EFFECT OF TIME OF INSEMINATION AND CALF REMOVAL AFTER ESTRUS SYNCHRONIZATION IN BEEF CATTLE

by

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INTRODUCTION

A reliable and effective estrus synchronization program would allow for a shorter breeding season and a more uniform calf crop due to an earlier average conception date.

Various experimental methods for estrus synchronization have been used extensively in heifers and mature cows with varying results reported. Long term progestagen treatments via injection (Trimberger and Hansel, 1955), orally (Hansel et al., 1961; Lantz et al., 1968; Bloss et al., 1966; O'Brien et al., 1968; Hendricks et al., 1973; Chakraborty et al., 1971; Beatty et al., 1971), and subcutaneous implants (Foote et al., 1973; Reynolds et al., 1973; Knox et al., 1972) administered over 14 consecutive days, have resulted in high levels of synchronization but substantially reduced fertility rates at the first estrus following hormonal withdrawal.

To improve lowered fertility associated with long term progestagen treatments and still maintain successful synchronization results, luteolytic compounds have been administered in conjunction with various progestagens to reduce duration of hormonal exposure. Luteolysins work to regress the cow's corpus luteum, thus causing her to short-cycle and express estrus within 2 to 4 days (Wiltbank et al., 1969). Luteal regression has been successfully obtained with estradiol valerate (EV) if injected before mid-cycle (Wiltbank et al., 1961; Rich et al., 1972;

Lemon, 1975); however, Roche (1974b) observed cows treated with an injection of estrogen plus a progestagen implant were not successfully synchronized if treated very early or late in their cycle. However, low synchronization response in those cows near estrus was improved when a low level of progestagen was injected with the EV at time of implantation (Woody et al., 1967; Hobsen and Hansel, 1972; Roche, 1974b).

A successful treatment presently used to control the bovine estrous cycle under the trade name of Syncro-Mate B (G. D. Searle and Company), consists of an injection of 5 mg EV and 3 mg norgestomet,[@] plus a 9 day subcutaneous ear implant containing 6 mg norgestomet.[@]

Syncro-Mate B treatment has been shown to control time of ovulation precisely enough to utilize timed insemination programs without significantly decreasing fertility (Wishart, 1975). Advantages offered from "breeding by appointment" include less labor required for heat detection and concentrated use of an artificial insemination technician. Wishart and Young (1974) and Sreenan and Muleville (1975) also reported an added advantage when they noticed some Syncro-Mate B treated cows ovulated but failed to express overt signs of estrus; therefore, timed insemination increased pregnancy rates in these groups. The optimum time of insemination following Syncro-Mate B treatment has not been completely established, but research done by Sreenan and Muleville (1975), Wishart and Young (1974), and Morrison et al. (1975) indicates inseminating once or twice from 48 to 60 hrs post-implant removal results in conception rates similar to controls.

Delayed onset of estrus in lactating postpartum cows is a major problem to producers trying to maintain a yearly calving interval. A new management tool experimentally used to significantly shorten this interval involves interruption of the cow's normal postpartum anestrous period by early weaning her calf. Increased conception rates and shorter postpartum intervals were noted in mature cows and first calf heifers whose calves were weaned earlier than controls (Wiltbank, 1970; Poosey and Smart, 1975; Wiltbank, 1977; McKee and Fink, 1978; Kimple et al., 1978). Oxenreider (1968) and Randel and Welker (1977) showed decreased intensity of lactation also significantly decreased the postpartum interval in cows hand-milked or suckled once a day when compared to unrestricted, normally suckled cows. Temporary calf separation for 48 hrs indicated complete weaning was not necessary for a response on return to estrus, as more cows expressed estrus earlier in the breeding season with improved conception rates when compared to controls (Smith, 1976; Trevillyan et al., 1978; Ott, 1977; Wiltbank, 1977).

The following trials were conducted to determine if Syncro-Mate B treatment could effectively be used prior to breeding by appointment and still maintain normal first service conception rates. Furthermore, various pre-determined breeding times were compared to evaluate optimum time of insemination following synchronization procedures. Short term calf removal was also super-imposed on synchronized groups in one trial to evaluate its effectiveness on return to estrus and subsequent conception rates in the beef cow.

LITERATURE REVIEW

Practical estrus synchronization techniques offer several advantages to today's producer such as reducing length of the breeding season, reducing labor requirements for heat detection, and possible incorporation into super ovulation and embryo transfer programs. Management techniques such as short term calf removal and breeding by appointment could also be used in conjunction with estrus synchronization to improve reproductive efficiency of the beef cow.

Synchronizing estrus in the beef cow can be accomplished in three basic ways: (1) preventing heat and ovulation, (2) cessation of the cycle, or (3) using a combination of the two (Heersche et al., 1979). Compounds used in these synchronization procedures have been administered via intrauterine infusions, vaginal sponges, orally, intramuscular injections and subcutaneous implants.

Christian and Casida (1948) reported progestagens were effective in preventing estrus and ovulation when an exogenous source was administered daily, with estrus occurring 2 to 3 days following removal of the progestagen supply. Trimberger and Hansel (1955) suppressed estrus by giving daily injections of a progestagen, but noted lowered fertility at the synchronized estrus. Woody and Ginther (1968), however, reported progestagens injected early in the cycle (days 1 to 10) reduced cycle length by causing early luteal regression.

In recent years, many orally active progestagens have been reported effective in experimentally synchronizing estrus by inhibiting heat and ovulation. Zimbelman (1963) concluded daily feeding of MAP (6-methyl-17-acetoxyprogesterone) could be used for successful synchronization in 2 and 3 year old heifers. Hansel et al. (1961) reported daily feeding of MAP resulted in high levels of synchronization with a significant decline in fertility ($P<.05$). Although Nelms et al. (1961) and Anderson et al. (1962) also reported high levels of synchronization after feeding MAP, they observed no reduction in fertility.

CAP (6-chloro-6-dehydro-17-acetoxyprogesterone) fed at a rate of 12 mg daily for 18 days resulted in a high degree of synchronization within 7 days following treatment with no decrease in conception rate (Van Blake et al., 1963). In a comparison study between CAP and MAP, Hansel et al. (1966) observed CAP fed at 10 mg per day for 18 days did not significantly lower fertility of treated heifers; however, MAP fed at 240 mg per day for 18 days resulted in significantly higher conception rates than either CAP fed or control heifers. Conception in CAP fed heifers improved if human chorionic gonadotropin (HCG) was injected following 2 weeks exposure to CAP (Baker and Coggins, 1968); however, the number of heifers showing estrus and intensity of behavioral estrus declined. Grunert (1975) injected 1.5 mg of gonadotropin releasing hormone (GnRH) following CAP withdrawal and prior to insemination which resulted in increased conception of treated heifers. In comparison, he noted heifers injected with 5 mg estradiol benzoate (EB) two days post-CAP treatment increased level of behavioral estrus, but resulted in no

change of fertility. Rey (1975) studied effects of double short term treatments of CAP on fertility rates in mature beef cows, and reported those treated with a second 9 day treatment of CAP following 12 untreated days showed an increased estrus response within 5 to 7 days with improved fertility when compared to cows treated only once for 9 days.

Behavioral estrus was less variable and a longer interval from end of estrus to ovulation was observed in heifers fed 500 mg DHPA (dihydroxy-progesterone acetophenide) twice daily when compared to controls (Wiltbank et al., 1967). Lantz et al. (1968) fed heifers 120 mg DHPA for 9 consecutive days and injected 5 mg estradiol valerate (EV) on day 2 of the treatment and found a high level of synchronization, but only a 20% first service conception rate. Using the same experimental procedure but feeding only 75 mg DHPA, Wiltbank and Kasson (1968) effectively synchronized estrus, but reported no detrimental effect on fertility or pregnancy rates.

MGA (melengestrol acetate), another orally active progestagen which has been used to increase gains and feed efficiency in feedlot heifers, is effective in synchronizing estrus although lowered fertility has been observed (O'Brien et al., 1968; Bloss et al., 1966; Hendricks et al., 1973; Ayalong and Marcus, 1975). This is in agreement with work done by Chakraborty et al. (1971) and Beatty et al. (1971) who found lowered conception rates in heifers fed MGA daily for 2 consecutive weeks. In an effort to improve lowered fertility associated with MGA treatments, Boyd and Tasker (1971) compared heifers injected with HCG 72 hours following MGA treatment to heifers injected with pregnant mare

serum (PMS) 36 hours post-MGA treatment and HCG 36 hours post-PMS injection. Fertility rates were not improved in either treatment when compared to heifers fed only MGA.

