers treated with Syncro-Mate-B®, an advantage was shown in first service conception when treatment was initiated before day 10 of the estrous cycle compared with starting treatment after day 10. Further unpublished work at Kansas State with cows when stage of the estrous cycle was determined by radioimmuno assay of serum progesterone also showed an advantage in first service conception rates when treatment was initiated early in the estrous cycle. Therefore, it appeared that a method of causing cows to be in the early part of the cycle at the start of SMB treatment would improve conception rates after SMB treatment.

Godke et al. (1979) reported over 90% of cows having progesterone levels over 1.5 ng/ml responded to an injection of $PGF_{2\alpha}$ by exhibiting estrus behavior within 96 h of injection. Adeymo and Heath (1980) reported progesterone levels over 1.0 ng/ml from day 4 through day 19 of the estrous cycle.

In theory, a cow having serum progesterone levels > 1 ng/ml, $PGF_{2\alpha}$ would regress the corpus luteum and estrus would occur about 72 h later. If a period of 5 d passes between the injection of $PGF_{2\alpha}$ and initiation of SMB, the cow would be on day 2 of her cycle when implanted. If the cow was not far enough into her cycle (before day 5) , at the time of injection for $PGF_{2\alpha}$ to regress the corpus luteum, she would still be a maximum of 10 d into her cycle when SMB treatment started. If the cow was too far into her cycle (beyond day 16), at the time of injection, the corpus luteum would regress naturally and the cow would still be early in the cycle at the time of SMB treatment. By determining serum progesterone levels at bleedings 5 d apart and detecting estrus between the two bleedings it appeared feasible to estimate the stage of the estrous cycle for all cows.

The objective of this experiment was to determine if an injection of $PGF_{2\alpha}$ given 5 d before initiation of the SMB treatment would result in higher conception rates at insemination after SMB treatment.

MATERIALS AND METHODS

Trial 1

Ninety-one fall calving crossbred cows and heifers located at the Ft. Hays Branch Experiment Station were divided into two groups by age and postpartum interval. Average age and postpartum intervals for Group 1 and 2 respectively, were 4.9 y and 64.06 d, 4.1 y and 62.87 d. Both groups were bled by jugular venipuncture before treatment was started. Blood was collected into 16 x 127 mm sterile evacuated blood collection tubes. Blood was transported on ice to the laboratory where serum was collected by centrifugation (2400 rpm for 20 min) within 24 h of collection. Serum was stored at -8^{o} C until radioimmunoassayed for serum progesterone (Stevenson et al., 1984). Group 1 received $PGF_{2\alpha}$(30 mg, im) immediately following blood collection. KAMAR® heatmount detectors were placed on the rump of all cows at the time of blood collection. The KAMAR®'s were used to detect if the cows had been in estrus between the time of the first blood sample and the second blood sample to aid in determining stage of the estrous cycle at SMB treatment. A second blood sample was collected from all cows 5 d later and all cows then received a 6 mg norgestomet implant along with an injection of 3 mg norgestomet and 5 mg estradiol valerate in sesame oil (standard SMB treatment). Group 2 received the standard SMB treatment at the same time as Group 1. Implants were removed after 9 d and calves were separated from cows from the time of implant removal until after the cows were inseminated 48-52 h later. Heifers were inseminated approximately 46 h after implant removal. Inseminators were stratified over the two groups and females early and late in their cycle to remove inseminator bias in the final results. Semen in ampules was thawed in an ice bath maintained at 5° C. Semen in .5 cc straws was thawed for 20 sec in a water bath maintained at $35\text{-}37^{\circ}$ C. The same number of cows in each group were inseminated with semen from each bull used to eliminate sire bias. Cleanup bulls were placed with females 3 d after artificial insemination for a period of 60 d. Pregnancy diagnosis by rectal palpation at 77 d after artificial insemination was used to calculate conception rates.

