ESTROUS SYNCHRONIZATION AND INDUCED PUBERTY IN BEEF HEIFERS

by

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Literature Review

Control of the estrous cycle or synchronization of estrus can be obtained by inhibiting estrus and ovulation until the corpus luteum has regressed and progesterone production has ceased; then, estrus will occur shortly after the inhibitor is removed. Or, if a compound is given which causes the corpus luteum to regress, causing progesterone level to decline, estrus will occur within a few days.

Various progestagens (CAP, MAP, MGA, norethandrolone, SC9880, SC21009) and luteolytic compounds (PGF2α, estrogen, ICI79939, ICI80996) have been administered by vaginal sponges, intrauterine infusions, intramuscular injection, orally, or subcutaneous implants to achieve synchronization of estrus.

Trimberger and Hansel (1955) reported that daily injections of progesterone would successfully control the interval from one estrus to another. The progesterone treatment provided an opportunity for shifting the time of estrus, but had no advantage in predicting estrus on a particular day. Thimonier et al. (1975) reported that 100% of the cows treated with daily injections of norethandrolone (17-ethyl-19-norestosterone) showed signs of estrus within 5 days after the end of the treatment. Fertility at the synchronized estrus was low, suggesting that a high degree of synchronization obtained by a long progestagen treatment was incompatible with a high conception rate. These results were confirmed by Knox et al. (1972). Lemon (1975) reported that daily injections of norethandrolone for 10 days had no effect on the development of the corpus luteum or its life span. Progesterone concentrations increased to normal levels during the luteal phase, luteal regression was normal, and the cycle length was not altered. Wishart (1975) compared the effects of daily injections of

SC9880 and SC21009 for a 21 day period. The treatments neither affected the timing nor the pattern of ovulation but SC9880 reduced the duration of estrus when compared to SC21009. He suggested that SC21009 implanted for 9 days provided a possible means of estrous synchronization.

After a 9 day treatment of chlormadinine acetate (CAP) of 25 mg/hd/day, fertility rate was normal if the induced cycle was not longer than 25 days (Rey, 1975). If a second 9 day treatment of CAP followed 12 days later, 93 to 97 percent of the treated cows exhibited estrus within 5 to 7 days. Fertility was higher in those treated twice than in those treated once. CAP being fed for 18 days (10 mg/hd/day) to heifers did not result in synchronized estrus because no optimal service time could be determined (Grunert, 1975).

Silicone rubber implants impregnated with progesterone inhibited estrus when placed in the neck for a period of 20 days (Reynolds et al. 1973). Conception was low at the synchronized estrus but normal conception was obtained for the second service. Lauderdale et al.(1972) and Ayalon and Marcus (1975) reported that 14 day implants of melengestral acetate (MGA) resulted in a synchronized estrus with low fertility. Implants of norethandrolone placed in the flank region for 16 days synchronized estrus to a 96 hour period in 87% of the heifers treated (Wiltbank et al. 1971). Thirty-eight percent of the synchronized heifers conceived, showing fertility was low following treatment. Woody and Pierce (1974) reported that neither 9 day or 16 day implants of norethandrolone was satisfactory if the goal was to have the most heifers in estrus in a short period of time with high fertility. The 9 day treatment did not induce early luteal regression in heifers implanted early in the cycle and the 16 day treatment appeared to reduce fertility in those implanted late in the cycle. Rachow

and Marion (1973) showed that the progestin, SC21009 (17a-acetoxy-11b-methyl-19-norpreg-4-ene-3, 20-dione), could be used as an earplant contraceptive device and still achieve a high rate of fertility (100%) when compared to controls. Similar results were reported for a 16 day implant of SC21009 by Kinder and Ellington (1974). Chupin et al. (1975) reported that when using SC21009, a higher degree of synchronization could be obtained with a 12 mg implant for 9 days than a 6 mg implant for 11 days.

Although synchronization of estrus can be obtained through progestagens, fertility seems to suffer from the synchronization treatments. It has been shown that when the duration of the treatment is increased, the degree of synchronization increases but the fertility at the synchronized estrus decreases (Chupin et al. 1975).

Prostaglandins (PG) are unsaturated 20-carbon fatty acids whose actions on smooth muscle and blood pressure vary with their structural configuration. Prostaglandin F2α (PGF2α) and its analogues are luteolytic in the bovine and other species. Inskeep (1973) was able to induce luteal regression with PGF2α in cattle during days 5 to 18 of the estrous cycle and in sheep with functional corpora lutea (CL) in ovaries transplanted to the neck region.