Possible causes for lowered fertility in MGA synchronized cows have been studied, but results have been inconclusive. Zimbelman (1966) reported MGA tripled follicular fluid weights when fed to heifers without a functional corpus luteum (CL), but produced no ovarian changes when fed to heifers in the luteal phase of the cycle. This is not in agreement with work done by Guthrie et al. (1970) who observed atrophy of follicular cells and degeneration of granulosa cells in MGA treated heifers. Reed and Rich (1972) found higher percentages of abnormal ova due to delayed cleavage of germinal cells. Altered hormonal relationships just prior to onset of estrus in MGA treated heifers was believed to be another reason for lowered fertility. Britt and Ulberg (1972) and Dobson et al. (1973) reported a peak in plasma progesterone 2 to 3 days before estrus, causing an imbalance in the progesterone-estrogen relationship of MGA fed heifers compared to controls. Further research on altered hormonal balance indicated that MGA fed late in the cycle (day 15) resulted in lowered conception rates when compared to heifers treated early in their cycle (day 4) (Hill et al., 1971). Less mucous production was observed in late treated heifers indicating altered estrogen levels and/or increased progesterone influence. Research done by Hendricks et al. (1973) also showed MGA administered late in the cycle caused altered uterine and oviduct secretions, therefore less available nutrients for the developing ovum which could result in lowered fertility.

Another route of administration for exogenous progestagens is via a progesterone releasing intrauterine device (PRID) which is a spiral attached to a progesterone releasing matrix. Breuer et al. (1977) reported a high level of synchronization within 72 hours following a 14 day PRID treatment in cows, with no significant decrease in fertility. A 100 mg GnRH injection 30 hours after removal of the PRID was used to insure a LH peak for ovulation and resulted in identical conception rates for treated and untreated heifers (Mauer et al., 1975). Roche and Gosling (1977) observed cows not synchronized after PRID insertion had significantly lower plasma progesterone levels in the first 2 days of progesterone treatment. Also, cows successfully synchronized but exhibiting a longer interval from end of treatment to onset of estrus had higher plasma progesterone levels in the final days of the PRID treatment. Looking at the relationship between delay in onset of estrus and blood progesterone levels, Ulberg et al. (1951) observed a shorter interval from the final progesterone treatment to onset of estrus when lower progesterone levels were administered.

Implants impregnated with progesterone and placed in the neck or at the base of the ear is another effective route of administration to inhibit estrus in cattle, although lowered fertility has been reported if left intact for over 14 consecutive days (Foote et al., 1973; Reynolds et al., 1973). Knox et al. (1972) compared ear implants with daily injections of norethandrolone and found the implant was more effective in synchronizing estrus although both treatments caused decreased fertility. They reported norethandrolone treatments had no apparent effect on CL formation, function, or regression, but simply

supplemented endogenous progesterone supplies to suppress estrus. Johnson and Ulberg (1965) and Thimonier et al. (1975) studied the relationship between long term progesterone treatments and lowered fertility and found decreased mucous production and widely varied rectal temperatures in treated heifers, indicating abnormal estrogen levels. Rodeffer et al. (1972), also believing altered estrogen production caused decreased conception rates in long term progesterone treated heifers, reported estrogen levels peaked 12 hours after the ovulatory luteinizing hormone (LH) surge in treated heifers, whereas estrogen peaked 12 hours before the LH surge in untreated heifers. Wordinger et al. (1970) reported long term progesterone treatment decreased glycogen content within the uterus, thus creating an unsuitable environment for the developing ovum, resulting in lowered fertility.

Lauderdale and Ericson (1970) hypothesized long term progesterone treatments affected the sperm cell rather than the ovum. They reported sperm capacitation was lower, resulting in decreased fertile life-span of sperm cells in treated heifers. Increased phagocytosis of abnormal sperm cells was also noted. Boyd et al. (1973) tried to increase fertility in progesterone treated heifers by increasing sperm cell concentration 45 million per insemination but found no difference in conception rates between groups.

Rachow and Marion (1973) and Kinder and Ellington (1974) researched short term progesterone treatments and found they could successfully synchronize estrus using implants containing the progestagen SC21009 (17-acetoxy-11-methyl-19-norpreg-4-ene-3,20-dione, or commercially

referred to as norgestomet®) without decreasing fertility rates if treatments lasted under 14 days. Woody and Pierce (1974) and Lemon (1975) also found short term exposure to progestagens did not lower fertility of heifers, but resulted in a low degree of synchronization when used alone without a luteolytic compound to regress the newly formed CL in heifers just beginning the metestrus phase of their cycle.

Wiltbank et al. (1961) and Rich et al. (1972) looked at effects of injected steroid hormones on ovarian function and observed estrogens had luteolytic actions if administered early or before mid-cycle. When SC21009 was used in conjunction with EV before day 12 of the cycle, Lemon (1975) also observed short-cycles, indicating luteolytic activity of estrogens early in the cycle. Shelton and Casida (1970) were not in agreement with this, however, as they reported estrogens were not effective in regressing a functional CL until after mid-cycle.

Combining compounds which inhibit estrus with luteolytic compounds has produced the most satisfactory results in synchronizing estrus to date (Wiltbank et al., 1969). Roche (1974a) compared fertility rates of heifers receiving a long-term progesterone implant to heifers receiving a 10 day progesterone implant plus a 5 mg injection of EB at the time of implantation. He reported the latter treatment resulted in a decreased synchronization response but increased fertility rates. EV used with a 13 day SC21009 implant also resulted in a two-fold increase in conception rates when compared to heifers receiving only progesterone implants (Knox et al., 1972). Wiltbank et al. (1971) found a 9 day implant of norethandrolone with a 5 mg injection of EV

at time of implantation resulted in identical conception rates when compared to control heifers, whereas estrogen injected 24 hours post-implant removal caused lower pregnancy rates but increased level of synchronization. Whitman et al. (1972) and Chupin et al. (1975) noted synchronization response increased as dosage of SC21009 increased above 6 mg but fertility decreased as progestagen exposure extended beyond 7 consecutive days. They concluded 9 mg of SC21009 was the minimum dosage that could be used to effectively synchronize estrus without lowering fertility. They also looked at optimum levels of EV used for synchronization purposes and reported dosage above 5 mg increased the degree of synchronization but decreased fertility. Kiracofe et al. (1978) observed no differences in fertility or synchronization response when either 5 or 6 mg EV was used.

Roche (1974b) found females injected with 5 mg EB followed by a 9 day progesterone implant on days 5 to 15 of their cycle exhibited a high level of synchronization, while those treated early or late in the cycle were not effectively synchronized. He concluded those heifers in very early stages of their cycle needed a stronger luteolytic agent for regression of the newly formed CL, and those very late in their cycle ovulated according to their natural cycle rather than being controlled by this progesterone-estrogen treatment. Woody and Pierce (1974), using the same treatment, also observed a low synchronization response in heifers treated before day 10 of their cycle, but reported no differences in heifers treated late in their cycle. Heifers implanted at estrus exhibited the lowest synchronization

response when compared to heifers in all stages of the estrual cycle (Woody and Abenes, 1975).

Woody et al. (1967) and Hobsen and Hansel (1972) found progesterone injected with estrogen following a pre-treatment of progesterone increased synchronization rate of heifers treated near estrus. Roche (1974b) administered 50 mg of progesterone with 5 mg EB at time of implantation and reported synchronization response increased in heifers treated late in their cycle, but showed no advantage in heifers treated before day 3 of their cycle. He concluded progesterone worked synergistically with estrogen in controlling the rapid increase of LH needed for ovulation, thus an increased estrus response. Hobsen and Hansel (1972) concluded the underlying physiological mechanism of progesterone working with estrogen to increase synchronization of heifers not in mid-cycle was due to progesterone inhibiting an immediate response of LH to estrogen; therefore, the LH surge was more closely controlled for an increased synchronization response.

Environmental factors have also been studied to explain lower estrual response in fall calving cows receiving synchronization treatment in cold weather as opposed to spring calving cows treated during warm weather (Goodall and Findley, 1953). They hypothesized the physiological response of vasoconstriction of blood vessels to the body core and away from extremities (such as the implantation site located at the base of the ear) in an effort to maintain a constant core temperature, decreased the level of progestagen actually entering the bloodstream to below the minimum dosage necessary for successful synchronization. Results of this study were inconclusive, however,

as they recorded no significant differences between implant sites or levels of treatment on synchronization response.

After much research to find optimum dosages and length of treatments for optimum synchronization results, Wiltbank and Gonzalez-Padilla (1975) concluded a 9 day implant of 6 mg norgestomet® accompanied by an injection of 5 or 6 mg EV and 3 mg norgestomet® at time of implantation gave the highest synchronization response without lowered fertility. This treatment is presently known as the Syncro-Mate B[1] procedure for synchronization. Woody and Abenes (1975) also reported identical first service conception rates in Syncro-Mate B treated heifers when compared to controls. Syncro-Mate B treated heifers and mature cows had an earlier average conception date and 25 day pregnancy rates were significantly higher than controls (Kiracofe et al., 1978).