<u>Trial 2</u>

Forty Angus and Angus-cross cows privately owned by a commercial cow calf producer were divided as in Trial 1. Groups 1 and 2 received identical treatments as stated for Trial 1 except insemination was by estrus with insemination occurring approximately 12 h after the detection of estrus. Cows were considered to be in estrus only when they stood to be mounted by other cows or an intact bull altered to prevent copulation. Average age and postpartum interval for Groups 1 and 2, respectively, were 7.2 y and 133.2 d, 7.0 y and 123.5 d. Cows were exposed to a cleanup up bull for 45 d after artificial insemination. Pregnancy diagnosis by rectal palpation 73 d after the first cows were inseminated was used to calculate conception rates.

Stage of the estrous cycle at SMB treatment was estimated by use of KAMAR® heatmount detectors and blood serum progesterone levels. Two blood samples with serum progesterone < 1 ng/ml and no KAMAR® response was considered an indication that the female was non-cycling at the initiation of SMB treatment. An activated KAMAR® was considered a positve indication that estrus had occurred between PGF_2 and SMB treatment, and that the female was early in the cycle at the initiation of SMB treatment. Serum progesterone levels > 1 ng/ml at the first bleeding and an unactivated KAMAR® at the time of SMB treatment was interpreted as a female late in her cycle at initiation of SMB treatment as well as both serum progesterone levels > 1 ng/ml without an activated KAMAR®. A further indication of a female late in her cycle was an initial progesterone level > 1 ng/ml and the second level < 1 ng/ml without an activated KAMAR®.

Statistical analysis was performed by general linear models (SAS, 1979) on the following variables: treatment group, initial and final progesterone level, stage of the estrous cycle at initiation of SMB treatment, age of the female, and insemination following estrus detection or by appointment.

RESULTS AND DISCUSSION

TRIAL 1

An injection of $PGF_{2\alpha}$ 5 d before the start of SMB treatment (Group 1) was an effective method of ensuring that cows would be early in their estrous cycle (estimated day 10 or before) since 87.8% (36/41) of the cycling cows pretreated with $PGF_{2\alpha}$ were early in the cycle as compared to 50% (20/40) not pretreated. However, the conception rate in Group 1 (43.5%) was not different than in Group 2 (42.2%). Altering estrous cycles in order that SMB treatment was initiated early in the cyle did not improve conception rate at a timed insemination. In fact, conception rate was slightly higher when SMB treatment was started after day 10 (52%) than earlier (44.6%) regardless of group. Conception rates for cows started on SMB in early and late cycle in Group 1 were 41.6% and 60.0% and in Group 2 were 40% and 50%, respectively.

In this trial, conception rate was not lower when the female was late (estimated after day 10) in her cycle when SMB treatment was initiated. This conflicts with the results reported by Woody and Abenes (1975, inseminating by estrus) and Brink et al. (1985, inseminating by appointment) where starting SMB treatment later in the cycle decreased conception rates at a subsequent insemination. In this trial, stage of the cycle did not have a significant effect on first service conception rate which does not support and tends to be in opposition to results obtained by Woody and Abenes (1975) and Brink et al. (1985).

Trial 2

An injection of $PGF_{2\alpha}$ before SMB treatment resulted in 90.5% (19/21) of the cycling cows being early in the cycle as compared to 52.6% (10/19) not recieving $PGF_{2\alpha}$ before SMB treatment. As in Trial 1 with timed insemination, conception rates when inseminating by estrus in Trial 2 were also not different between Group 1 (42.9%) and Group 2 (52.6%). A similar trend was also noted for higher conception rates in cows where SMB treatment was started in late cycle (70%, 7/10) rather than early cycle (36.7%, 11/30), regardless of group. Conception rates for females started on SMB early and late in the cycle in Group 1 were 42.1% and 50% and in Group 2 were 40% and 66.7%, respectively. $PGF_{2\alpha}$ was effective in altering the cycle, but once again starting SMB treatment early in the cycle did not have a positive effect on first service conception rates. The interval from implant removal to insemination did not effect conception rates in cows inseminated 12 h after the detection of standing estrus (table 9). Average interval to insemination following implant removal for Groups 1 and 2 respectively, were 110 h and 77 h. Spitzer et al. (1978) had reported that heifers not exhibiting estrus by 5 d following implant removal were usually before d 4 or after d 17 of the estrous cycle at the time of implantation of norgestomet. In this experiment, none of the females treated before d 5 exhibited estrus after 96 h following implant removal. Holtz et al. (1979) had reported an increase in first service conception rate, following SMB treatment, as the interval from implant removal increased up to 72 h. Acceptable conception rates (>40%) occurred from 24-96 h after implant removal. In this experiment, first service conception rates reached the highest level 108-120 h after implant removal and remained constant until all cows had been inseminated (table 9).

