INDUCED CALVING AND ESTRUS SYNCHRONIZATION IN BEEF CATTLE

by

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REVIEW OF LITERATURE

Induced Calving in Beef Cattle

Endocrine basis for Parturition. The necessity of a functional hypothalamic-pituitary-adrenal axis in the fetus of cattle and sheep for normal parturition has been confirmed by various researchers. Kennedy et al. (1957) discovered that parturition was delayed in cattle by adenohypophysial aplasia which caused adrenal hypoplasia. Liggins et al. (1967) reported prolonged gestation in sheep after fetal hypophysectomy which resulted in hypoplasia of the fetal adrenal glands. Liggins et al. (1972) further showed that stimulation of the developing fetal hypothalamic-pituitary-adrenal system by administering adreno-corticotrophic hormone (ACTH) to the sheep fetus during the last one third of pregnancy resulted in premature parturition. The researchers concluded that this data supports the hypothesis that parturition in the sheep is controlled by the fetal adrenal cortex through its secretion of glucocorticoids. Based on the reports of prolonged gestation in cattle, a similar conclusion seems likely in this specie (Wagner, 1970).

The end of gestation and the onset of parturition are characterized by dramatic changes in hormone secretion. Progesterone levels remain high throughout gestation and are being produced by the corpus luteum, the adrenal gland and the placenta. Smith et al. (1973) found that serum progesterone levels of the cow remained at 7.6 ± 0.9 ng/ml until 2 days before parturition, then fell to 0.6 ± 0.1 ng/ml at parturition. Parturition occurs in sheep in the presence of substantial progesterone concentration in peripheral circulation (Thompson and Wagner, 1974). The level was found to be approximately 8 to 10 ng/ml within 24 hours of parturition, but had decreased to less than 1 ng/ml by 24 hours post-lambing.

There is a gradual increase in estrogens throughout pregnancy in most mammals and a sharp increase occurs a few days prepartum. Smith et al. (1973) showed that estradiol and estrone levels in the cow increased linearly from 26 to 5 days before parturition, but had doubled by 2 days prepartum. He further reported an equally sharp drop by 1 day postpartum to about 1/6 the level seen 1 day prepartum.

Corticoid levels have been observed in some species and a rather sharp increase occurs just prior to parturition. Adams and Wagner (1970) reported that corticoid levels in the cow begin a significant rise by 4 days prepartum. Smith et al. (1973) found that the increase in serum glucocorticoids occurs approximately 12 to 18 hours before parturition and then declines rather rapidly to its prepartum level shortly after parturition. Thompson and Wagner (1974) reported a similar occurrence in sheep while Molokwu and Wagner (1973) found that the corticoid increase in swine occurs as early as 3 days prepartum and then follows the same trend as that seen for cattle and sheep.

According to Wagner (1974), prostaglandins must be considered relative to parturition because of their effects. Increased prostaglandin production by the uterus follows the rise in fetal glucocorticoids and can be produced by administration of exogenous glucocorticoids. Prostaglandins may exert an effect on myometrial activity, cause a decrease in progesterone production, effect an oxytocin release, and stimulate estrogen production by the placenta.

The fetal adrenal gland of the sheep doubles in size during the last 10 days before parturition which is a probable result of increased adrenal stimulating hormones from the fetal pituitary gland (Liggins et al. 1972). In the same work a several fold increase in the plasma concentration of corticoids of the fetus was noted in the 3 to 4 days prior to parturition. This rise is also seen when glucocorticoids are infused to immature fetal lambs (Liggins, 1969). This infusion leads to premature parturition as would be expected if the fetal corticoids are the signal for the onset of labor.

For a hypothetical model of the hormonal relationships which occur at parturition see Wagner (1974). A knowledge of these relationships is essential in order to understand how various substances are used for induction of parturition.

Induced Parturition. The parturition inducing effect of some glucocorticoids was discovered in the late 1960's (Brown et al. 1970). Before that time corticoids had been used in veterinary medicine for treatment of such problems as musculoskeleton, pregnancy toxemia, shock, fractures, etc. However, since the parturition inducing effect of corticoids was discovered, numerous workers have reported on the use of various compounds in the initiation and control of parturition. Adams (1969) was one of the first to confirm the corticoid inducing effect when he used intramuscular injections of dexamethasone on 22 cows. In another experiment, Adams and Wagner (1970) induced calving within 72 hours in 46 of 54 cows after a 20 mg dexamethasone injection given intramuscularly. The mean gestation length was 274 days and the mean interval from injection to fetal expulsion was 49 hours.