Prostaglandins are another commonly used synchronization agent administered to beef cattle to interrupt the normal course of the cycle by regressing the CL before the end of its normal life-span. Prostaglandins are unsaturated 20-carbon fatty acids which vary in action according to their chemical structure. The "F" series has shown luteolytic properties in the bovine, thus is most commonly used for synchronization purposes (Walpole, 1975). Babcock (1966) reported higher levels of prostaglandins were found in non-pregnant cows late in their cycle, at the time CL regression would normally occur, than in blood samples taken at comparable times from pregnant cows, indicating

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[1]G. D. Searle & Co., Chicago, Illinois 60680.

prostaglandins do in fact work as a luteolysin. He also reported prostaglandins were secreted from uterine endometrium and regressed the CL through local circulation via anastamosis between the uterine vein and ovarian artery.

The physiological mechanism underlying prostaglandin effectiveness was studied by Phariss and Wyngarden (1969) who suggested prostaglandin $F_2\alpha$ ($PGF_2\alpha$) was an effective luteolysin by acting as a vasoconstrictor to reduce blood flow to the CL, therefore resulting in luteal regression.

Prostaglandin has been reported as an effective synchronization agent only when a functional CL is present on the ovary, or from days 5 through 18 of the cycle (Inskeep, 1973; Hill et al., 1973; Hafs et al., 1975; Turman et al., 1975). This is in agreement with Lauderdale (1972) who reported 30 mg of injected $PGF_2\alpha$ had no effect in controlling cycle length in heifers treated before day 5 of their cycle but caused onset of estrus within 48 to 96 hours following injection of heifers treated on days 6 through 16 of their cycle. Looking at possible compounds which would increase effectiveness of $PGF_2\alpha$, Hansen and Cupps (1974) reported an increased estrual response in heifers given PMS prior to a $PGF_2\alpha$ injection, than in heifers only receiving $PGF_2\alpha$.

Louis et al. (1974) looked at effects of $PGF_2\alpha$ administered through intrauterine infusions on hormonal balance of heifers treated during mid-cycle, and found hormonal patterns normally observed during the proestrus stage of the estrous cycle. This included decreased progesterone production and doubled estrogen production resulting in a LH peak, onset of estrus, and eventual ovulation 95 hours following $PGF_2\alpha$

treatment (Louis et al., 1975). Successful synchronization was also achieved by Hendricks et al. (1974) who used an intrauterine infusion of $PGF_2\alpha$ (2 mg) in heifers treated in the luteal phase of their cycle, but lowered conception rates were reported at the first synchronized estrus. This is in agreement with Fulka et al. (1975) who also observed decreased fertility at the synchronized estrus following two consecutive infusions of 2 mg $PGF_2\alpha$. Heersche et al. (1974) and Heersche et al. (1979) reported contradictory results, however, as they observed no significant decrease in first service conception rates of $PGF_2\alpha$ injected heifers when compared to controls, indicating $PGF_2\alpha$ treatments did not alter normal relationships involved with estrus and ovulation when administered via injection rather than intrauterine infusion.

Several studies have indicated a double injection of $PGF_2\alpha$ or one of its analogues such as ICI 80996 or ICI 79939, given 11 days apart will effectively synchronize estrus within 48 to 96 hours (Fulka et al., 1975; Cooper and Rowson, 1975; Lauderdale, 1975; Dobson et al., 1975). Wishart (1974) injected $PGF_2\alpha$ following a pre-treatment of SC21009 and observed a 94% synchronization rate within 5 days, which was significantly higher ($P<.05$) than heifers receiving only $PGF_2\alpha$. Ellicot et al. (1974) reported a more predictable ovulation time in $PGF_2\alpha$ treated heifers than in controls, indicated by a more uniform interval from onset of estrus to the ovulatory LH surge in those heifers injected with $PGF_2\alpha$. However, in an effort to make time of ovulation even more predictable, Welch et al. (1975) injected EB 48 hours following $PGF_2\alpha$

treatment to get an immediate LH surge, thus causing less variation in time of ovulation when compared to heifers treated with $PGF_2\alpha$ alone.

Predictable ovulation time is necessary for utilization of scheduled breeding times or "breeding by appointment," which is a relatively new management technique used in conjunction with estrus synchronization to improve reproductive efficiency of the beef cow. Timed insemination programs can be useful following synchronization treatments by decreasing labor required for estrus detection and increasing possible pregnancies in cows not showing overt signs of estrus; however, a concise knowledge of the estrual cycle and eventual ovulation time must be known before satisfactory fertility rates can be attained (Deas, 1970).

To look at the effect of time of insemination on fertility of cattle, a modified timed insemination experiment was conducted by Heekin (1977) which was designed to see if a once-a-day breeding program would decrease fertility rates in synchronized cows when compared to cows bred 12 hours following behaviorial estrus. She observed decreased conception rates in cows on a once-a-day breeding schedule compared to cows bred by estrus. She concluded decreased fertility was due to a possible 36 hour interval from actual onset of estrus to insemination in those cows bred once daily.

Advantages of timed insemination programs were suggested by Wishart and Young (1974) and Sreenan and Muleville (1975) when they noticed some cows synchronized by an estrogen injection following a pre-treatment of progesterone (Syncro-Mate B) failed to undergo behaviorial estrus during the synchronized period, but showed overt

signs of estrus 20 to 23 days later, indicating they ovulated 2 to 3 days following treatment. They suggested it was these heifers bred 48 and 60 hours following implant removal, although never showing behaviorial estrus, that were responsible for increased pregnancy rates observed in timed insemination groups when compared to estrus-bred heifers.

Research done by Wishart (1975) indicated Syncro-Mate B procedures used to control estrus made ovulation time predictable enough to utilize timed insemination programs without lowering fertility. In an effort to find the optimum time of insemination following Syncro-Mate B treatment, Morrison et al. (1975) looked at pregnancy rates in heifers inseminated at 48, 50, and 60 hours following implant removal. Those heifers bred 60 hours post-implant removal had a 38.1% first service conception rate compared to 33.3% for controls, and 26.3% and 23.8% for 48 and 50 hour breeding times, respectively. This is in agreement with work done by Wishart and Young (1974) who also noted higher conception rates in heifers bred at 48 and 60 hours than in heifers bred only at 48 hours or bred by estrus.

Research conducted by Zaied et al. (1976) looked at possible advantages of a GnRH injection administered 30 hours following removal of progesterone implants to increase conception rates in appointment-bred heifers compared to heifers bred by estrus and non-injected heifers bred 60 hours following implant removal. He reported GnRH treated heifers had significantly higher pregnancy rates than either of the latter groups. This is in agreement with Roche (1975) and Roche (1976) who also reported higher conception rates in GnRH

injected heifers inseminated 48 hours following a 12 day PRID treatment when compared to heifers treated with the PRID only. However, he concluded both treatments resulted in satisfactory fertility since neither had conception rates below those of heifers bred according to estrus. Other researchers have agreed a 30 mg injection or a 5 mg intrauterine infusion of $PGF_2\alpha$ will synchronize time of ovulation close enough to use in timed insemination programs. Lauderdale et al. (1974) reported 53.5% conception rate in controls compared to 52.2% observed in heifers bred twice at 72 and 90 hours post-$PGF_2\alpha$ treatment. Louis et al. (1975) reported no decrease of fertility in heifers bred 90 hours following $PGF_2\alpha$ treatment, and Edqvist et al. (1975) observed a 69% first service conception rate in $PGF_2\alpha$ heifers bred by appointment, indicating possible practical application of scheduled insemination following estrus synchronization with $PGF_2\alpha$.

In order to more closely control time of ovulation, Tervit et al. (1973) and Hansen and Cupps (1974) pre-treated heifers with PMS before administering $PGF_2\alpha$ and observed more uniform intervals from end of treatment to estrus and ovulation. Britt et al. (1974) and Graves et al. (1975) attempted more precise synchronization of ovulation by using GnRH treatments via implants and injection in conjunction with $PGF_2\alpha$. They both observed a shorter interval from end of $PGF_2\alpha$ treatment to ovulation, making optimum time of insemination more predictable.

Another management tool used to increase effectiveness of estrus synchronization followed by timed insemination is short term calf removal, or a 48 hour calf withdrawal period preceding the first synchronized estrus (Pexton et al., 1978). Justification of early weaning

was first reported by Wiltbank (1970) who observed the interval from calving to first estrus in suckled vs non-suckled cows decreased as much as 37 days in non-lactating cows without calves at side. This indicated the postpartum interval to first estrus could be significantly shortened if the suckling effect was removed or at least decreased. This is in agreement with Oxenreider (1968) who reported normally suckled cows had longer intervals from parturition to first estrus compared to cows hand-milked once a day, and Randel and Welker (1977) who observed an 81 and 25 day decrease in postpartum intervals of 2 and 3 year old cows suckled once a day when compared to normally suckled cows. Reeves et al. (1978) also studied once daily suckling management programs and reported onset of estrual activity 21 days earlier in restricted cows than normally suckled cows. A slight advantage in pregnancy rate was also noted for the 90 day breeding season in the once daily suckled group.