Luteolysis induced by intrauterine (5 mg) or intramuscular (15, 30, or 60 mgs) administration of PGF2α resembled that which normally occured during the 3 days before estrus in cattle (Louis et al. 1975). After two injections of PGF2α, 12 days apart, inseminations performed at predetermined intervals resulted in fertility as high as that in controls. Hendricks et al. (1974) were able to achieve 100% synchronization in heifers treated intrauterine with 2 mg of PGF2α after day 5 of the estrous

cycle. Low fertility was reported at the synchronized estrus and was thought that the route of administration rather the PGF2α was the cause for low fertility in this experiment. After administration of 5 mg of PGF2α in the uterine horn contralateral to the ovary with the CL on day 11, Louis et al. (1974) demonstrated a decline in serum progesterone, an increase in estrogen secretion, an ovulatory surge of LH, onset of estrus, and ovulation. The mean interval from treatment to estrus and ovulation after a intrauterine infusion of PGF2α was 66.4 and 93.7 hours; respectively (Wishart, 1974). Fulka et al. (1975) obtained similar results by infusing PGF2α (.2 mg) intrauterine twice on consecutive days in all treated animals. Fertility was low at the synchronized estrus and was thought to be due to ova not being present in the oviduct to be fertilized. Lauderdale (1972) reported the effects of PGF2α on different stages of the estrous cycle.

Thirty milligrams of PGF2α THAM salt injected subcutaneously after day 5 of the estrous cycle was successful in inducing estrus an average of 3 days later but injecting before day 5 had no effect on estrus. Roche (1974) reported that a single injection of either 20 mg or 30 mg of PGF2α was effective in synchronizing estrus only when injected from days 5 through 20 of the estrous cycle with fertility equal to that of controls. A single injection of 30 mg PGF2α will synchronize estrus if a functional CL is present on the ovary (Turman et al. 1975). Eighty-eight percent of those cows with a palpatable CL showed estrus on day 2, 3, and 4 after a single injection of 30 mg PGF2α (Lauderdale et al. 1974). Similarity of fertility between controls and cows inseminated at appointed times suggest that PGF2α may be useful to allow breeding with normal fertility at predetermined times, independently of estrus detection.

Prostaglandin F2α (25 mg) injected intramuscular or subcutaneously on day 8 or 14 of the estrous cycle caused standing heat to occur 48 to 96 hours post treatment (Edqvist et al. 1975). Sixty-nine percent of those treated conceived to the synchronized estrus. Fertility was reported to be similar to controls when cows with palpable CL were given 30 mg PGF2α then artificially inseminated 12 hours after the onset of estrus or inseminated 72 and 90 hours after PGF2α injection (Lauderdale, 1975). Under range cattle management conditions, Lambert et al. (1975) showed that a single injection of PGF2α, to those cows not exhibiting estrus by the 4th day of the breeding season, would bring 74% of those treated cows to estrus, increasing first service conception. Elving et al. (1975) were able to achieve 85% synchronization when PGF2α was administered on two consecutive days, 25 mg and 12.5 mg, respectively. Hafs et al. (1975a) reported two injections of PGF2α given two days apart resulted in 68% of the treated heifers synchronized within 88 hours after the second injection. It was found that 20 mg of PGF2α for heifers and 30mg for cows was sufficient to produce maximal responsiveness in ovulation control (Hafs et al. 1975b). Administration of PGF2α on two consecutive days to cows between the 6th and 16th day of the estrous cycle was no more effective than a single injection treatment (Moore, 1975). Of those treated twice only 75% were synchronized with low fertility (22%) at the controlled estrus. No explanations for the low results were given.

A potent luteolytic analogue of PGF2α, ICI80996, was used by Cooper (1974). He reported that a 500μg injection after day 4 of the estrous cycle would cause luteal regression. When two injections, 10 to 12 days apart, was given to heifers estrus occurred within 72 hours after the second injection with normal fertility. Cooper and Rowson (1975) reported

that 97% of the heifers given two injections of ICI80996, eleven days apart, exhibited behavioral estrus between 48 and 96 hours after treatment. Fertility at the synchronized estrus was assumed to be normal although the data was not available. After a double injection of ICI79939, 10 days apart, precise synchronization of estrus was obtained (Dobson et al. 1975). After the second injection there was a fall in plasma progesterone, rapid follicular growth with secretion of estrogen and a surge of LH that caused ovulation. Synchronization of estrus was low, 82% within 5 days, when ICI80996 was administered twice 10 days apart (Thimonier et al. 1975). It was concluded that synchronization was low due to ovulation without estrus, long follicular phases and failure of luteal regression after the second injection. Tervit et al. (1973) reported that an intrauterine infusion of ICI79939 on two consecutive days gave precise synchronization of estrus. If the animals were pretreated with PMSG, a more precise synchronization would be achieved. Phillippo and Rowson (1975) reported that animals treated with 1500-2000 IU PMSG between day 8 to 12 of the estrous cycle had no more than eight ovulations. With the use of PGF2α and PMSG it appears that it is possible to control multi-ovulations in the cow and control multiple pregnancies. To shorten the interval to first ovulation Britt et al. (1974) implanted gelatin capsules containing gonadotrophin releasing horomone (GnRH) (100μg) on day 14 of the estrous cycle. Although this caused the interval to first ovulation to be shortened it did not shorten the interval to first estrus. Tervit et al. (1973) were able to achieve a precise synchronization of estrus by giving a intrauterine infusion of ICI79939 (300μg) on two consecutive days. Fertility was not reported but an earlier and more precise synchronization resulted when PMSG was used as a pretreatment.