The same sequence of events that occur in natural parturition seem to occur when parturition is induced with exogenous glucocorticoids. Jochle (1971) stated that administration of corticoids to cattle late in pregnancy acts as a premature signal which normally comes from the fetal adrenal. His observations following corticoid administration, namely the drop in plasma progesterone levels, the dramatic rise in estrogen levels, and the high corticoid blood levels are much the same as occurs in non-induced parturition. Jochle explained that increasing estrogen levels reach a critical point and act along with the rise in corticoids to shut off the source of progesterone. The removal of the progesterone block on the myometrium and its sensitization by available estrogens for oxytocic activities create conditions mimicking normal parturition.

Fylling (1971) was able to induce lambing in three ewes with an intravenous injection of 0.25 mg of ACTH followed by a daily injection of 10 mg of dexamethasone given intramuscularly for 4 days. However, he failed to induce lambing in two eves given 6 mg of dexamethasone daily for 4 days. Bosc (1972) induced lambing using an 8 or 16 mg intramuscular injection of dexamethasone. Parturition followed approximately 50 and 48 hours post-injection when the gestation length was 144 days.

Alm _et al_. (1972) treated 12 mares with 100 mg of dexamethasone once a day for 4 days beginning 18 days prior to an expected foaling date of 338 days gestation. The treated mares responded by foaling 10 $\pm$ 1.6 days early.

Jochle (1971) reported that neither dexamethasone of flumethasone would induce parturition in swine. However, North _et al_. (1973) did shorten gestation by administering 70 mg of dexamethasone intramuscularly on days 101, 102, and 103 of gestation. This treatment caused parturition at an average gestation of 112.6 days while the control animals farrowed at 114.7 days of gestation. Killian and Day (1974) administered 10 mg of prostaglandin $F_{2\alpha}$ to 15 sows and gilts on either 111, 112 or 113 days of gestation.

Parturition occurred in 87% of the animals 24 to 36 hours following the injection.

The phenomena of induced parturition seems to have drawn particular interest in the cattle industry, both dairy and beef. This seems to stem from attempts to control the entire management program. During the past 5 years, much has been learned relative to the time interval when parturition can be expected, the effects on the dam, and the effects on the viability and performance of the calf after induction of parturition. Adams and Wagner (1970) defined a successful induction with corticoids as having occurred within 72 hours post-injection. Osinga et al. (1971) used either 2.5, 5.0, or 10 mg injection of flumethasone to induce calving in 26 dairy cows 268 to 270 days gestation. Of the 26 cows, 23 calved within 3 days post-injection with an average of 47.7 $\pm$ 1.4 hours. The three animals that did not calve within 72 hours post-injection were given the 2.5 mg injection. He further reported that parturition was induced within 3 days in 3 of 5 and 4 of 6 cows that received either 5 or 10 mg of flumethasone orally. Wagner et al. (1974) reported that only 159 of 189 cows calved within 72 hours after a 20 mg dexamethasone injection; however, 100% of the cows calved within 72 hours after doses of 30, 50 or 60 mg. Beardsley et al. (1973) induced calving in 21 of 25 Holstein cows by giving dexamethasone at a dose level of 4.4 mg/100kg of body weight. Parturition occurred at 45.5 $\pm$ 12 hours after injection. Winter (1974) compared intramuscular and intravenous injections using 20 mg dexamethasone per injection. The cows were treated 7 to 14 days before the expected calving date. Parturition was induced an average of 52.5 and 57.4 hours post-injection in 81.8 and 83.3% of the cows in the two groups, respectively. Lauderdale (1974) administered various amounts of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) intramuscularly to 30 beef cows. The treatment did cause parturition, however, the response was variable with cows calving in a period of 2 to 8 days post-injection. Spears *et al.* (1974) administered either 20 mg of $PGF_{2\alpha}$ or a combination of 3 daily injections of estradiol valerate plus a 20 mg injection of $PGF_{2\alpha}$ with the third estradiol injection to two groups of beef cows. Only 14.2% of the $PGF_{2\alpha}$ injected cows calved early while 90.5% of the estradiol plus $PGF_{2\alpha}$ injected cows calved early at an average time of 42.8 ± 2.3 hours post-injection.