Increased conception rates and shorter postpartum intervals were noted in mature cows and heifers whose calves were weaned up to 140 days earlier than cows having a normal, uninterrupted lactation period (Poosey and Smart, 1975; Wiltbank, 1977; McKee and Fink, 1978; Kimple et al., 1978). Similar results were reported by Laster (1975) when calves were weaned eight days prior to the start of a 42 day breeding season and pregnancy rates increased 26, 16, and 8% in 2- and 3-year-old heifers and mature cows, respectively. He also noted an increased number of cows showing estrual activity during the breeding season of 29, 27, and 16% in 2- and 3-year-old and mature cows, respectively, when compared to suckled cows of the same ages.

Smith et al. (1976) showed complete weaning was not necessary for a response on return to estrus since a short term calf removal period prior to breeding increased the percentage of cows showing estrus within 21 days from 31% in controls to 62% in the calf removal group. Trevillyan et al. (1978) reported temporary calf separation for two 48 hour periods a week apart in non-synchronized cows did not significantly affect mature cows, but 2- and 3-year-old heifers showed estrus 5 days earlier than normally suckled controls. Weaning calves from anestrous cows caused a higher percentage of cows to show estrus within a 25 day period than a non-calf removal group; however, 78.3% of the non-suckled cows had 7 to 10 day short cycles compared to 16.6% of normally suckled cows (Ward et al., 1979).

Short term calf removal has been used successfully in conjunction with Syncro-Mate B procedures for estrus control. Higher conception rates were reported when calves were removed for 48 hours at implantation than when weaned at implant removal (Kiracofe, 1978). Ott (1977) reported 92% of a calf removal group showed estrual behavior within 25 days compared to 82% of a non-calf removal group following Syncro-Mate B treatments. Using the same synchronization procedures, Wiltbank (1977) reported 85% of cows having their calves removed for 48 hours at implant removal were detected in estrus within 42 hours compared to 45% of cows nursing calves.

Physiological interactions between lactation and depression of ovarian function necessary for estrual activity have not been fully established, but may be related to pituitary dysfunction associated with lactation. During intense lactation, prolactin function is

maximal, and prolactin inhibiting factor (PIF) function is minimal (Hafez, 1975; Erb et al., 1976). Suckling may inhibit estrus by depressing gonadotropin secretion and increasing prolactin. However, after use of 2α-bromoergocryptine (CB-154), a compound known to successfully inhibit prolactin secretion, no significant decline in progesterone and estrogen blood levels were noted (Williams and Ray, 1978); therefore, they concluded high levels of prolactin during the early postpartum period was not a factor directly involved with failure of lactating cows to show estrus. However, Symington (1969) as reported by Hafez (1975) indicated an indirect relationship of prolactin on estrual activity, since any factor which limits PIF secretion (thus creating high prolactin levels) will also suppress secretion of luteinizing hormone releasing factor (LRF) which in turn inhibits production and secretion of LH; therefore, final follicular maturation and ovulation cannot occur and estrus is inhibited. Echternkamp (1978) also concluded lactation suppresses gonadotropin secretion in early postpartum cows since anestrous cows treated with PMS at 42 days postpartum initiated estrogen and a subsequent LH surge in anestrous suckled and non-suckled cows, whereas PMS only stimulated estrogen and not LH in cows already cyclic at 42 days postpartum. In another trial, he reported non-suckled heifers had increased spontaneous LH secretion when compared to suckled heifers. Short et al. (1972) and Crighton and Lamming (1969) showed that after weaning, FSH and LH blood levels increased causing increased average diameter of ovarian follicles as well as an increase in length and weight of the uterus, indicating onset of estrus.

Level of circulating progesterone is reported by Sceery et al. (1978) to have a direct effect on estrual activity. Jugular blood samples collected at 3 day intervals following calving with those collected between day 15 postpartum to 9 days following estrus were analyzed for progesterone and estradiol-17β by radio immuno-assay. Highly variable estradiol-17β was not significantly affected by weaning, but progesterone levels increased rapidly with onset of estrus as a result of weaning. Heifers with early weaned calves had significantly higher progesterone levels than late weaned heifers on days 39 (1.23 vs .14 ng/ml) and 42 (2.44 vs .08 ng/ml). Hendricks et al. (1971) also reported elevated progesterone levels 4 days prior to estrus, indicating progestational dependence for estrual behavior. This brief elevation in circulating progesterone immediately preceding the first postpartum estrus is of ovarian origin and is preceded by an increase in serum estradiol. This might explain why 48 hour calf removal with the use of Syncro-Mate B has given good results (Williams and Ray, 1978).

Other blood assays done to determine possible effects on reproductive performance have included glucose, hematocrit, hemoglobin, and phosphorus with no significant differences noted when comparing early weaned cows with normally suckled cows (McCarter, 1972).

To determine if the suckling effect was the only factor involved in estrus suppression in lactating cows, Short et al. (1972) removed the entire mammary gland after parturition and showed the turgid mammary gland in non-suckled cows was also a potential inhibitory factor on estrual activity. The mammary gland response was indicated

when the mastectomized group showed estrus an average of 13 days earlier than those cows in the non-suckled group.

Physiological mechanisms underlying early weaning effectiveness are inconclusive at this time and not completely understood. Much research still needs to be done to maximize efficiency and utilize to the fullest extent the advantages this new management tool can offer today's cattlemen.

MATERIALS AND METHODS

Four hundred seventy-three first calf heifers and mature cows were used in a 2-year study to evaluate effects of synchronization, short term calf removal and breeding by appointment on reproductive efficiency of English and exotic beef cattle. Two separate synchronization trials were conducted using both fall and spring calving cows. Syncro-Mate B procedures[1] for estrus synchronization were used in both trials, which consisted of a single intramuscular injection of 5 mg estradiol valerate (EV) and 3 mg norgestomet® suspended in a solution of sesame oil and 10% benzyl alcohol, plus a 9 day 6 mg norgestomet® (SC21009) implant placed subcutaneously on the posterior side of the ear.

Trial 1

Three hundred sixty-eight 2- and 3-year-old fall calving cows (courtesy of the Ramsey Ranch, El Dorado, Kansas) consisting of 175 Angus, 160 half-blood Maine Anjou x Angus, and 33 three-quarter Maine Anjou x Angus were randomly allotted to four treatment groups and a control group. The experimental procedure requested for each treatment group was as follows:

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[1]G. D. Searle and Company, Chicago, Illinois.

Group 1. Sixty-four cows were synchronized and their calves were withdrawn at implant removal for 48 hrs or until the cow expressed estrus, whichever came first (CR). The entire group was to be artificially inseminated after 60% of the cows within the group expressed estrus.

Group 2. Sixty-two cows were treated exactly as Group 1; however, these cows were to be artificially inseminated 12 hrs after visual detection of estrus.

Group 3. Sixty-three cows were synchronized and allowed to run with their calves with no separation period (NCR). The entire group was to be appointment bred using the same procedure as Group 1.

Group 4. Sixty-two cows were synchronized and remained with their calves exactly as in Group 3; however, these cows were to be inseminated following estrual behavior just as in Group 2.

Group 5. One hundred seventeen control cows received no hormonal treatment, did not have their calves removed, and were artificially inseminated approximately 12 hrs after detected in estrus.

However, breeding records received from the ranch manager clearly indicated the experimental procedure regarding time of insemination was not followed because all synchronized cows were inseminated at 20, 28, 44 or 52 hrs following implant removal, according to their pasture group rather than by treatment group or estrual behavior. Therefore, to make statistically valid comparisons, treatment groups were

re-allocated according to age, time of insemination and calf removal procedures,* and are as follows:

Group 1a. Thirty-two 3-year-old cows had their calves withdrawn and were all inseminated 20 hrs post-implant removal.

Group 1b. Thirty-two 3-year-old cows were inseminated at the same time as Group 1a, but did not have their calves removed.

Group 2a. Thirty-two 3-year-old cows were separated from their calves with the entire group inseminated 28 hrs after hormonal withdrawal.

Group 2b. Thirty-two 3-year-old cows were also inseminated at 28 hrs, but were allowed to run with their calves with no separation period.

Group 3a. Thirty 2-year-old cows had their calves withdrawn and were all inseminated 44 hrs post-implant removal.

Group 3b. Thirty 2-year-old cows were inseminated at the same time as Group 1b, but did not have their calves removed.

Group 4a. Thirty-two 2-year-old cows were separated from their calves with the entire group inseminated 52 hrs after hormonal withdrawal.

Group 4b. Thirty-one 2-year-old cows were also inseminated at 52 hrs, but were allowed to run with their calves with no separation period.

Group 5. One hundred seventeen control cows received no hormonal treatment, did not have their calves removed and were

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*Calf removal groups underwent a separation period of 48 hrs or until the cow was inseminated, whichever came first.

artificially inseminated approximately 12 hrs after detected in estrus.