When PGF2α THAM salt (30 mg) was injected on day 10 to 18 of the estrous cycle, estrus occurred within 48 hours (Hansen and Cupps, 1974). A higher percentage of the animals exhibited behavioral estrus sooner if they received PMSG + PGF2α than those animals receiving only PGF2α (72.7 vs 27.2%).

Daily feeding of (120 mg) 16-alpha, 17-dihydroxyprogesterone acetophenonide (DHPA) for 9 days and injecting estradiol valerate (5 mg) on the second day of feeding, Lantz et al. (1968) were able to synchronize estrus in more than 80% of the heifers treated, with less than 20% conceiving to the synchronized estrus. Wiltbank and Kasson (1968) were able to achieve 95% synchronization of estrus when DHPA (400μg) was fed for 9 days and injecting estradiol valerate (5 mg) on the second day of feeding. Fifty-four percent of the synchronized heifers conceived to first service which was greater than the controls. It was found that by dissolving the DHPA in sesame oil before mixing in the feed made it possible to achieve similar results with 75 mg as with 400 mg DHPA. Improvement of the estrus symptoms was achieved by administering estradiol benzoate 24 hours before first insemination in CAP treated heifers (Grunert, 1975). Pregnancy resulting from the first service was similar to those receiving only CAP. The use of HCG, 6 hours before insemination lowered the conception rate for some unknown reason. Lauderdale (1975) reported that feeding MGA for 5 days followed by an injection of PGF2α resulted in synchronizing 75% of the animals to a 4 day period with 60% first service conception.

Reynolds et al. (1973) showed an 11 day progesterone impregnated silicone rubber implant, placed in the neck, and an injection of estradiol benzoate on the day of implantation gave a low synchronization and

conception rate. Silastic coils (Roche, 1975) impregnated with progesterone and inserted intravaginally for 12 days with an estrogen-progesterone injection given at the time of insertion gave a high degree of estrus synchronization with normal fertility at the controlled estrus. This method allowed animals to be inseminated at a predetermined time with or without GnRH. To achieve a higher degree of synchronization Wiltbank et al. (1971) and Woody and Pierce (1974), implanted heifers with norethandrolone for 9 days and injected estradiol valerate on the day of implantation or on the day of implant removal. Although a higher degree of synchronization was obtained in those animals given estradiol valerate at implantation, both groups had a lowered fertility at the synchronized estrus. Knox et al. (1972) reported the effect of injecting norethandrolone on day 0 and 6 or an ear implant of SC21009 for 9 days plus an injection of estradiol valerate on day 0, respectively. Although synchronization was greater with the implant (92% vs 65%) fertility at the synchronized estrus was low for both. Injecting estradiol valerate plus SC21009 implanted for 13 days increased fertility over using SC21009 alone (45.8% vs 26.9%) (Chupin et al. 1975). Fertility increased with the dose of SC21009 (from 6 to 12 mg) and decreased with the duration of the treatment (from 7 to 11 days). A multiplicity of effects occurred when estrogen was injected with an implant of SC21009; luteotrophic or antiluteotrophic at the beginning of the cycle, luteolytic during most of the luteal phase, and antiluteolytic at the end of the luteal phase (Lemor, 1975). This is not in agreement with Wiltbank et al. (1961) and Wiltbank and Gonzalez-Padilla (1975) who have reported estrogens to be effective only in the early stages of the estrous cycle. When SC21009 was given with estradiol valerate it had a greater inhibitory

effect on the CL than did norethandrolone given with estradiol valerate (Lemon, 1975). Wiltbank and Gonzalez-Padilla (1975) showed that estradiol valerate was an important component in the estrogen-progesterone treatment. More heifers receiving an injection of norgestomet (SC21009) exhibited estrus than those receiving no norgestomet. This treatment appeared to induce estrus in prepuberal heifers although fertility was generally low at the synchronized estrus. Gonzales-Padilla et al. (1975a) reported that an injection of progesterone followed by an injection of estrogen stimulated the release of LH in prepuberal heifers. Short et al. (1976), were able to induce cycling in prepuberal heifers after a progesten implanted for 6 days, and an injection of estrogen. First service conception was low in those animals and repeated cycles of within 7 days was noted. Gonzalez-Padilla et al. (1975b) were able to induce puberty in heifers with an injection of norgestomet (3 mg) plus estradiol valerate (5 mg) and an implant of norgestomet (6 mg) that was removed 9 days later. Estrus was detected in 94% of the treated heifers and fertility at the first service was 50%.