In comparing the results of Trial 1 and 2 (table 10), no significant differences occurred in first service conception rates due to inseminating by estrus or appointment. Anderson et al. (1982) reported a 40% decrease in first service conception rate when inseminating by appointment following SMB treatment as compared to inseminating by estrus, in this experiment somewhat contradictory results were observed. Conception rates for Trial 1 (inseminated by appointment) and Trial 2 (inseminated after detection of estrus) were 42.86% (39/91) and 47.5% (19/40) respectively, without regard to group or stage of the cycle at initiation of SMB treatment. Overall conception rates in data pooled from the two trials for early and late cycle, regardless of treatment, were 40.7% (35/85) and 57.14% (20/35) respectively. No significant differences occurred in first service conception rate in relationship to whether cows were early in their cycle naturally or were induced by $PGF_{2\alpha}$, conception rates of 41.8% (23/55) in $PGF_{2\alpha}$ pretreated and 40% (12/30) in cows not pretreated were obtained to artificial insemination.

Upon statistical analysis, the following variables were determined to have had no effects on conception rates in this experiment; progesterone levels at either blood sample, age of the female, method of insemination (by estrus or appointment), semen used for insemination, or inseminator.

From the results obtained in this experiment, the use of $PGF_{2\alpha}$ before SMB treatment to increase conception rates by increasing the number of females early in their estrous cycle at SMB treatment is not feasible. Further work needs to be done to resolve the effects of treatment with SMB at various stages of the estrous cycle. Early research with norgestomet and other progestagens had shown prolonged progesterone stimulation would decrease fertility (Hansel et al., 1966; Wiltbank et al., 1971; Burrell et al., 1972; Screenan and Mulvehill, 1975; Woody and Abenes, 1975; and Brink et al., 1985). It would seem that a female later in her estrous cycle at the initiation of SMB treatment would have reduced fertility due to an unnaturally long period of progesterone stimulation. In both trials in this experiment, first service conception rates were higher for females later in their estrous cycle at the initiation of SMB treatment. From these results, it would appear that $PGF_{2\alpha}$ may be used to some advantage before SMB treatment by lengthening the interval from $PGF_{2\alpha}$ to SMB treatment to place a higher number of females later in their cycle at initiation of SMB treatment.

TABLE 9. CONCEPTION RATES TO ARTIFICIAL INSEMINATION FOLLOWING ESTRUS DETECTION AFTER SYNCHRONIZATION WITH SYNCRO-MATE-B® (SMB) TREATMENT (Trial 2)

INTERVAL TO INSEMINATION[a]	NO.	NO. PREG.	%
48-60 h	15	7	46.7
72-84 h	11	4	36.4
108-120 h	4	2	50.0
132-156 h	6	3	50.0
168-192 h	4	2	50.0

[a] Approximately 12 h after detection of standing estrus

TABLE 10. COMPARISON OF FEMALES PRETREATED WITH $PGF_{2\alpha}$ PRIOR TO SYNCRO-MATE-B® (SMB) TREATMENT AND FEMALES NOT PRETREATED