The deviation from original experimental procedure and subsequent redistribution of treatment groups made it impossible to compare breeding by appointment with breeding according to estrus, or to see if calf removal increased the number of cows expressing estrual activity during the synchronized period. Also, evaluation of optimum time of insemination following Syncro-Mate B treatment was difficult because of age differences associated with the appointed breeding times.

All cows were maintained on an identical nutritional regime of native pasture and supplemental feed for the duration of the trial.

Onset of the 90 day breeding season was 17 days later for synchronized groups than for controls, due to delayed shipment of hormonal implants. During the final 21 days of the breeding season, all cows were placed with clean-up bulls and allowed to mate naturally. Final conception dates were determined by actual calving dates recorded the following year.

Trial 2

One hundred and five spring calving purebred Angus and Hereford cows consisting of 20 2-year-olds, 24 3-year-olds, and 61 mature cows (4 years and older) were randomly distributed among the following three treatment groups:

Group 1: Thirty-three cows were synchronized with the entire group appointment-bred 48 hours following implant removal with no regard to estrual behavior.

Group 2: Thirty-three cows were synchronized and artificially inseminated approximately 12 hours after detected in estrus.

Group 3: Thirty-nine control cows received no hormonal treatment and were bred according to standard artificial insemination procedure 12 hours after estrus detection.

All heifers were maintained on native range for the duration of the trial and received increased energy supplementation prior to the breeding season.

Because of a delay in hormonal treatment, onset of the 60 day breeding season was 7 days later for synchronized groups than for controls. Estrus detection for artificial insemination was aided by androgenized cows equipped with chin-ball markers. During the final phase of the breeding season, all cows were placed with clean-up bulls and allowed to mate naturally. Final conception dates were determined by actual calving dates recorded the following spring.

Data for both trials were analyzed by least squares analysis of variance (Kemp, 1972), and direct comparisons were made between synchronized and non-synchronized cows; calf removal and non-calf removal; breeding by appointment and breeding according to estrus; breeding by appointment in combination with either calf removal or non-calf removal.

RESULTS

Trial 1

Estrus synchronization using Syncro-Mate B treatment was considered successful since all cows receiving hormonal treatment were inseminated within 52 hours after implant removal and still maintained a slightly improved, although non-significant, first service conception rate when compared to controls (50.6 to 48.0%) (Table 1). These results indicate Syncro-Mate B treatment can effectively control the estrous cycle without any detrimental effect on fertility at the estrus immediately following hormonal withdrawal.

TABLE 1. EFFECT OF SYNCHRONIZATION ON FIRST SERVICE CONCEPTION RATE

	Conceived First Service (%)	
	Synchronized	Non-synchronized
No. Conceived	127	48
No. Inseminated	251	100*
% Conception	50.6%	48.0%

*17 control cows were never detected in estrus or inseminated during the breeding season.

First service conception rates of synchronized groups were also found to be essentially identical when comparing 3-year-old cows inseminated at 20 and 28 hours post-implant removal to 2-year-old cows inseminated at 44 and 52 hours following hormonal withdrawal (53.9 to 47.2%), indicating neither age or time of insemination had a noticeable effect on fertility at the synchronized estrus (Table 2). Effect of calf removal in synchronized cows was also evaluated at each appointed breeding time, with calf removal groups having slightly decreased rates of 53.1 vs 59.4% and 40.6 vs 62.5% at 20 and 28 hours, when compared to non-calf removal groups. However, at 44 and 52 hours this trend was reversed when a 3.3 and 14.5% increase in first service conception rate was noted in favor of calf removal, although none of these differences at the four insemination times were significant.

To evaluate treatment effect on fertility throughout the entire breeding season, the number of services required/conception was calculated for each group by dividing the total number of inseminations (including open cows that were inseminated one or more times) by the number of cows that conceived. Synchronized and non-synchronized cows were essentially identical with 2.1 and 1.9 services/conception required for each respective group, indicating no subsequent fertility problems were caused by hormonally controlling the estrous cycle (Table 3).

TABLE 2. EFFECT OF CALF REMOVAL AND TIME OF INSEMINATION*
ON FIRST SERVICE CONCEPTION RATE OF SYNCHRONIZED COWS

Conceived First Service (%)

	3-Year-Olds				2-Year-Olds			
	20 Hours		28 Hours		44 Hours		52 Hours	
	1a CR	1b NCR	2a CR	2b NCR	3a CR	3b NCR	4a CR	4b NCR
No. Conceived	17	19	13	20	16	15	16	11
No. Inseminated	32	32	32	32	30	30	32	31
% Conception	53.1	59.4	40.6	62.5	53.3	50.0	50.0	35.5

*Time of insemination refers to number of hours post-implant removal.

TABLE 3. EFFECT OF SYNCHRONIZATION ON SERVICES REQUIRED/CONCEPTION

	Services/Conception	
	Synchronized	Non-Synchronized
No. Conceived	215	86
No. of Inseminations	456	162
No. Services Required/Conception	2.1	1.9

Also, no significant effect on subsequent fertility was noted because of age, time of insemination, or calf removal since the largest difference recorded for inseminations required/conception when comparing each of these factors was 0.1, 0.25, and 0.4, respectively (Table 4). However, the trend in favor of calf removal at 44 and 52 hours compared to earlier breeding times of 20 and 28 hours where non-calf removal showed the advantage was observed here exactly as recorded at the first synchronized estrus, indicating a possible interaction between time of insemination and effectiveness of short term calf withdrawal.

Pregnancy rate, defined as the number of cows conceived/number in the group, was determined at 5, and 25 days from the beginning of the breeding season and also at the conclusion of the breeding season. Synchronization resulted in a marked improvement in the number of pregnancies obtained early in the breeding season with 50.9% of all synchronized cows pregnant within 5 days compared to only 6.9% of

TABLE 4. EFFECT OF CALF REMOVAL AND TIME OF INSEMINATION* ON SERVICES REQUIRED/CONCEPTION IN SYNCHRONIZED COWS

	Services/Conception							
	3-Year-Olds				2-Year-Olds			
	20 Hours		28 Hours		44 Hours		52 Hours	
	1a CR	1b NCR	2a CR	2b NCR	3a CR	3b NCR	4a CR	4b NCR
No. Conceived	28	31	30	31	23	23	24	25
No. of Inseminations	63	63	66	56	45	52	53	58
No. of Services Required/Conception	2.3	2.0	2.2	1.8	1.9	2.3	2.2	2.3

*Time of insemination refers to number of hours post-implant removal.

non-synchronized cows (P<.001). Twenty-five day pregnancy rates were also significantly different (P<.001) in favor of synchronized over non-synchronized cows (67.2 to 26.1%). Pregnancy rate of all synchronized groups at the close of the breeding season was still slightly improved over controls (85.5 to 83.1%), but the difference was not significant.

TABLE 5. EFFECT OF SYNCHRONIZATION ON PREGNANCY RATE DURING BREEDING SEASON

	Pregnancy Rate(%)	
Breeding Season	Synchronized	Non-Synchronized
5 Days	50.9	6.9[a]
25 Days	67.2	26.1[a]
90 Days	85.5	83.1

[a]Mean is significantly different (P<.001).

In Table 6, pregnancy rates were calculated according to age of cow and then compared between calf removal and non-calf removal groups to determine if interrupting the normal lactation cycle of synchronized cows would increase the number of cows conceiving early in the breeding season. Results regarding calf removal appeared inconclusive though, when contradictory but non-significant results were recorded between age groups inseminated at various times. Three-year-old normally suckled cows inseminated at 20 and 28 hours had a 12.5% improved pregnancy rate at 5 days compared to 3-year-olds with their calves

removed, while 2-year-old cows inseminated at 44 and 52 hours showed a 9.1% advantage over 2-year-olds left with their calves. However, by 25 days after onset of the breeding season, pregnancy rates of calf removal and non-calf removal groups were essentially identical within each age group. This indicates short term weaning of calves at implant removal had a possible effect on the number of cows conceiving at the estrus immediately following hormonal withdrawal, but had virtually no effect late in the breeding season.

TABLE 6. EFFECT OF CALF REMOVAL ON PREGNANCY RATE OF SYNCHRONIZED COWS

	Pregnancy Rate (%)			
	3-Year-Olds		2-Year-Olds	
Breeding Season	CR	NCR	CR	NCR
5 Days	48.4	60.9	51.8	42.7
25 Days	70.3	78.1	59.9	60.7
90 Days	90.6	96.9	75.8	78.7

Optimum time of insemination following Syncro-Mate B treatment was also looked at, although only limited comparisons could be made because of age differences associated with the four pre-determined breeding times (Table 7).

TABLE 7. EFFECT OF TIME OF INSEMINATION* FOLLOWING SYNCHRONIZATION ON PREGNANCY RATE

	Pregnancy Rate (%)			
	3-Year-Olds		2-Year-Olds	
Breeding Season	20 Hours	28 Hours	44 Hours	52 Hours
5 Days	57.8	51.6	51.7	42.8
25 Days	73.4	75.0	63.3	57.2
90 Days	92.2	95.3	76.7	77.8

*Time of insemination refers to number of hrs post-implant removal.