Side effects. There are some major side effects caused by using induced calving. The most serious effect is that retained placenta occurs in a high percentage of cases. The definition of a retained placenta varies, however, it is usually diagnosed if membranes are still observed 24 hours after delivery (Carroll, 1974). There is a problem in diagnosing a retained placenta in that some of the membranes may remain in the uterus although none are visible externally. Garverick *et al.* (1974) felt it necessary to examine cows by both rectal and vaginal exploration before classifying the cow as retained or non-retained.

Jochle *et al.* (1972) treated cows with progesterone both before and after a 10 mg flumethasone injection which was administered on day 270 of gestation. Their results showed an increase in the number of stillborn calves and a very high percentage of the cows experienced dystocia. In addition, no reduction in the occurrence of retained placenta was observed. Garverick *et al.* (1974) treated cows with 6 mg of estradiol benzoate in conjunction with a 20 mg injection of dexamethasone. Their results showed a significant reduction in the occurrence of retained placenta with only 32.3% of the animals retaining the fetal membranes in the estrogen treated group while 75% retained the placenta in the group that did not receive estrogen in conjunction with a dexamethasone injection. This is contrary to the finding of LaVoie and Moody (1973) who administered varying levels of either estrone, estradiol-17α or estradiol-17β from 6 days prior to either $\frac{1}{2}$ day prior or 1 day after a dexamethasone treatment. Their results showed no decrease for the incidence of retained placenta which was 89.5%.

Welch et al. (1973) reported that induced calving in New Zealand is widely used being performed on more than 120,000 cows each year. He further reported on the use of three so-called long-acting corticoids: dexamethasone trimethylacetate (20 mg), triamcinolone acetomide (30 mg) or 10 mg of a flumethasone suspension. For all treatments, the average time to calving was 15 $\pm$ 8 days. He also reported that the main problem with long-acting corticoids was the high mortality rate which was reported as being 31.1, 31.5, and 44.6% for the three treatments, respectively. Bailey et al. (1973) administered 30 mg of dexamethasone trimethylacetate to 15 cows 240 to 252 days of gestation. The cows responded by calving an average of 12.1 days later. Only two of the cows retained the placenta.

The occurrence of retained placenta after induced calving seems to depend on the day of gestation. Wagner et al. (1971) reported that retained placenta occurred according to days of gestation at a rate of 66% $<$ 270; 57% 270 to 274; 48% 275 to 279 and 26% $>$ 280. This high occurrence of retained fetal membranes causes concern about the degree of postpartum fertility following induced calving. Marion et al. (1968) reported that a highly significant increase in the interval from parturition to uterine involution occurs following retained placenta. Their observations showed that the time to complete uterine involution after retained placenta was 45.1 $\pm$ 3.2 days and 50.1 $\pm$ 4.9 days for primiparous and pluriparous cows, respectively. Perkins and Kidder (1963) reported that uterine involution was complete by 37.7 days postpartum in cows that did not retain the placenta.

Erb et al. (1958) stated that young cows with retained placenta have an average of one less calf than comparable cows not retaining the fetal membranes. They further reported, however, that cows that do not develop genital disorders following retention of fetal membranes were nearly as fertile as cows not retaining the placenta; although genital disorders occurred 20% more often in cows that did retain the placenta. Jones et al. (1956) used furea, a drug containing 1.45% micropulverized nitrofurazone and 98.55% powdered crystalline urea, for treatment of cows with retained placenta. This drug was used after manual removal of the placenta had been accomplished. In all their cases, the condition improved rapidly and the treatment did effectively prevent endometritis. They further reported that the addition of urea is advantageous since it has a proteolytic and topical debriding effect and also a deoderizing effect. Rude (1959) also recommended insertion of furea boluses into the uterus following manual removal of the placenta. Following this procedure, 28 of 30 cows which had retained placenta became pregnant. Homan (1969) compared intrauterine infusions of nitrofurazone, proteolytic enzymes, and a combination of these in an effort to shorten postpartum interval from calving to conception in clinically normal cows. The interval was not shortened with any treatment and it was found that the nitrofurazone treated group had an interval from parturition to conception significantly longer than the other groups. The combination of nitrofurazone with proteolytic enzymes produced an interval comparable with the cows that received no treatment. He concluded that if nitrofurazone was to be infused intrauterine for retained placenta or impaired fertility that it should be combined with proteolytic enzymes if the interval from parturition to conception is to be kept at a minimum. Jochle (1971) stated that the best method for treatment of retained placenta is parental application of systemic antibiotics and to make no attempt to remove the placenta manually. His experience shows that attempts to remove the placenta tends to increase the chances of causing metritis and pyometra. He further stated that spontaneous delivery of the membranes will usually occur within 8 to 10 days after induced calving or about the time normal parturition would have taken place if the cow had not been subjected to induced parturition.

