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Management of Reproduction in Dairy Herds Based on the Synchronization of Successive Estrous Cycles

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Abbreviations and Definitions

A.I.	- artificial insemination
EDI	- estrus detection and insemination week.
NE _L	- net energy for lactation
P ₄	- progesterone
P.D.	- pregnancy diagnosis by rectal palpation
PG	- prostaglandin F _{2α} or its analogue
Breeding intervals, days	- interval from first postpartum A.I. (cows) or first A.I. (heifers) to conception.
Open days	- interval from calving to conception
Conception rate, %	- number of pregnancies x100/number of inseminations (including inseminations of cows that did not conceive).
Pregnancy rate, %	- number of pregnancies x100/number of cows inseminated.

Abstract

- Five experiments, including dairy cows and heifers (N=1,354) were carried out. Estrous cycles were synchronized every three weeks. Observations of estrous behavior and A.I. were carried out following treatment, during 6 d out of each three weeks. Heifers, treated with two PG injections, 12 d apart and inseminated at estrus had a conception rate and breeding interval of 59% and 26 d vs. 51% ($P<.05$) and 37 d ($P<.04$) in heifers given an improved fixed-time A.I. No. of A.I./conception was 2.0 and 2.8, respectively ($P<.0001$).
- Primiparous cows were treated with two PG injections given either 11 or 14d apart; conception rates were 60.6% and 61.8% , a breeding interval of <30d was reached by 61.9% and 84.2% of cows ($P<.05$) and number of open days was 141 and 118d ($P<.06$) for cows of the two treatments, respectively.
- Cows were treated with either: two PG injections 14 d apart (treatment A), a PRID for 7 d and a PG one day before its removal (treatment B); two PG 14 d apart and a PRID for 7 d inserted 8 d after the first PG (treatment C). Conception rates of multiparous cows in estrus, were 42, 56 and 66% for treatments A, B and C, respectively ($P<.02$). Percent of cows pregnant, 90 d after calving was 37, 43 and 58% ($P<.02$). In treatment A cows with plasma P_4 levels of <3 ng/ml 4 d before the second PG injection, had a conception rate of 33% vs. 73% in cows with higher P_4 levels ($P<.05$). In treatment C, plasma P_4 levels were not related to conception and cows with levels of <3 ng/ml had a conception rate of 71% vs. 33% in treatment A ($P<.02$). The positive effect of PRID on fertility was not related to its contribution to P_4 levels. Synchronization with PG only can result in high fertility in cows with high P_4 levels, while cows with low P_4 level require a PRID.
- Multiparous cows were given either treatment C or a single PG, followed by treatment C in cows not detected in estrus. Conception rate of cows in estrus was 69% and 39% for cows given treatments C and PG, respectively ($P<.05$). The breeding interval and pregnancy rate were not different between treatment C and the combination PG followed by treatment C.
- Cows were either untreated, inserted with a PRID for 7 d with a PG injected one day before PRID removal (treatment B), or given treatment B with another PRID inserted during days 12 to 19 following A.I. (treatment C). First A.I. conception rates were 52%, 33% and 35% for cows of treatments A, B and C, respectively ($P<.05$). First A.I. conception rates of cows in estrus were 52%, 50% and 52% in treatments A, B and C, respectively. Number of days open were 96, 94 and 104 (N.S.) respectively.

Objectives

- a. To develop a system of reproductive management that, by means of synchronization of consecutive estrous cycles, will reduce the intercalving interval. Under this system not less than 70% of the cows should conceive within a 25-day period, thus enabling the insemination of each age group at an optimal postpartum interval. The system should also reduce the period required for estrus detection and A.I. to 3-6 out of each 21 days.
- b. To compare several available estrus synchronization methods as to their suitability for the synchronization of the first of a series of synchronized cycles in dairy cows.
- c. To develop a method of estrus synchronization that will not impair conception resulting from previous inseminations and to investigate the applicability of a second synchronization treatment for the reproductive management system.

General Introduction

The success of any method of ovulation control depends on the degree of estrus synchronization and ensuing fertility, following artificial insemination (A.I.) or breeding. Many reports in the literature indicate, as does the experience of the authors of this report, that there is a great variation in the degree and timing of estrus appearance and fertility obtained by most methods of estrus synchronization. Even when animals are inseminated following estrus detection, considerable differences are encountered between the conception rates of estrus synchronized and untreated control animals in different experiments.