Although statistically valid comparisons could not be made between age groups, it appears inseminating anywhere from 20 to 52 hours post-implant removal will result in satisfactory numbers of cows conceiving within the first 5 days of the breeding season, since the lowest recorded rate for any of the appointed breeding times was 42.8% for 2-year-old cows inseminated at 52 hours. However, there is a possibility that this percentage was affected by cow age, and in actuality may have been improved, since an age effect was indicated when 3-year-old cows maintained a decided advantage in pregnancy rates of 74.2 to 60.3% at 25 days and 98.8 to 77.3% at 90 days over the 2-year-old group.

Insemination times were compared within age groups, with slight but non-significant differences recorded in each, when 3-year-old cows inseminated at 20 hours showed a 6.2% improvement in pregnancy rate

over those inseminated at 28 hours, and an increase of 8.9% was recorded for 2-year-old cows inseminated at 44 hours compared to 52 hours. Time of insemination following synchronization appeared to have no effect on subsequent fertility, however, as 25 and 90 day pregnancy rates showed virtually no differences when compared within age groups.

Table 8 simply combines calf removal and time of insemination data collected from synchronized cows to check for possible interactions between treatments, and therefore explain contradictory results regarding effectiveness of calf removal. Although no significant differences were seen, an association between treatments was noted when trends observed earlier were repeated, as non-calf removal at 28 hours had a 21.9% increase in pregnancy rate at 5 days, whereas a 14.5% increase in favor of removing calves was noted at 52 hours. Smaller differences were noted between calf removal groups at 20 and 44 hours but trends observed matched differences seen at 28 and 52 hours. These results indicate that for calf removal to be effective in synchronized cows, insemination time must be sometime later than 28 hours post-implant removal. Possible interactions observed between insemination time and short term weaning during the synchronized period were not noticeable at the subsequent estrus 25 days later, and by the close of the breeding season pregnancy rates were essentially identical within each age group.

Average conception dates were calculated for synchronized groups and controls, including only those cows that conceived, to

TABLE 8. COMBINED EFFECT OF CALF REMOVAL AND TIME OF INSEMINATION* OF PREGNANCY RATE OF SYNCHRONIZED COWS

	Pregnancy Rate(%)							
	3-Year-Olds				2-Year-Olds			
	20 Hours		28 Hours		44 Hours		52 Hours	
Breeding Season	1a CR	1b NCR	2a CR	2b NCR	3a CR	3b NCR	4a CR	4b NCR
5 Days	56.3	59.4	40.6	62.5	53.3	50.1	50.0	35.5
25 Days	75.0	71.9	65.6	84.4	60.1	66.7	59.4	54.8
90 Days	87.5	96.9	93.8	96.9	76.7	76.7	75.0	80.7

*Time of insemination refers to number of hours post-implant removal.

demonstrate benefits offered from synchronization (Table 9). Mean conception dates appear to be extremely close when comparing combined synchronized groups to non-synchronized controls; but if the 17 day difference in onset of the breeding season is taken into consideration, synchronized groups conceived from 8 to 19 days earlier than controls. Although separate means were calculated for each synchronized group, no apparent effect of either calf removal or time of insemination was noted since small but contradictory results were recorded within each of these groups.

TABLE 9. TREATMENT EFFECT ON MEAN CONCEPTION DATE*

Treatment Group	Average Conception Date
3-Year-Olds	
1a (20 hrs., CR)	December 30
1b (20 hrs., NCR)	January 5
2a (28 hrs., CR)	January 4
2b (28 hrs., NCR)	December 30
2-Year-Olds	
3a (44 hrs., CR)	January 3
3b (44 hrs., NCR)	December 29
4a (52 hrs., CR)	January 3
4b (52 hrs., NCR)	January 9
5 (Controls)	December 31[a]

*Only includes those cows that conceived.
[a]Onset of the breeding season for non-synchronized controls was 17 days earlier than for all other treatment groups.

Calf removal was also evaluated for its effectiveness on reducing the interval from calving to conception within each age group (Table 10). A trend in favor of short term calf withdrawal was observed in both age groups since a decrease in interval length of 7.4 to 8.9 days was recorded in 3-and 2-year-old cows respectively, although neither difference was significant.

TABLE 10. EFFECT OF CALF REMOVAL ON INTERVAL FROM CALVING TO CONCEPTION IN SYNCHRONIZED COWS

	Days Postpartum	
Age	Calf Removal	Non-calf Removal
3-year-olds	121.6 ± 10.1	130.5 ± 10.1
2-year-olds	75.6 ± 6.0	83.0 ± 6.1

*Interval from calving to conception is listed as the mean ± standard error.

No significant effect was found from breed, AI technician, or interval from calving to synchronization, which were the other factors that were considered in analysis of the data. Age was not included since these two groups were considered separate and analyzed as such.

Trial 2

Estrus synchronization using Syncro-Mate B treatment caused a lower but non-significant first service conception rate in combined synchronized groups (39.4%) when compared to non-synchronized controls (56.4%), indicating this hormonal treatment could possibly reduce

fertility at the synchronized estrus (Table 11). However, time of insemination at the first estrus following hormonal withdrawal may have been partially responsible for the observed difference in first service conception rate of synchronized and non-synchronized groups since cows inseminated 48 hours post-implant removal regardless of estrual behavior did not have significantly lowered fertility when compared to controls (45.5 to 56.4%), whereas cows bred according to estrus were significantly lower (P<.10) with a 23.1% decrease in first service fertility compared to non-synchronized controls. This indicates breeding by appointment can result in normal fertility at the synchronized estrus and even have improved conception rates when compared to synchronized cows bred by estrus.

TABLE 11. TREATMENT EFFECT ON FIRST SERVICE CONCEPTION RATE

	1 Appointment	2 Estrus	3 Controls
No. Conceived	15	11	22
No. Inseminated	33	33	39
% Conception	45.5[ab]	33.3[a]	56.4[b]

[ab]Means with different superscripts are significantly different (P<.10).

To evaluate treatment effect on subsequent fertility throughout the breeding season the number of services required/conception was calculated for each treatment group by dividing the total number of inseminations (including open cows inseminated one or more times) by

the number of cows that conceived (Table 12). Synchronized groups were not significantly different from the non-synchronized group with appointment-bred cows requiring 0.3 fewer services/conception and estrus-bred cows requiring an increase of 0.4 services/conception when compared to controls, thus indicating fertility throughout the breeding season was not reduced by hormonally controlling the estrous cycle. However, a significant difference ($P<.10$) was noted between the appointment-bred and estrus-bred groups when 1.4 and 2.1 services were required/conception for each respective group. Since time of insemination at the synchronized estrus would not be expected to affect fertility at subsequent estrus periods, these results indicated a possible reproductive problem within the group, which may have been partially responsible for the reduced first service conception rate observed in the estrus-bred group rather than hormonal treatment or time of insemination.

TABLE 12. TREATMENT EFFECT ON SERVICES REQUIRED/CONCEPTION

	1 Appointment	2 Estrus	3 Controls
No. Conceived	29	26	38
No. of Inseminations	41	55	65
No. of Services Required/Conception	1.4[a]	2.1[b]	1.7[ab]

[ab]Means with different superscripts are significantly different ($P<.10$).

Pregnancy rate defined as number conceived/number in the group was calculated at 5, 25, and 60 days of the breeding season. These results also reflect abnormally low fertility in the estrus-bred group since these cows expressed reduced pregnancy rates throughout the entire breeding season of 9.1 to 18.4% when compared to cows bred by appointment, although these differences were not large enough to be significant (Table 13). However, a significant difference ($P<.01$) was noted between the synchronized group that was time inseminated and non-synchronized cows at 5 days with 45.5% compared to only 10.5% settled in each respective group. Also, at 25 days, 72.7% of synchronized cows bred by appointment had conceived compared to 45.5% of non-synchronized controls ($P<.10$), indicating synchronization can effectively increase the number of cows cycling early in the breeding season and therefore substantially improve pregnancy rates after only one estrual cycle. At 60 days a significant difference ($P<.05$) was observed between synchronized cows bred by estrus (78.8%) and control cows (97.5%), which should not be expected at the conclusion of the breeding season, thus further indicating a possible fertility problem within Group 2.

TABLE 13. TREATMENT EFFECT ON PREGNANCY RATE

	Pregnancy Rate (%)		
Breeding Season	1 Appointment	2 Estrus	3 Controls
5 Days	45.5^{a}	33.3^{ab}	10.5^{b}
25 Days	72.7^{c}	54.6^{cd}	45.5^{d}
60 Days	87.9^{ef}	78.8^{e}	97.5^{f}

^{ab}Means with different superscripts are significantly different ($P<.01$).