Wishart (1974) concluded that the combination of SC21009 with PGF2α resulted in a higher number of animals in estrus than if either PGF2α alone or the combination of SC21009 + estradiol valerate was used. He concluded that this treatment also offers a successful method of synchronization on the farm by increasing the proportion of the herd exhibiting estrus without adversely affecting fertility. Ninety-four percent of the heifers treated with a 7 day implant of SC21009 followed by an injection of PGF2α were in estrus within 5 days post-treatment (Heersche et al. 1974). Sixty-four percent of those synchronized conceived to a first service insemination. Kaltenbach et al. (1974)

reported that synchronization of ovulation could be obtained with GnRH when it was given in conjunction with either a progestional compound or PGF2α. GnRH was given to ensure a large increase of serum LH would occur. Eighty-five percent of the cattle treated with a 18 to 21 day progesterone releasing intravaginal device (PRID) followed by an injection of GnRH 28 to 30 hours after removal showed estrus within 46 hours (Mauer et al. 1975). Graves et al. (1975) reported estrus occurred within 48 hours in cows implanted with norgestomet for 7 days and receiving PGF2α 24 hours before implant removal. Administration of GnRH shortened the interval from implant removal to ovulation which appears to have a practical merit for predetermined insemination times. Ninety-four percent of the cows treated with an implant of SC21009 followed by an injection of ICI80996 were in estrus within 5 days (Thimonier et al. 1975). Treatment started at the beginning of the cycle resulted in a lower number synchronized than those started late in the cycle (28% vs 80%).

Introduction

There are various methods one can use to synchronize the estrous cycle in cows and heifers. Daily injections of progesterone (Trimberger and Hansel, 1955), norethandrolone (Thimonier et al. 1975) or SC21009 (Wishart, 1975) controlled the estrous cycle but low conception at the synchronized estrus occurred.

Feeding of a progestinal compound such as CAP (Rey, 1975), MGA (Beatty et al. 1971) or using an implant form of MGA (Lauderdale et al. 1972; Ayalon and Marcus, 1975), norethandrolone (Wiltbank et al. 1971; Woody and Pierce, 1974) or SC21009 (Rachow and Marion, 1973; Kinder and Ellington, 1974; Chupin et al. 1975) resulted in synchronization of estrus but fertility at the synchronized estrus was usually reduced.

When regression of the corpus luteum (CL) occurs estrus in the bovine animal is usually exhibited within 4 days. Wiltbank et al. (1961) and Lemon (1975) reported that luteal regression could be obtained with an injection of estrogen. Prostaglandin F2α (PGF2α) when infused into the uterus (Louis et al. 1974; Wishart, 1974; Fulka et al. 1975) will cause regression of the CL. Larger doses of PGF2α can be injected to cause luteal regression (Lauderdale, 1972; Roche, 1974; Turman et al. 1975; Edqvist et al. 1975).

Combinations of the above treatments have been used to synchronize estrus. Progesterone implant plus an injection of estradiol valerate (Wiltbank, 1971; Woody and Pierce, 1974; Knox et al. 1972) has been used. A treatment of SC21009 plus estradiol valerate has been used to induce puberty in non-cycling heifers (Gonzalez-Padilla et al. 1975 a and Short et al. 1976). Heersche et al. 1974; Graves et al. 1975; and Wishart, 1974,

successfully synchronized estrus when an implant of SC21009 was followed by an injection of PGF2α, however, data are quite variable and the proper synchronization procedure to use in any given situation is still unknown.

The following experiments were conducted to further investigate possible means of inducing puberty and synchronizing the estrous cycle under specified situations. We chose to use only cycling heifers in order to test the ability of norgestomet implants and prostaglandin F2α to synchronize estrus in yearling beef heifers. Non-cycling heifers were used to test the ability of norgestomet and estradiol valerate to induce puberty in yearling beef heifers.

Materials and Methods

Trial I. Norgestomet plus PGF2α 24 hours before implant removal. Fifty yearling Angus, Hereford, Polled Hereford, and Simmental X Hereford heifers that had been in estrus or had palpable corpus luteum were implanted subcutaneously with norgestomet[1] (SC21009, 6 mg) on the posterior side of the ear. Six days later each heifer was injected with 33.3 mg of prostaglandin[2] THAM salt (PGF2α). One day later the implant was removed and the heifers were confined to dry lot and checked frequently during the day for estrus. They were artificially inseminated 12 to 24 hours after estrus was detected. First service conception was determined by rectal pregnancy diagnosis 45 to 65 days after insemination.

Trial II. Norgestomet plus estradiol valerate. Twenty-six yearling Polled Hereford and Simmental X Hereford heifers that had not cycled by the beginning of the breeding season were implanted subcutaneously with norgestomet[1] (SC21009, 6 mg) on the posterior side of the ear and given an intramuscular injection of 3 mg norgestomet plus 6 mg estradiol valerate[2]. The implants were removed 9 days later and all 26 heifers were confined to dry lot. Heifers ranged from 374 to 460 days old (avg. 417) and weighed 510 to 957 pounds (avg. 660). Heifers were checked for estrus continuously from 06.00 hour to 20.00 hour and were artificially inseminated 18 to 26 hours after being observed in standing estrus. First service conception was determined by rectal pregnancy diagnosis 45 to 65 days after insemination.