The main objective of the present study was therefore to compare various synchronization methods and their effect on fertility of cattle, and to identify factors which affect conception.

General Methods

for Experiments 1 to 4 carried out in Israel

Animals. Cows and heifers of the Holstein-Israeli dairy breed were used in all experiments. The cows were part of a large herd, including 300 cows with an annual average milk yield of approximately 9,000 kg. Cows and heifers were kept in open sheds, bedded with straw or gin-trash.

Cows were allotted into experimental treatments according to parity, interval from calving and body condition score determined 6 to 7 weeks after calving.

Feeding. During the dry period, cows were fed hay and silage at a level intended to supply the maintenance and pregnancy requirements only. During the last two weeks of the dry period, cows were also fed some 3 kg dry matter of the ration fed to milking cows. After calving, cows were fed ad-libitum a whole mixed diet containing 70% of concentrates and 30% of hay and silage. During the first part of the lactation period, the concentration of the diet in dry matter was 1.78 Mcal NE_L /kg. During the second part of the lactation period, the concentration of the diet was 1.65 Mcal NE_L /kg. The transfer of cows from diet to diet was carried out according to milk yield and body condition score. Heifers were fed a diet intended to maintain a live-weight gain of 650-700 g/day. The mixed whole diet of heifers consisted of corn stover, wheat straw, soya-bean meal, corn silage and wheat silage. This is a typical diet fed to dairy heifers in Israel. Because roughage is more expensive than cereal grains, various wastes and by-products were included in the diet of heifers. During ten months of the second year of the experiment, heifers were also fed gin-trash. Liquid whey was offered to cows and heifers ad libitum. Vitamins and minerals were added to the mixed diets in quantities recommended by the U.S. National Research Council. The only exceptions were that 2 g of calcium and 150,000-200,000 IU of vitamin A were fed per cow/day.

Management of reproduction. The herd was under a strict veterinary health scheme service throughout the experimental period. An experienced veterinarian was visiting the herd once a week to check and treat any symptoms of reproductive disorders and to diagnose cows for pregnancy. Approximately 30 days after calving, the reproductive tract of all cows was checked by the veterinarian and the cows were treated for any disorders found.

In order to maximize milk and calf production (41), it was intended to have the first postpartum artificial insemination (A.I.) of primiparous cows 80 to 100 days after calving and of multiparous cows 60 to 80 days after calving. The management of

reproduction was based on a scheme of estrus synchronization (Fig. 1). All cows and heifers were given an estrus synchronization treatment prior to the first postpartum insemination. Cows that calved within a three-week period were treated simultaneously. Thus a cluster of cows and heifers was synchronized once in every three weeks (9). Healthy cows and heifers were given synchronization treatments according to their calving date. The synchronization of cows that were under veterinary observation or treatment was postponed to subsequent clusters.

Artificial inseminations were carried out only during six days out of each three weeks. The termination of synchronization treatment of cows, i.e. removal of PRIDs or administration of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) or its analogue (PG) were carried out every third Friday. Insemination of cows commenced the following Sunday. Depending on the experimental protocol, cows were given either one or two fixed-time inseminations or a single insemination following the detection of estrus. A second fixed-time A.I. was not given if estrus was detected prior to the first fixed-time A.I. If estrus was detected during later days following the two fixed-time inseminations, a third insemination was carried out. When estrus was first detected, just prior to insemination, cows and heifers were reinseminated the following morning. Visual observations of cows and heifers in order to detect signs of estrus were carried out following synchronization treatment, from Saturday noon until Friday morning. Observations were carried out approximately every 6 hr; each observation lasted more than 30 min. Observations of animals were not carried out during feeding or milking. The number of mountings (head or tail), standings to mount and runnings away were recorded in each observation. The week during which estrus detection and artificial insemination were carried out is designated as the EDI (Estrus Detection and Inseminations) week.