^{cd}Means with different superscripts are significantly different ($P<.10$).

^{ef}Means with different superscripts are significantly different ($P<.05$).

Average conception dates were calculated for each treatment group and compared in Table 14. Even without adjusting for the 7 day difference in onset of the breeding season, synchronized cows clearly show an advantage over non-synchronized cows by having earlier mean conception dates of 8 to 15 days, or 15 to 22 days if the 7 day adjustment is made. This reconfirms the data in Table 13 that synchronization will result in cows conceiving earlier in the breeding season, which can be a major advantage if trying to maintain a 12 month calving interval.

TABLE 14. TREATMENT EFFECT ON MEAN CONCEPTION DATE*

Treatment	Average Conception Date
1 (Appointment)	June 6
2 (Estrus)	June 13
3 (Controls)	June 21[a]

*Only includes those cows that conceived.

[a]Onset of the breeding season was 7 days earlier for non-synchronized controls than for Groups 1 and 2.

No significant effect was recorded from age, AI technician, or interval from calving to synchronization, which were the other factors that were considered in analysis of the data.

DISCUSSION

Synchronization of estrus in the beef cow can best benefit the cattleman by substantially increasing the number of cows expressing estrus early in the breeding season, resulting in the opportunity for improved pregnancy rates within 25 days following onset of the breeding season. This was indicated when significantly improved 5 and 25 day pregnancy rates were noted in both trials when comparing synchronized to non-synchronized cows, which is in agreement with work done by Kiracofe et al. (1978). This advantage was especially evident in Trial 1 where the combined 5 day pregnancy rate of synchronized groups was 44.0% higher than in non-synchronized controls, with 50.9% of all synchronized cows pregnant within less than a week after onset of the breeding season. To demonstrate even more clearly the importance of getting such large numbers of cows settled within this short time-span, 5 day pregnancy rates of combined synchronized groups were compared to the 25 day rate of non-hormonally treated cows. A 24.8% advantage was still recorded in favor of synchronized cows even after control cows had the opportunity to complete an estrual cycle within the 25 day period. Similar data were reported by Ott (1977) when he observed a 35 to 37% increase in pregnancy rates at 5 days in synchronized compared to non-synchronized cows, and still a 10 to 12% improvement when 5 day rates were compared to 25 day rates

for each respective group. Pregnancy rates in Trial 2 also showed a 28.9% advantage in favor of synchronization when evaluated at 5 days, but treated and non-treated cows were essentially identical when percentages were compared between 5 and 25 days.

Earlier estrual activity of synchronized cows resulting in improved pregnancy rates within 25 days following onset of the breeding season was clearly demonstrated when earlier average conception dates of 8 to 19 days and 15 to 22 days were recorded for synchronized groups compared to non-synchronized controls in Trials 1 and 2, respectively. This is in agreement with work done by Whitman et al. (1972) who reported an 85 to 90% synchronization response within 5 days following Syncro-Mate B treatment, resulting in earlier average conception dates of these groups when compared to controls. Earlier conception dates could be very beneficial to the cattleman trying to maintain a yearly calving interval by minimizing the number of late calving cows that may not readily rebreed within the time allowed because of short postpartum intervals. Also, an earlier average conception date would mean an older more uniform calf crop at weaning which can result in a substantial increase in calf weights and more economic value to the producer.

Effects of hormonal treatment on fertility were closely evaluated to help determine if estrus synchronization could be practically utilized by the cattleman. Controlling the estrous cycle by treatment with Syncro-Mate B did not significantly reduce first service or subsequent conception rates during the breeding season when compared to non-hormonally treated controls in Trial 1, which is in agreement with Wiltbank et al. (1971) who also reported heifers receiving this

treatment had conception rates equal to controls. However, in Trial 2 synchronized cows bred by estrus had a 23.1% decrease in first service conception rate which was significantly lower than controls, while the remaining synchronized group bred by appointment expressed essentially identical fertility compared to non-synchronized cows.

Subsequent fertility throughout the breeding season was evaluated for each treatment group and below normal rates were still observed in synchronized cows bred by estrus at the conclusion of the 60 day period, indicating a possible reproductive problem within this group. Therefore, past records of these cows were examined, and the three cows in the herd with known reproductive problems were found in this group, although the cows had been randomly allotted at the beginning of the trial. Therefore, unequal distribution of these cows could have been partially responsible for the abnormally low first service conception rate observed in Group 2 rather than effects of hormonal treatment or time of insemination.

Normal fertility rates were observed for most synchronized groups of both trials with the exception of the synchronized estrus-bred group, thus decreased fertility at the synchronized estrus was not considered a disadvantage of Syncro-Mate B treatment. This is in agreement with Woody and Abenes (1975) who also observed normal fertility in Syncro-Mate B treated heifers compared to controls, but is not in agreement with some work done by Wiltbank and Gonzalez-Padilla (1975), who reported significantly lower first service conception rates in three out of seven trials using identical hormonal treatment.

Various timed insemination procedures were also looked at to see if cattlemen could effectively decrease labor requirements with this management technique and still maintain normal fertility. Results from these trials indicate breeding by appointment anywhere from 20 to 52 hrs post-implant removal will result in first service conception rates which are not significantly different from first service conception rates observed in control cows bred by estrus and are therefore considered to be in the normal range for fertility. This is in agreement with work done by Morrison (1975) and Wishart (1975) who inseminated heifers at various pre-determined times within 60 hrs after implant removal and observed normal fertility when compared to synchronized cows inseminated 12 hrs following estrual activity.

Evaluation of insemination times used in Trial 1 was difficult because of the associated age differences; therefore, only suggestions and not conclusions were made regarding optimum time of insemination following Syncro-Mate B treatment. Although insemination times could not be statistically compared between age groups, the one exception to noticeable differences in fertility between 2- and 3-year-old cows at each specified insemination time throughout the breeding season suggested a possible treatment effect. Two-year-old cows had consistently lower pregnancy rates of 8.8 to 18.6% when compared to 3-year-olds, except when inseminated at 44 hrs, where 2-year-olds showed essentially identical 5 day results compared to the 3-year-old group (51.6 to 54.7%). Therefore, this suggests inseminating at 44 hrs post-implant removal gave optimum results when compared to appointed breeding times of 20, 28, and 52 hrs.

Results in Trial 2 also indicated satisfactory results could be obtained with this approximate insemination time since cows inseminated at 48 hrs following hormonal withdrawal showed no significant decline in first service fertility when compared to non-synchronized cows. Furthermore, breeding by appointment at 48 hrs even surpassed the first service conception rate of synchronized cows bred according to estrus by 12.2%, although this may be explained by previously reported reproductive problems associated with the estrus-bred group. Another explanation might be since estrus detection in a group of synchronized cows is quite difficult, inseminating according to estrual behavior may result in some cows being inseminated that have not actually experienced standing heat or failing to detect estrus in some that have, thus decreased pregnancy rates could occur in these groups (Wishart and Young, 1974). Increased first service pregnancy rates of appointment-bred cows could also be the result of some synchronized cows ovulating but not showing overt signs of estrus at the synchronized period, such as was occasionally observed by Wishart and Young (1974) and Sreenan and Muleville (1975); therefore, breeding by appointment would increase pregnancy rates in these groups. A third reason may be that 48 hrs following Syncro-Mate B treatment might be the optimum insemination time for most cows, which is what is indicated from trends observed in Trials 1 and 2 when comparing 5 day pregnancy rates of cows inseminated at various pre-determined times. Mares et al. (1977) reported similar results when they observed improved pregnancy rates in appointment-bred cows inseminated at 48 hrs compared to cows bred by estrus. However, research done by Wishart and Young

(1974), Morrison (1975) and Wishart (1975) indicated inseminating at 48 hrs was too early since increased conception rates were observed in cows inseminated at 50, 58 and 60 hrs following Syncro-Mate B treatment compared to cows inseminated at 48 hrs.

Any conclusion based on effectiveness of calf removal was difficult because of the mandatory redistribution of treatment groups; however, trends were observed and suggestions made accordingly. A consistent trend did appear when evaluating fertility at the first synchronized estrus and also in pregnancy rates observed at 5 days of the breeding season. This trend indicated an interaction between time of insemination and calf removal since cows inseminated at 20 and 28 hrs consistently showed a 12.5% increase in favor of non-calf removal groups, whereas an advantage of 9.1% was noted in cows whose calves were temporarily weaned when time of insemination was 44 or 52 hrs post-implant removal. A possible explanation for these contradictory results may be due to experimental procedure calling for temporarily weaned calves to be returned after 48 hrs or after the cow was inseminated, whichever came first. Therefore, those cows inseminated at 20 or 28 hrs did not undergo a long enough separation period for calf removal to be effective, whereas inseminating at 44 hrs allowed enough time for calf removal to start taking effect and by 52 hrs a substantially increased response was noted in favor of this treatment. This trend was not seen at 25 or 90 days of the breeding season, however, which was expected since temporary calf removal following synchronization should only have an effect at the

first estrus immediately following hormonal withdrawal rather than at subsequent estrus periods in the breeding season.