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[1]G. D. Searle & Company, Chicago, Illinois
[2]The UpJohn Company, Kalamazoo, Michigan

Trial III. Norgestomet plus PGF2∝. One hundred twelve yearling Angus, Hereford, Polled Hereford and Simmental X Hereford heifers that had been in estrus or had palpable corpus luteum before the start of the trial were implanted subcutaneously with norgestomet[1] (SC21009, 6 mg) on the posterior side of the ear. Seven days later prostaglandin F2∝ (33.3 mg THAM salt) was injected intramuscularly after the implant was removed from half of the heifers in the morning (am) and half in the evening (pm). All 112 heifers were confined to dry lot and were observed for estrus every four hours during a five-day period. Heifers were then bred artificially 6, 10, 14, 18, 22 or 26 hours after being observed in standing estrus. Heifers detected in estrus at each time were divided into AM and PM breedings. Conception rates were determined by rectal palpation 50 to 85 days after insemination.

Trial IV. Norgestomet plus estradiol valerate and HCG. Twenty-one yearling Angus, Polled Hereford and Simmental X Hereford heifers that had not cycled by the beginning of the breeding season were used in this trial. Heifers ranged from 374 to 445 (avg. 415) days of age and weighed 580 to 940 pounds (avg. 664). Ovaries were palpated seven days before and at the time of implantation to insure that they had not ovulated. Fifteen of the 21 heifers were implanted subcutaneously with norgestomet[1] (SC21009, 6 mg) on the posterior side of the ear and given an intramuscular injection of 3 mg norgestomet plus 5 mg estradiol valerate[2]. The implants were removed 9 days later and all 21 heifers were confined to dry lot. Heifers were checked for estrus every four hours during a five day period. Heifers were then bred artificially 6, 10, 14, 18, 22 or 26 hours after being observed in standing estrus. Heifers detected in estrus at each time were divided into an AM and PM breeding group.

Seven of the fifteen treated heifers received an intramuscular injection of HCG[3] (1000 IU) at the first breeding and 5 days later. The 6 non-synchronized heifers were used as controls. Conception rates were determined by rectal palpation 50 to 85 days after insemination.

Data for the 4 trials was analyzed as a composite by least squares analysis of variance (Kemp, 1972) and by Duncans New Multiple Range Test (Snedecor and Cochran, 1973).

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[3]Ayerst Laboratories Inc., New York, New York

RESULTS

Trial I. Norgestomet plus PGF2α, 24 hours before implant removal. Estrus and conception data are in Table 1. Forty-one of the 50 heifers (82%) were in estrus within a 72 hour period after removal of the norgestomet implant. Forty-five of the 50 (90%) were in estrus within 120 hours post-implant removal. All five heifers not synchronized exhibited estrus within the first five days of breeding season.

Of the 45 synchronized heifers, 31 (68.9%) conceived to the first insemination; 41 of the 45 (91.1%) conceived in two inseminations. Four of the five non-synchronized heifers conceived to first service. The conception rate for the 50 heifers for the 65 day breeding season was 94%.

TABLE 1. OCCURRENCE OF ESTRUS AND CONCEPTION RATES IN HEIFERS TREATED WITH NORGESTOMET[a] AND PROSTAGLANDIN ($F_2\alpha$)[b]

	Days post treatment[c]										
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	Total
No. in estrus	6	19	3	10	0	3	0	3	1	0	45[d]
No. conceived 1st service	5	12	3	6	0	3	0	1	1	0	31

[a]G. D. Searle & Co. (6 mg, ear implant in place 7 days).

[b]The UpJohn Co. (33.3 mg THAM Salt injected 24 hours before implant removal).

[c]Implant removed AM day 0.

[d]Five of 50 heifers showed no signs of estrus during the days, four of the 5 later conceived with first service.

Trial II. Norgestomet plus estradiol valerate. Twenty-five of the 26 heifers (96.2%) were in estrus 24 to 72 hours after removal of the norgestomet implant (Table 2). Nine had repeated estrus periods after the first insemination, generally in estrus every other day. Estrus periods were repeated 1 to 4 times in the nine heifers. Some were inseminated only at the first estrus, some at each estrus, but none conceived until completing one normal cycle. The treatment was effective in inducing puberty; however, conception was low at the first service (23.1%). Seventeen of the 26 (65.4%) conceived in two inseminations. Conception for the 65 day breeding season was 92.3%.