Cows and heifers that did not conceive from the first postpartum insemination and returned in estrus during the subsequent EDI weeks were reinseminated without additional synchronization; cows that manifested estrus outside the EDI weeks were not inseminated. Approximately 45 days following A.I., pregnancy diagnosis was carried out by rectal palpation of the uterus. Cows and heifers that were diagnosed as not pregnant and animals that were seen in estrus outside an EDI week were given an additional estrus synchronization treatment. In some experiments, where only cows in estrus were inseminated, an additional synchronization treatment was given to cows and heifers that did not manifest estrus during the EDI week following the first synchronization.

Figure 1. Time schedule for synchronization treatments, estrus detection and insemination of successive clusters of cows and heifers.

Evaluation of reproductive performance. Most of the reproductive indices were calculated for cows that conceived, as well as for the total number of cows. For cows culled following a negative pregnancy diagnosis, an estimated "conception date" was calculated by adding 63 days to the date of the last, unsuccessful, insemination and one insemination was added to the number of A.I. previously carried out. For the very few cows that were culled prior to a pregnancy diagnosis, the date of the last insemination was regarded as the date of conception, and the number of inseminations carried out hitherto was regarded as the number of A.I. per conception.

In Israel, the A.I. centers are not paid by the farmer for each insemination or dose of semen. The payment is made per cow submitted for insemination following calving and includes all the inseminations carried out during any given lactation until the cow has conceived or has been culled. Thus, our calculation of the number of inseminations per conception is carried out in two ways: (a) the number of EDI weeks during which the cow or heifer was inseminated. For this calculation, all the inseminations carried out during any EDI week are regarded as one insemination; (b) the number of inseminations including the fixed-time ones are counted.

The breeding interval was defined as the number of days from the first postpartum A.I. to conception. Conception rate is defined as the number of cows pregnant per 100 inseminations and pregnancy rate was defined as the number of cows pregnant per 100 cows subjected to synchronization treatment and insemination.

For the calculation of conception rate, all the inseminations carried out during a single EDI week are regarded as one insemination.

Materials. Synchronization of estrus was carried out by using a progesterone releasing intravaginal device (PRID) produced by CEVA, France. Depending on the experiment, the silastic rubber covering the steel spring of the PRID was either 2 mm thick and containing 1.55 g progesterone, or 3 mm thick containing 2.25 g of progesterone. In all cases, the PRID was used without the estradiol-benzoate capsule with which it is usually marketed. The first postpartum synchronization of estrus was carried out by new PRIDs. The additional synchronizations were carried out by used PRIDs. The used PRIDs were prepared as follows: Following their insertion into cows for 7 days, PRIDs were removed, washed with a detergent and soaked for 30 min in an organic iodine solution (Polydin, Fischer Pharmaceuticals, Tel Aviv). The used PRIDs were rinsed, dried and kept until further use. One day prior to their insertion, the used PRIDs were autoclaved for 30 min under a pressure of one atmosphere. PRIDs were reused only once during the experiments described in this report. Depending on the experiment, either 25 mg of the synthetic $\text{PGF}_{2\alpha}$, dinoprost (Lutalyse, Upjohn), or

0.5 mg of cloprostenol, a $\text{PGF}_{2\alpha}$ analogue (Estrumate, ICI), were administered per cow or heifer.

Blood collection. Unless otherwise specified, blood was collected between 6 and 7 a.m. from the jugular vein into heparinized vacutainers. The tubes were put on ice, centrifuged and the plasma kept at -18°C .

Radioimmunoassay of hormones. Plasma progesterone concentrations were determined by RIA (33). LH concentrations were determined by a solid phase RIA (31). The antiserum for the LH RIA was supplied by Dr. W. Hansel and the purified LH for iodination and standards was provided by NIAMDD, Bethesda, Md.

Statistical analysis. Differences between means were assessed using the SAS GLM analysis procedure. Difference in frequency distributions were assessed using the SAS Freq. procedure. Non parametric (categorical) variables were analyzed by the SAS CATMOD procedure (34).