Most workers have reported that fertility is not impaired following induced calving. Poncelet et al. (1974) stated that no significant differences occurred for fertility and percent pregnant between induced and non-induced cows. LaVoie and Moody (1974) reported no differences occurred in first service conception rates between induced and non-induced cows. Wagner et al. (1974) found no severe metritis cases following induced calving and reported that the number of days from calving to conception was 81 and 82 days for retained and non-retained animals, respectively.

A possible added cause to the number of retained placenta is that of increased dystocia. Carroll (1974) states that induced calving produced no decrease in difficulty of birth and in some instances dystocia is increased. Ball (1973) states that one of the most common sequelae to dystocia is retained placenta which may be associated with lowered conception. In studies reviewed by the American Breeders Service (1973), calving difficulty increases the percentage of cows that do not resume their normal estrual cycle before the end of the breeding season.

Another side effect of induced calving, as reported by Jochle (1973), is that the onset of milk production is somewhat slower than normal. Beardsley et al. (1973) induced parturition in 21 of 25 Holstein cows using dexamethasone. He found that the average daily milk production for the first 9 weeks was 24.7 and 27.6 kg for treated and non-treated animals, respectively. No differences in milk fat were found.

Effects on the Offspring. Another question governing the widespread use of induced parturition is the effect on the offspring. A consistent finding is the decrease in birth weight following induced parturition. Osinga et al. (1971) reported that the birth weight of dairy calves after induced calving was reduced 3.6 kg. Winter (1974) reported that a reduction of as much as 7 to 8 kg could be expected with induced parturition of beef cows. Wagner et al. (1974) found that birth weight of induced calves was highly correlated with the length of gestation with larger calves being born closer to term.

Survival and viability of induced calves does not seem to be decreased significantly from non-induced calves. Carroll (1974) reported that calf viability, like birth weight, is dependent on the duration of pregnancy. He found no trouble occurs when calves are born after 270 days, but a high death loss occurs when calving is induced prior to 260 days gestation.

There seems to be very little effect on the ability of induced calves to perform following birth. Beardsley et al. (1973) reported the average daily gain of dairy calves following induction was 1.39 pounds compared with 1.32 pounds for non-induced calves. LaVoie and Moody (1974) found the weaning weights between induced and non-induced calves to be comparable with the induced calves being slightly heavier.

Estrus Synchronization in Beef Cattle

The number of cows in a herd that shows estrus on any one day is proportional to the length of the estrous cycle; and any technique that significantly increases this number results in synchronization of ovarian cycles (Lamond, 1964). Estrus synchronization may be attained through inhibition of ovulation, induction of ovulation or induction of or delay of corpus luteum regression (Lauderdale and Zimbelman, 1974).

Progesterone, produced by a corpus luteum in a normal uncontrolled cycle, inhibits maturation of the Graafian follicles (Lamond, 1964.) Christensen et al. (1974) found the levels of progesterone in the serum of cycling beef cows to be the lowest during estrus and remained low until 4 days after estrus when it began increasing until it reached a peak on day 15 of the cycle. Exogenous as well as endogenous progesterone will inhibit ovulation and, therefore, control the estrus cycle of cattle (Lamond, 1964). Exogenous progesterone can be administered in a number of ways. Ulberg and Lindley (1960) injected varying amounts of progesterone in oil subcutaneously to virgin heifers. They found that 60, 83 and 80 percent of the treated animals showed estrus within 10 days after 14 daily injections of either 12.5, 25 or 50 mg per injection. Lamond (1964) stated that generally, doses of progesterone of more than 50 mg per day were detrimental to fertility.

Progesterone can also be administered orally. Hansel and Malven (1960) fed medroxyprogesterone acetate to two groups of 22 and 10 Hereford cows for 20 days. Nine of 22 and 7 of 10 came into estrus on the third and fourth day following the end of the treatment. Van Blake et al. (1963) fed 6-chloro-Δ^6-dehydro-17-acetoxyprogesterone (CAP) to 69 Holstein heifers at a rate of 0.02 mg per pound of body weight. The cycles were synchronized within a period of 4 to 6 days after hormone withdrawal. Hansel ot al. (1967) fed 6-methyl-17-acetoxyprogesterone (MAP) at an average rate of 240 mg/head/day for 18 days. Eighty-one of 96 cows came into estrus in a 9 day period following cessation of feeding. Roussel et al. (1969) fed 1mg/head/day of melengestrol acetate (MGA) for 14 days to 15 dairy heifers. Ten of 15 showed estrus within 3 to 5 days following withdrawal of the MGA.