The majority of previous research regarding short term calf removal has reported increased conception rates in cows whose calves were temporarily withdrawn, but results observed by Heekin (1977) disagree since she observed lower conception rates in calf removal groups than in normally suckled cows. However, when Wiltbank (1977) removed calves for 48 hrs following Syncro-Mate B treatment, he observed a 40% increase in estrual activity within 48 hrs in calf removal groups compared to cows remaining with their calves. Using the same experimental procedure, Ott (1977) also reported a 10% increase in estrual behavior within 25 days when comparing calf removal to non-calf removal.

Another trend, although non-significant, was recorded in Trial 1 in favor of short term calf removal when the postpartum interval of these cows was shortened from 7.4 to 8.9 days, which is in agreement with results reported by Smith (1976), Trevillyan et al. (1978) and Wiltbank (1977), who also reported shorter intervals from calving to conception in cows whose calves were removed for 48 hrs. This could be helpful in reducing the number of late calving cows which can be a major contributing factor to decreased calf crops (Wiltbank, 1970).

Since physiological interactions associated with lactation and estrual activity are not yet completely understood, it is difficult to explain the contradictory results short term calf removal has produced in synchronized cows. The variation might partially be explained by the time at which calves are actually removed from the cows.

Kiracofe (1978) suggested this might be a factor when he reported higher conception rates and fewer short-cycles in cows whose calves were removed for 48 hrs at time of implantation rather than at implant removal. His explanation was cows whose calves were removed at implantation had several more days for circulating levels of luteinizing hormone (LH) to reach the necessary threshold for corpus luteum maintainence, which is needed for either normal cycle length or pregnancy. Further research involving calf removal and associated underlying physiological mechanisms must be completed, however, before varied results regarding this experimental management tool can be fully and accurately explained.

SUMMARY

Four hundred seventy-three lactating cows were used in two separate trials to determine if hormonal control of the estrous cycle with or without short term calf removal had any effect on subsequent fertility or reducing the interval from calving to conception. Inseminating cows at various pre-determined times following estrus synchronization was also studied in cows receiving Syncro-Mate B treatment (9 day ear implant containing 6 mg norgestomet® and a single injection of 5 mg estradiol valerate plus 3 mg norgestomet®) to evaluate which insemination time produced optimum results and if normal conception rates could be maintained in time inseminated cows compared to cows bred by estrus.

In the first trial, 368 fall calving 2- and 3-year-old Angus and crossbred Maine Anjou cows were allotted to the following treatments: Groups (1-4) were synchronized and time inseminated at 20, 28, 44, and 52 hrs post-implant removal, respectively. Each synchronized time inseminated group was also equally sub-divided as follows: (a) cows were separated from their calves at implant removal for 48 hrs or until the cow was inseminated, and (b) cows were allowed to remain with their calves with no separation period. The control group (5) consisted of non-synchronized cows that were allowed to remain with their calves and bred according to estrus. First service conception rates and services/conception for Groups 1a, 1b-4a, 4b, respectively, were 53.1

2.3; 59.4, 2.0; 40.6, 2.2; 62.5, 1.8; 53.3, 1.9; 50.0, 2.3; 50.0, 2.2; and 35.5, 2.3 with no significant effect from either calf removal or time of insemination on fertility when treatments were compared within age groups. First service conception rate and services/conception were also not significantly different between synchronized and non-synchronized cows (50.1, 2.1 to 48.0, 1.9), indicating normal fertility was maintained in hormonally treated cows. Five, 25, and 90 day pregnancy rates were similar for synchronized cows within age groups; however, a trend was established at 5 days that suggested effectiveness of calf removal depended on when cows were inseminated following hormonal withdrawal. Five day pregnancy rates were 56.3, 59.4, 40.6, 62.5, 53.3, 50.1, 50.0, and 35.5 for Groups 1a, 1b-4a, 4b, respectively. Although calf management had no significant effect within each time of insemination, these results indicate short term weaning did not have a beneficial effect unless cows were inseminated later than 28 hrs post-implant removal. Highly significant differences were recorded at 5 and 25 days between synchronized and non-synchronized cows (50.7, 67.2 to 6.9, 26.1), resulting in synchronized groups conceiving 8 to 19 days earlier in the breeding season than controls.

In the second trial, 105 spring calving Angus and Hereford cows of all ages were randomly allotted to the following groups: (1) synchronized and inseminated 48 hrs post-implant removal; (2) synchronized and inseminated according to estrus; and (3) non-synchronized controls inseminated approximately 12 hrs after detected in estrus. First service conception rates were 45.5, 33.3, and 56.4 for Groups 1-3, respectively, with non-synchronized cows significantly higher than

the synchronized group bred by estrus. A significant advantage was noted in services required/conception (1.4, 2.1 and 1.7) for cows bred by appointment compared to synchronized estrus-bred cows, indicating pre-determined insemination times could be used without reducing fertility. Controls were not significantly different from either synchronized group, however, which demonstrates hormonal treatment did not have any detrimental effect on fertility. Five, 25, and 60 day pregnancy rates were 45.5, 72.7, 87.9; 33.3, 54.6, 78.8; and 10.5, 45.5, 97.5 for Groups 1-3 with significant differences at 5 and 25 days between synchronized cows bred by appointment and non-synchronized controls. At 60 days, synchronized cows bred by estrus were still significantly lower than non-synchronized cows, suggesting factors other than treatment were at least partially responsible for abnormally low conception rates recorded for this group early in the breeding season. However, both synchronized groups still conceived from 15 to 22 days earlier than non-synchronized controls, with appointment-bred cows showing a 7 day advantage over estrus-bred cows.

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EFFECT OF TIME OF INSEMINATION AND CALF REMOVAL AFTER ESTRUS SYNCHRONIZATION IN BEEF CATTLE

by

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Four hundred seventy-three lactating cows were used in two trials to determine if hormonal control of the estrous cycle with or without short term calf removal had any affect on subsequent fertility or reducing the interval from calving to conception. Inseminating cows at various pre-determined times following estrus synchronization was also studied in cows receiving Syncro-Mate B treatment (9 day ear implant containing 6 mg norgestomet® and a single injection of 5 mg estradiol valerate plus 3 mg norgestomet®) to evaluate which insemination time produced optimum results and if normal conception rates could be maintained in time inseminated cows compared to cows bred by estrus.

In the first trial, 368 fall calving 2- and 3-year-old Angus and crossbred Maine Anjou cows were allotted to the following treatments: Groups (1-4) were synchronized and time inseminated at 20, 28, 44 and 52 hrs post-implant removal, respectively. Each synchronized time inseminated group was also equally sub-divided as follows: (a) cows were separated from their calves at implant removal for 48 hrs or until the cow was inseminated, and (b) cows were allowed to remain with their calves with no separation period. The control group (5) consisted of non-synchronized cows that were allowed to remain with their calves and bred according to estrus. First service conception rates and services/conception for Groups 1a, 1b-4a, 4b, respectively, were 53.1, 2.3; 59.4, 2.0; 40.6, 2.2; 62.5, 1.8; 53.3, 1.9; 50.0, 2.3; 50.0, 2.2; and 35.5, 2.3. First service conception rate and services/conception were not significantly different for synchronized and non-synchronized cows (50.1, 2.1 vs 48.0, 1.9). Five, 25, and 90 day pregnancy rates were similar for synchronized cows within age groups, indicating no

significant effect of calf removal or time of insemination. However, differences were highly significant at 5 and 25 days between synchronized and non-synchronized cows (50.7, 67.2 to 6.9, 26.1), which resulted in synchronized groups conceiving 8 to 19 days earlier than controls.

In the second trial, 105 spring calving Angus and Hereford cows were randomly allotted to the following groups: (1) synchronized and inseminated 48 hrs post-implant removal; (2) synchronized and inseminated according to estrus; and (3) non-synchronized controls inseminated approximately 12 hrs after detected in estrus. First service conception rates were 45.5, 33.3 and 56.4 for Groups 1-3, respectively, with non-synchronized cows significantly higher than synchronized cows bred by estrus. A significant difference was also noted in services/conception (1.4, 2.1 and 1.7) between the two synchronized groups with different insemination times; however, the controls were not significantly different from either synchronized group. Five, 25, and 60 day pregnancy rates were 45.5, 72.7, 87.9; 33.3, 54.6, 78.8; and 10.5, 45.5, 97.5 for Groups 1-3 with significant differences at 5 and 25 days between appointment-bred synchronized cows and non-synchronized controls. At 60 days, synchronized cows bred at estrus were still significantly lower than non-synchronized cows. However, both synchronized groups still conceived from 15 to 22 days earlier than non-synchronized controls, with appointment-bred cows showing a 7 day advantage over estrus-bred cows.