**A comparison between two PG injections given 11 days apart vs. 14 days apart -
Experiment 1**

Summary

Primiparous cows (N=87) were given two injections of PG either 11 days apart or 14 days apart. During the EDI week, 75.0% and 79.1%, respectively, of cows were detected in estrus. Cows given the 11-day treatment appeared in estrus significantly earlier than cows given the 14-day treatment. Conception rate of cows in estrus following the first A.I. were 60.6% and 61.8% for the 11- and 14-day groups, respectively. The mean breeding interval was 38 and 18 days ($P<0.09$) and the number of open days 141 and 118 ($P<0.06$) for the 11- and 14-day groups, respectively. The percentage of cows with a breeding interval of 30 days or less was 61.9% and 84.2%, respectively, ($P<0.05$) for the two groups. Significantly more cows of the 14-day group reached, prior to the second PG injection, a plasma progesterone level of more than 5 ng/ml. Cows with a plasma progesterone level of more than 5 ng/ml, during four days prior to the second PG injection, had a higher, sometimes significantly, conception rate than cows with a lower level of progesterone.

Introduction

It was previously shown (1,17,19) that a considerable proportion of cows and heifers treated for the synchronization of estrus with two PG injections given 11 days apart, do not respond to the second injection. It has been hypothesized that the poor estrous response was due to insufficient development of the C.L. which had been found following the first PG injection and ensuing estrus. The purpose of this experiment was to determine whether a prolongation of the interval between two PG injections will affect plasma progesterone levels, manifestation of estrus and fertility.

Experimental

Eighty-seven primiparous cows were allotted into two groups. Cows of the first group were given two PG injections 11 days apart, cows of the second group were given two PG injections 14 days apart. The second PG injection was given to all animals on the Friday prior to the EDI week. Only cows that were detected in estrus during the EDI week were inseminated following estrus detection. Cows that were not detected in estrus were not inseminated and were given a third PG injection 3 weeks after the second PG injection. Again, only cows that were detected in estrus were inseminated. Those cows which were not observed in estrus were treated with a PRID for 7 days and

a PG injection that was administered one day prior to PRID removal. This method of synchronization is designated PRID7/PG6. Following this, third, synchronization all the cows were inseminated 48 and 72 hr following PRID removal. Cows that were detected in estrus, during the EDI week, after the 72-hr insemination, were reinseminated.

Results

Following synchronization treatment, 75.0% of the cows given 2PGs 11 days apart and 79.1% of the cows given 2PGs 14 days apart manifested estrus during the EDI week (Table 1).

The frequency distribution of the interval from the second PG injection to the onset of estrus is shown in Table 1. It can be seen that when the two PG injections were given 11 days apart, the interval to estrus was slightly shorter than in the cows in which PG was injected 14 days apart. The percentage of cows that appeared in estrus between 49 and 96 hr (8 visual observations) following the second PG administration was 63.6% and 61.8% in the 11- and 14-day groups, respectively. The percentage of cows that appeared in estrus between 49 and 120 hr (12 visual observations) was 72.7% and 79.4%, respectively.

Conception rates following the first postpartum synchronized insemination were similar in both groups (Table 2). However, following the second spontaneous estrus, the conception rate was higher in the 14-day group. Conception rates following the subsequent synchronized inseminations differed between treatments; however, as the number of inseminated animals is small, the differences are not statistically significant. The relationship between the interval from the second PG to estrus and conception rate and the relationship between body condition score and conception rate were calculated together for cows of Exps. 1 and 2 and are presented in Tables 23 and 25, respectively.

The mean interval from calving to the first postpartum A.I. was similar in both groups (Table 3), whereas the breeding interval and number of open days, in cows that conceived, was by 20 and 23 days, respectively, smaller in cows given the 2PG injections 14 days apart ($P < 0.06-0.09$).

The percentage of cows with a breeding interval of 30 days or less is significantly greater in the 14-day group (Table 4). Similarly, the frequency distribution of open days (Table 5) is significantly in favor of the 14-day treatment.

Table 1. Frequency distribution of estrus appearance following the second PG injection in Exp. 1¹.

Treatment	2PG 11 days apart	2PG 14 days apart	P
Number of cows	44	43	
Cows in estrus	33	34	
Interval from PG injection to estrus, hr	----- Frequency distribution ----- (% of cows in estrus)		
19 - 42	3.0	0	
43 - 66	54.5	26.5	0.02
67 - 90	21.2	44.1	0.05
91 - 114	3.0	17.7	0.05
115 - 138	12.1	5.9	
139 - 162	0	2.9	
163 - 186	6.1	2.9	
49 - 96	63.6%	61.8%	
49 - 120	72.7%	79.4%	

¹The distribution of the intervals from PG injection to estrus appearance is significantly different between treatments ($P < 0.001$).