Another approach to provide exogenous progesterone is through the use of various implants. Dziuk et al. (1967) used silicone rubber implants impregnated with MGA. These implants were placed subcutaneously in the neck and left in place for either 22, 43 or 64 days. Estrus was observed in 45 cows (64%) between 36 and 72 hours after implant removal. Lauderdale et al. (1972) used polyurethane polymers containing MGA which were implanted into the ears of 32 heifers for 14 days and 31 heifers for 28 days. Percent of the heifers detected in estrus during days 2 to 6 after implant removal was 87.5 for both groups. Reynolds et al. (1973) used silicone rubber implants impregnated with progesterone to synchronize estrus in 13 cows. The implants were surgically placed subcutaneously in the neck and remained in place for 20 days. None of the cows showed estrus during the implant period, while all cows had shown estrus by 62 hours following implant removal.

A fourth way that can be used for administration of progestogens is by using intra-vaginal pessaries. Wishart and Hoskin (1968) treated 81 heifers with intra-vaginal pessaries impregnated with 200 mg of SC9880 (17α-acetoxy-9α-fluoro 11β-hydroxy-4-pregnene-3,20 dione). The pessaries were removed 21 days following insertion, however, only 66 of the 81 heifers had retained the pessaries. Estrus was successfully blocked in all 66 of these heifers.

Lauderdale and Zimbelman (1974) concluded that although effective control of the estrous cycle can be attained with each of the progestogens and routes of administration studied; conception rate of cows inseminated at the first synchronized estrus is normally somewhat lower than that for untreated herdmate controls. However, conception rate of second synchronized estrus, occurring about one normal estrous cycle later, has usually been equal to or somewhat greater than untreated herdmate controls.

Another approach to synchronization of estrus is induction of corpus luteum regression. Hansel et al. (1961) used seven daily subcutaneous injections consisting of 100 U.S.P. units of oxytocin to recycle cows so that they could be bred during a predicted target period. Daily injections of oxytocin during the first 6 or 7 days of the estrous cycle prevents the formation of a normal corpus luteum and results in precocious estrus and ovulation at the eighth to tenth day of the cycle (Lamond, 1964). Early regression of the corpus luteum can be induced in heifers with a single injection of an estrogen (Wiltbank et al., 1961). Wiltbank and Kasson (1968) fed 400 mg of the progestational compound 16-alpha-17 dihydroxyprogesterone acetophenonide (DHPA) per head per day for either 7 or 9 days. On the second day of the DHPA treatment either 5 or 10 mg of estradiol valerate was injected to cause regression of any existing corpus luteum. Their results showed that 100% of the heifers treated exhibited estrus during a 48 hour period which began when the first heifer showed estrus. Lauderdale (1972) injected 30 mg of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) subcutaneously to cows on one of the following days of the estrous cycle: group A- 2, 3 and 4: group B- 6, 7, 8 and 9 or group C- 13, 14, 15 and 16. For group A the corpus luteum life span was normal with the average interval to estrus being 17 days. However, in groups

B and C, the corpus luteum regressed within 2 to 4 days with the heifers experiencing estrus. Exogenous $PGF_{2\alpha}$ induces luteal regression in cattle during days 5 through 18 of the estrous cycle (Inskeep, 1973). Liehr et al. (1972) infused 6 mg $PGF_{2\alpha}$ into the ipsilateral or contralateral uterine horn in two groups of six heifers each on day 9 of the cycle. The average length of the cycle was 11.4 for the ipsilaterally treated heifers and 15.2 for the contralaterally treated heifers. Heersche et al. (1974) injected 30 mg of $PGF_{2\alpha}$ in 5 ml of Tham buffer following a period of 7 days when the heifers were implanted with Syncro-Mate B, a progestogen implant. Forty-seven of 50 heifers exhibited estrus during an 84 hour period between 1 to 5 days after the $PGF_{2\alpha}$ injection.