	$PGF_{2\alpha}$ + SMB		SMB ONLY	
	No.	%	No.	%
FEMALES	67	-----	64	----
EARLY IN ESTROUS CYCLE[a]	55	82.1	30	46.9
LATE IN ESTROUS CYCLE[b]	7	10.5	29	45.3
NON-CYCLING[c]	5	7.5	5	7.8
INSEMINATED BY TIME	46	68.7	45	70.3
INSEMINATED BY ESTRUS	21	31.3	19	29.7
PREGNANT TO ARTIFICIAL INSEMINATION				
EARLY CYCLE[a]	23	41.8	12	41.4
LATE CYCLE[b]	4	57.1	16	55.2
NON-CYCLING[c]	2	40.0	1	20.0
INSEMINATED BY TIME	20	43.3	19	42.2
INSEMINATED BY ESTRUS	9	42.9	10	52.6
TOTAL	29	43.3	29	45.3

[a] SMB treatment started before day 10

[b] SMB treatment started after day 10

[c] 2 serum progesterone samples below 1 ng/ml and not exhibiting estrus between the 2 blood samples

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SYNCHRONIZATION OF ESTRUS IN BEEF CATTLE: VARIOUS USES OF SYNCRO-MATE-B® AND A COMPARISON OF SYNCHRONIZATION AND ARTIFICIAL INSEMINATION WITH NATURAL SERVICE

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ABSTRACT

A total of 337 cows and heifers were used in three experiments involving the use of Syncro-Mate-B® (SMB).

In the first experiment, 167 crossbred cows and heifers of Hereford, Angus, and Simmental origin were assigned to two treatment groups in two similar trials. Group 1 received the SMB treatment which included an implant of 6 mg SC21009 (norgestomet) for 9 d and an injection of 3 mg norgestomet and 5 mg estradiol valerate at implantation. Calves were separated from lactating cows from the time of implant removal until after insemination 48-54 h later. Cows in group 2 were not synchronized but were allowed to mate naturally during a 60 d breeding season which began the day that the treated group was artificially inseminated. SMB treatment resulted in a decrease in the average interval from the start of the breeding season to calving ($P<.05$) and also decreased calving interval ($P<.05$). In Trial 1 where calves were weighed, calves born to cows in the treatment group were 11 kg heavier when weighed 5.5 mo after the calving season began.

In the second experiment 14 non-lactating Simmental and Polled Hereford cows received a second 6 mg norgestomet implant after synchronization with SMB and a timed insemination. The second implant period of 9 d began 9 d after the timed insemination. Cows that had exhibited estrus by 48 h after removal of the second implant were inseminated 48 h after removal. Of 10 cows not showing estrus by 48 h after second implant removal, 9 were pregnant to the initial insemination. Of 4 cows exhibiting estrus in the 48 h period, 3 conceived to the second insemination. This resulted in 12/14 (85.7%) of the cows pregnant to artificial insemination with only a 48 h period of estrus detection required. This also resulted in an 85.7% pregnancy rate in 20 d and 100% pregnancy rate in 28

d as the other 2 cows conceived to artificial insemination after estrus was detected within 8 d following the second timed insemination.

In the third experiment, 40 Angus and 91 crossbred cows of Angus, Hereford, and Simmental origin were divided into two similar groups in each of two trials. Group 1 received a 30 mg injection of prostaglandin $F_{2\alpha}$ (Lutalyse®) 5 d before initiation of the SMB treatment. Group 2 received the standard SMB treatment. The SMB treatment started the same day in Groups 1 and 2. In Trial 1, Groups 1 and 2 were artificially inseminated by appointment 48-54 h after implant removal. In Trial 2, Groups 1 and 2 were artificially inseminated 12 h after the detection of standing estrus. In both trials, calves were separated from the cows at the time of implant removal and were returned after insemination 48-52 h later. No significant differences were found in first service conception rates due to treatment, stage of the estrous cycle at initiation of SMB treatment, or breeding by estrus or appointment. Lutalyse was effective in initiating estrus in 33 of 39 (84.6%) cows having serum progesterone levels > 1 ng/ml at injection.