Plasma progesterone levels. Plasma progesterone levels following the first PG administration are shown in Table 7.

Plasma progesterone levels are lower in the 14-day group 3 and 7 days after PG administration. This is the result of more cows undergoing luteolysis following PG in this group. During days 10, 11 and 14 the progesterone levels are similar in both groups. The luteal phase of the 14-day group is by 3 days longer than that of the 11-day group, as a result of the experimental treatment. Nine, 10 and 11 days after the first PG administration, the plasma progesterone level of cows that conceived following the subsequent synchronized estrus and A.I. was significantly higher than that of cows that did not conceive.

Table 2. Conception rate of primiparous cows synchronized with two injections of PG given 11 or 14 days apart and inseminated following manifestation of estrus in Exp. 1¹.

Interval between the two PG injections	11 Days	14 Days
No. of cows	44	43
Conception rate following the 2nd PG injection		
1st A.I.	60.6 (33) ²	61.8 (34)
2nd A.I.	23.1 (13)	53.8 (13)
All A.I.	41.9 (74)	49.2 (63)
Conception rate following the 3rd PG injection		
1st A.I.	40.0 (5)	80.0 (5)
All A.I.	55.6 (9)	71.4 (7)
Conception rate following PRID7/PG6		
1st A.I.	33.3 (6)	25.0 (4)
All A.I.	42.9 (14)	44.4 (9)
Number culled	2	5

¹Cows that were not detected in estrus after the second PG injection, were given a third PG injection 21 days later. Cows that did not manifest estrus after 3PG injections were treated with the PRID7/PG6 method prior to the third EDI week.

²No. of inseminations in parentheses.

Table 3. Mean interval from calving to first postpartum A.I., breeding interval, open days and no. of A.I. and of synchronizations per conception in primiparous cows in Exp. 1.

Treatment	2PG 11 days apart	2PG 14 days apart	S.E.	P
No. of cows	44	43		
Interval from calving to first A.I., days				
All cows	102	100	± 2.5	N.S.
Pregnant cows	103	99	± 2.6	N.S.
Breeding interval, days				
All cows	47	39	± 11.3	N.S.
Pregnant cows	38	18	± 8.0	0.09
Open days				
All cows	150	139	± 11.4	N.S.
Pregnant cows	141	118	± 8.3	0.06
No. of EDI weeks/conception				
All cows	2.2	1.8	± 0.25	N.S.
Pregnant cows	2.0	1.5	± 0.19	0.08
No. of A.I./conception				
All cows	2.82	2.58	± 0.35	N.S.
Pregnant cows	2.55	2.08	± 0.28	N.S.
No. of synchronizations/cow				
All cows	1.36	1.33	± 0.11	N.S.
Pregnant cows	1.35	1.16	± 0.10	N.S.
No. of cows culled	2	5		

Table 4. Frequency distribution (%) of the breeding interval of pregnant cows in Exp. 1.

Treatment	<u>2PG 11 days apart</u>	<u>2PG 14 days apart</u>
No. of cows	42	38
Breeding interval, days	----- Frequency distribution, % -----	
≤ 30	61.9	84.2*
31 - 60	9.5	2.6
61 - 90	19.0	7.9
91 - 120	2.4	0.0
121 - 150	2.4	2.6
≥ 151	4.8	2.6

*Significant difference between treatments ($P < 0.05$).

Seven days prior to the second PG injection in the 14-day group and four days prior to this injection in the 11-day group, 60% of cows had a plasma progesterone level of less than 3.0 ng/ml (Table 8). During the subsequent 3 days, plasma progesterone levels increased and more than 50% of the cows had a plasma progesterone level of 5.0 ng/ml or more. One day prior to second PG injection, 80% of the cows in the 14-day group had a plasma progesterone level of more than 5.0 ng/ml vs. 57% in the 11-day group. Due to the three days prolongation of the luteal phase in the 14PG treatment, the difference in the frequency distribution of cows among the progesterone levels is highly significant on days 0, 1 and 4 prior to the second PG injection (Table 8).

Table 5. Frequency distribution (%) of open days of pregnant cows in Exp. 1¹.