TABLE 2. ESTRUS AND CONCEPTION IN NON-CYCLING HEIFERS TREATED WITH NORGESTOMET[a] AND ESTRADIOL VALERATE[b]

	AM	PM	AM	PM	AM	PM	AM	AM	TOTAL
Day[c]	1	1	2	2	3	3	4	5	
No. in estrus	11(3)[d]	10(1)	2	0	2(1)	0	0	1(1)	26(6)
Conceived 2nd service[e]	2	7	1	0	1	0	0	0	11
Conceived after 2nd service	5	1	1	0	0	0	0	0	7

[a]G. D. Searle & Co. (6 mg, ear implant in place 9 days).

[b]G. D. Searle & Co. (3 mg norgestomet and 6 mg estradiol valerate, injected at time of implant).

[c]AM day 0 was time implant was removed.

[d]No. heifers conceiving on first service in ().

[e]No. of heifers showing estrus at this time after treatment and that conceived on second cycle.

Trial III. Norgestomet plus PGF2α. Estrus and conception data are in Table 3. Ninety-four of the 112 heifers (83.9%) were in estrus within 72 hours after removal of the norgestomet implant and injecting PGF2α. One hundred and seven of the 112 (95.5%) were in estrus within 120 hours post treatment. Three of the 107 synchronized heifers were not bred at their first synchronized estrus and were not used to calculate first service conception. Seventy-two of the 104 heifers (69.2%) synchronized and bred conceived the first insemination. Five of the 104 heifers were not bred according to the experimental breeding schedule. Conception rates for the remaining 99 in the 6, 10, 14, 18, 22 and 26 hour breeding groups were 67, 60, 71, 68, 53 and 87 percent, respectively. (Table 4).

TABLE 3. ESTRUS AND CONCEPTION RATES IN HEIFERS TREATED WITH NORGESTOMET[a] AND PROSTAGLANDIN ($F_2\alpha$)[b]

Days post treatment[c]	1	2	3	4	5	Total
No. in estrus	26	47	21	12	1	107[d]
No. conceived 1st service	16	30	16	9	1	72
1st service conception	61.5	63.8	76.2	75.0	100.0	69.2[e]

[a]G. D. Searle & Co. (6 mg, ear implant in place 7 days).

[b]The UpJohn Co. (33.3 mg THAM Salt injected at implant removal).

[c]Implant removed day 0.

[d]Five of 112 heifers showed no signs of estrus during the 5 days.

[e]Three heifers found in heat were not bred and are not included in first service conception data.

TABLE 4. CONCEPTION RATES OF SYNCHRONIZED HEIFERS BRED AT INDICATED TIMES AFTER ONSET OF ESTRUS

Hours bred after estrus detected[a]		6	10	14	18	22	26	Total
No. of heifers bred at:	8 a.m.	6	9	6	12	7	10	50
	8 p.m.	12	6	11	7	8	5	49
% conception 1st service of heifers bred at:	8 a.m.	67	56	67	67	57	100	70
	8 p.m.	67	67	73	71	50	60	65
% conception by breeding period		67	60	71	68	53	87	67.6

[a]Estrus checked every four hours.

Trial IV. Norgestomet plus estradiol valerate and HCG. Individual data for estrus and conception are in Table 5. Fourteen of the 15 heifers (93%) were in estrus 24 to 48 hours after implant removal. The one heifer that was not in estrus by 48 hours had lost her implant during the treatment but exhibited estrus within 98 hours of removal of the other implants, which were not included in data.

Five heifers, three HCG treated, had repeated estrus periods after their first inseminations as noted in Trial II. Estrus periods were repeated 1 to 5 times in the five heifers. Five of the 6 controls were in estrus within 13 days of those induced suggesting that most heifers were close to cycling at the start of the study.

Six of the 15 treated (40%) and 1 of the 6 controls (17%) conceived to first service inseminations. Thirteen of the 15 treated (86.6%) and

all the control (100%) conceived in two inseminations. Conception for the treated and controls heifer for the breeding season was 95%.

A composite statistical analysis on days to first service conception for treatments used in trials I, II, III and IV is shown in Tables 6 and 7. Conception occurred significantly later in controls than any of the synchronization treatments (Table 7). Treatment involving the implant plus PGF2α (Trial III) resulted in first service conception occurring significantly later than the other synchronization treatments (Table 7). Herefords conceived significantly later than other breeds (Table 6) and year of birth had a significant affect ($P<.01$) on time of first service conception.

TABLE 6. MEANS $\pm$ STANDARD ERRORS BY BREED AND BIRTH YEAR FOR DAYS TO FIRST SERVICE CONCEPTION[a]

Breed	Number	Mean $\pm$ SE
A	14	$4.6 \pm .4^{b}$
H	13	$5.4 \pm .4^{c}$
PH	53	$4.7 \pm .2^{b}$
SxH	42	$4.7 \pm .3^{b}$
Birth Year		
74	37	$5.2 \pm .5^{d}$
75	85	$4.5 \pm .3^{e}$

[a]Model, Y=mean + breed + year + treatment + gain. Day 0 implant removed.