Louis et al. (1974) has shown that an intrauterine administration of $PGF_{2\alpha}$ causes events that do not differ significantly from normal estrous cycles. In their experiments, both luteal diameter and progesterone levels decrease rapidly by 48 hours post-administration. Estradiol increased from 5 to 12 pg/ml by 48 hours. A surge of LH was noted at 71 $\pm$ 4 hours with standing estrus beginning at 72 $\pm$ 5 hours. Ovulation occurred at 95 $\pm$ 5 hours following $PGF_{2\alpha}$ administration. The events were the same no matter which horn the $PGF_{2\alpha}$ was given in.

Roche and Crowley (1973) stated that although the estrous cycle can be controlled, the number of cows that show heat within a given period of time following any synchronization treatment has been inconsistent and fertility to natural and artificial matings at this heat is lower than normal. Hansel et al. (1961) found that only 50% of 26 heifers conceived to the first service following a combination of progesterone and oxytocin injections. Wiltbank and Kasson (1968) obtained a first service conception rate of 62% and 59% in two different trials using DHPA along with a single estrogen injection.

The controls in the experiment had an 83% first service conception rate. When Wishart and Hoskin (1968) used intra-vaginal pessaries which contained a progestogen, only 43.7% of the heifers conceived to the first service. Reynolds et al. (1973) used progesterone impregnated silicone rubber implants and obtained only a 38% conception rate following implant removal. However, non-implanted controls had a 67% first service conception rate.

Conception has improved slightly with the use of prostaglandins. Lauderdale et al. (1974) obtained a 52.2% conception rate following a 30 mg injection of $PGF_{2\alpha}$ as compared with a 53.3% conception rate in the non-treated cows. Heersche et al. (1974) gave $PGF_{2\alpha}$ after cows had been implanted with Syncro-Mate B for 7 days. In their work, 30 of 47 synchronized heifers conceived to the first service (63.8%).

Roche and Crowley (1973) proposed that animals should be inseminated in relation to the time of ovulation rather than in relation to the time of heat with the purpose of increasing first service conception rate. They further stated that this necessitates precise control of the time of ovulation.

Christensen et al. (1974) found the luteinizing hormone (LH) level of cycling beef cows peaked 7.38 ± 5.15 hours after the onset of estrus and remained at this level for 12 hours, then dropped rapidly and remained at a low level until the next estrus. Kaltenbach et al. (1974) administered 1 mg of gonadotrophin releasing hormone (Gn-RH) in a single injection to individual heifers on days 16, 18 or 20 of the cycle. He observed increases in serum LH on all days with greatest response occurring on the day of estrus. Subsequently, 250 ug of Gn-RH was given (im) to five heifers 24 hours after removal of a progestogen implant. Mean duration of the induced LH surge was 7 hours. All heifers exhibited estrus and ovulated. The researchers concluded that Gn-RH can be used to synchronize ovulation when used in conjunction with a progestational compound. Kinder and Ellington (1974) used ear implants containing 6 mg of Searle SC21009 progestogen with Pregnant Mare Serum Gonadotrophin (PMSG) and Human Chorionic Gonadotrophin (HCG) to study their effectiveness for control of the cycle in yearling beef heifers. In one trial, the animals were implanted for 16 days. When the implants were removed, the animals were injected subcutaneously with 500 IU PMSG. A high percentage of the heifers exhibited estrus during a 2 day period following the injection. In a second trial, cows were implanted for 16 days and 500 IU PMSG was given subcutaneously upon implant removal. In addition, a 1000 IU injection of HCG was administered 1 day following implant removal. Estrus was again observed in a high percentage of the animals. Graves and Dziuk (1968) fed MAP to cycling cows of mixed dairy breeding for 15 to 18 days. At predetermined times after the withdrawal of the MAP, the cows were injected (im) with 500 IU of HCG. They found the average time to ovulation following the HCG injection was 40 hours. The researchers concluded that if ovulation could be predicted, then insemination at some predetermined time could eliminate the need for estrus detection.

Roche and Crowley (1973) controlled estrus and the time of ovulation in 87 mature non-pregnant heifers by using silastic implants of MGA followed by an injection of HCG 48 hours after the removal of the implants. The heifers were allocated at random to three groups for insemination. Animals in groups 1 and 2 were inseminated once at 14 and 24 hours, respectively, after HCG while animals in group 3 were inseminated twice 14 and 24 hours after the HCG. All animals were bred without regard to estrus, however, only a 23% conception was obtained. Lauderdale et al. (1974) inseminated cows at 72 and 90 hours after a $PGF_{2\alpha}$ injection without regard to estrus. They obtained a 55.8% conception rate following this treatment.