[bc]Means with different superscripts are significantly different ($P<.05$) according to Duncans NMRT.

[de]Birth years are significantly different ($P=.01$) according to Duncans NMRT.

TABLE 5. ESTRUS AND CONCEPTION IN NON-CYCLING HEIFERS TREATED WITH NORGESTOMET[a] AND ESTRADIOL VALERATE[b]

Treatment[c]	I.D.	Day in Estrus[d]	Repeated Breedings[e]	1st Service Conception[f]
Non HCG	544	3	yes	no
	561	0	no	no
	575	1	yes	no
	5100	1	no	yes
	5121	1	no	yes
	5180	1	no	no
	72-G	1	yes	no
	255	1	no	yes
HCG	519	1	no	yes
	521	1	no	no
	540	1	no	yes
	5129	1	yes	no
	5140	0	yes	no
	5204	0	no	yes
	71-G	0	yes	no
Controls	509	0	no	no
	556	6	no	no
	581	10	yes	no
	593	13	no	yes
	597	12	no	no
	70-G[g]	Bull	Bull	Bull

[a]G. D. Searle & Co. (6 mg, ear implant in place 9 days.)

[b]G. D. Searle & Co. (3 mg Norgestomet + 6 mg estradiol valerate, injected at time of implantation).

[c]Ayerst Lab. Inc. (1000 I.U., HCG injected at time of breeding and 5 days later).

[d]Implant removed day 0.

[e]Multiple breedings due to repeated short estrous cycles or split estrus periods.

[f]Heifers with repeated estrus did not settle until one normal cycle (18 days) elasped.

[g]Data not available due to pasture breeding.

TABLE 7. EFFECT OF SYNCHRONIZATION TREATMENT ON DAYS TO FIRST SERVICE CONCEPTION[a]

Treatment	No.	Mean ± SE
Implant + PGF2α	73	3.2 ± .4[c]
Implant + PGF2α[b]	31	2.4 ± .4[d]
Implant + Estradiol Valerate	10	2.4 ± .4[d]
Implant + Estradiol Valerate; HCG	4	2.1 ± .7[cd]
Control	4	14.1 ± .7[e]

[a] Model, Y=mean + breed + starting age + treatment + gain.

[b] PGF2α injected 24 hours before implant removal.

[cdef] Means with different superscripts are significantly different (P<.05) according to Duncans NMRT.

DISCUSSION

Results were similar between trials I in 1975 and III in 1976 where heifers were synchronized with norgestomet and PGF2α; estrus occurred in 82% and 83.9%, respectively, within 72 hours after implant removal and 90% and 95.5% within 120 hours, respectively. Therefore, giving PGF2α 24 hours before implant removal (Trial I) had little effect on improving synchronization, however, estrus occurred slightly earlier in Trial I than when PGF2α was given at implant removal in Trial III and as reported by Heersche et al. 1974. Graves et al. (1975) reported that estrus occurred within 80 hours in 93% of the heifers treated with a 7 day norgestomet implant and given PGF2α 24 hours before implant removal. Ninety percent of the heifers treated with an implant of SC21009 and an injection of PGF2α were observed in estrus within 120 hours post-injection (Wishart,

1974). Although heifers show estrus earlier when PGF2α is given 24 hours before implant removal, first service conception is equal to that of injecting PGF2α at implant removal. Parallel results were reported by Graves et al.(1975). A disadvantage of injecting PGF2α 24 hours before implant removal is the added expense of working the cattle another time. Injecting PGF2α 24 hours early would appear to offer no benefit in heifers bred by estrus, however, there may be some benefit if heifers were bred by appointment.

First service conception for the synchronized heifers in Trials I and III was 68.9% and 69.2%, respectively. Heersche et al. (1974) reported first service conception after an implant of SC21009 (norgestomet) and an injection of PGF2α was 64% and Wishart (1974) reported 66.7%. This procedure appears to be extremely effective and repeatable for synchronization of estrus to a 5 day period in cycling heifers without affecting fertility.

The conception rates of the synchronized heifers in Trial III are summarized in Table 4. The results suggest that there is no difference in conception rates of heifers bred in the morning (am) or evening (pm). Also, acceptable conception rates were obtained by breeding as early as 6 hours or as late as 26 hours following the onset of estrus.

Induction of puberty, in Trials II and IV, was high successful; 96.2% and 93%, respectively. Wiltbank and Gonzalez-Padilla (1975) reported puberty was induced in 93% of heifers by an implant of norgestomet and an injection of estradiol valerate; Gonzalez-Padilla et al. (1975b) reported 94% and Short et al. (1976) reported 88% of heifers involved in their studies were induced. The incidence of repeated estrus or short estrous cycles was noted in 35% of the treated heifers in Trials II and

42.9% in trial IV. Short et al. (1976) reported similar repeated, short estrous cycles and suggested that it may be due to using a dose of estrogen that was too high causing a release of LH. HCG was not successful in suppressing the occurrence of repeated estrus in Trial IV since 42.9% and 37.5% of the heifers exhibited repeated cycles for the HCG and non-HCG treated groups, respectively.

The major detriment to induced puberty is the low first service conception encountered at the synchronized estrus. First service conception for Trials II and IV was 23.1% and 40.0%, respectively with normal conception occurring after the second cycle (65.4% and 86.6%). Wiltbank and Gonzalez-Padilla (1975) reported conception of 53%, Gonzalez and Padilla et al. (1975b) 50%, and Short et al. (1976) 53% following a treatment of norgestomet and estradiol valerate. All reported normal conception rates for the following estrus.

Year of birth significantly affected days to first service conception. This could be due to nutritional status of the animal, age, and other factors. The treatment of implant plus PGF2α took significantly longer to first service conception than when PGF2α was given 24 hours before implant removal. This is probably due to estrus occurring approximately 6 hours earlier in the later group. First service conception, however, was similar for the two groups (68.9% vs. 69.2%). Cattle also show estrus earlier after the implant plus estradiol valerate than the PGF2α treatment at implant removal thus contributing to significant differences obtained between those groups.

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ESTROUS SYNCHRONIZATION AND INDUCED PUBERTY IN BEEF HEIFERS

by

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Four trials were conducted over 2 years (1975-1976) to investigate methods of inducing puberty and synchronizing estrus in virgin heifers.

Trial I included 50 yearling Angus, Hereford, Polled Hereford and Simmental X Hereford heifers that were implanted with norgestomet (6 mg) for 7 days. On the sixth day after implanting, each heifer received 33.3 mg of prostaglandin (PGF2α) THAM salt. Within 72 hours after implant removal 82% were observed in estrus and 90% after 120 hours. Of the 45 heifers synchronized to a 5 day period, 68.9% conceived to first insemination and 41 (91.1%) conceived in two inseminations. Heifers were bred approximately 12 hours after detected in heat.

In Trial II, twenty-six Polled Hereford or Simmental X Hereford yearling heifers that had not cycled by the beginning of the breeding season were implanted with norgestomet (6 mg) and given an injection of norgestomet (3 mg) plus estradiol valerate (6 mg) at implantation. Implants were removed 9 days later. The treatment was effective in inducing puberty in 96.2% after implant removal. First service conception was 23.1% and 65.4% had conceived after two inseminations. Repeated estrus periods, 1 to 4 times in 10 days, were observed in 9 of the 26 treated heifers. None of the heifers having repeated estrus periods conceived until completeing one normal cycle or until at least 18 days after implant removal.

In Trial III, 112 yearling Angus, Hereford, Polled Hereford and Simmental X Hereford heifers that had cycled were implanted with 6 mg of norgestomet. Seven days later the implant was removed and PGF2α (33.3 mg THAM salt) was injected. Heifers were observed for estrus every 4 hours and bred 6, 10, 14, 18, 22 or 26 hours after the onset of estrus. Ninety-four of the 112 heifers (83.9%) were in estrus within 72 hours after removal of the implant and PGF2α injection and 107 (95.5%) were in estrus within 120 hours. Seventy-two of the

104 (69.2%) heifers synchronized and bred conceived the first insemination. Conception rates for the 6, 10, 14, 18, 22 and 26 hour breeding groups were 67, 60, 71, 68, 53 and 87 percent, respectively.

Twenty-one Angus, Polled Hereford or Simmental X Hereford prepuberal heifers were used in Trial IV. Fifteen of the 21 heifers received an norgestomet implant plus estradiol valerate as in Trial II. Implants were removed 9 days later. Fourteen of the 15 (93%) were in estrus by 48 hours and all by 98 hours, after implant removal. Seven of the 15 heifers received HCG at the first breeding and 5 days later in an attempt to reduce the occurrence of repeated estrous cycles noted in Trial II. Six of the 15 treated (40%) and 1 of 6 controls (17%) conceived to first service inseminations. Thirteen of the 15 (86.6%) treated and all of the controls (100%) conceived in two inseminations. Five heifers, three HCG treated, had repeated estrus periods as noted in Trial II.

The results suggest no advantage can be obtained by injecting $PGF2_{\alpha}$ 24 hours before implant removal when heifers are bred by estrus. No difference in conception rates occurred between heifers bred in the morning or evening and acceptable conception rates were obtained by breeding as early as 6 hours or as late as 26 hours following the onset of estrus in heifers synchronized with norgestomet and $PGF2_{\alpha}$. HCG was not successful in suppressing the occurrence of repeated estus periods noted in heifers with induced puberty.

Synchronization of cycling heifers to a 5 day period with norgestomet and $PGF2_{\alpha}$ appears to be extremely effective and repeatable without affecting fertility. Induction of puberty with an implant of norgestomet plus an injection of estradiol valerate was highly successful but low fertility was encountered at the synchronized estrus.