Treatment	<u>2PG 11 days apart</u>	<u>2PG 14 days apart</u>
No. of cows	42	38
----- Frequency distribution, % -----		
< 90	9.5	7.9
91 - 120	45.2	65.8
121 - 150	9.5	13.2
151 - 180	14.3	5.3
181 - 210	14.3	2.6
≥ 211	7.1	5.3

¹The distribution of open days is significantly different between the treatments ($P < 0.004$).

Table 6. Pregnancy rate (%)¹ at various intervals after calving in Exp. 1.

Treatment	<u>2PG 11 days apart</u>	<u>2PG 14 days apart</u>
No. of cows	44	43
----- Pregnancy rate, % -----		
Interval after calving,		
90	9.1	7.0
120	52.3	65.1
150	61.4	76.7
180	75.0	81.4
210	88.6	83.7
≥ 211	93.2	88.4
Percent culled	6.8	11.6

¹Percent of cows pregnant.

Table 7. Plasma progesterone levels (ng/ml) of primiparous cows following the first of two PG injections given 11 or 14 days apart in Exp. 1¹.

Treatment	Days following the first PG injection							
	0	3	7	9	10	11	14	17
<u>2PG 11 days apart</u>								
All cows								
	(24)	4.3	1.9	3.8	4.6	5.6	6.6	0.4
Cows that conceived	(15)	5.5	2.3	4.4	5.2	6.4	7.7	0.4
Cows that did not conceive	(9)	2.2	1.3	2.7	3.7	4.3	4.8	0.3
<u>2PG 14 days apart</u>								
All cows	(20)	4.7	0.6	2.0	4.7	6.2	7.3	7.8 0.3
Cows that conceived	(14)	4.0	0.7	2.6	5.7	7.0	7.9	8.0 0.2
Cows that did not conceive	(6)	6.2	0.4	0.9	2.6	4.4	5.8	7.1 0.4
<u>Both treatments</u>								
Conceived	(29)	4.8	1.5	3.6	5.4	6.7	7.8	4.2 0.2
Did not conceive	(15)	3.8	0.9	2.0	3.3	4.3	5.2	3.0 0.4
S.E.		1.26	0.48	0.85	0.88	0.79	1.03	0.58 0.07
<u>Significance</u>	Treatment	N.S.	0.02	0.07	N.S.	N.S.	N.S.	0.001 N.S.
<u>of effects</u>	Pregnancy	N.S.	N.S.	0.07	0.02	0.01	0.03	N.S. N.S.
	Treatment x pregnancy	0.05	N.S.	N.S.	N.S.	N.S.	N.S.	N.S. N.S.

¹Number of cows in parentheses.

Table 8. Frequency of distribution (%) of primiparous cows according to their plasma progesterone levels at various days prior to the 2nd PG injection in Exp. 1.

Treatment	<u>2 PG injections</u>			<u>2 PG injections</u>			p ²
	<u>11 days apart (30)¹</u>			<u>14 days apart (25)</u>			
Plasma progesterone (ng/ml)	≤3.0	3.1-5.0	≥5.1	≤3.0	3.1-5.0	≥5.1	
<hr/>							
Days prior to 2nd injection -----	Percent -----			-----			
- 7				60	20	20	
- 4	60	13	27	20	28	52	.001
- 1	23	20	57	12	8	80	.002
0	10	37	53	8	12	80	.001

¹Number of cows in parentheses.

²Statistical significance of the difference in the frequency distribution between the treatments.

The conception rate of cows with various plasma progesterone levels prior to the second PG injection is shown in Table 9. The conception rate of cows with progesterone levels greater than 5.0 ng/ml was higher than that of cows with progesterone levels of 3.0 ng/ml, or less. Due to the small number of animals in the Table, the data were pooled with data of cows in Exp. 2 treated with two PG injections given 14 days apart (14PG/PG); the pooled data are shown in Table 30.

Discussion

Despite the longer interval between the two PG injections in the 14-day group, estrus manifestation following PG treatment was only slightly higher than that in the 11-day group. In view of the studies which indicated that a considerable proportion of animals do not respond to the second PG as a result of a slowly developing corpus luteum (1,17,19), it seems that in the present study the development of the C.L. in the 11-day group was sufficient.

Table 9. Conception rate (%) following the first postpartum A.I., of cows¹ with different plasma progesterone levels prior to the 2nd PG injection in Exp. 1.

Plasma progesterone (ng/ml)		2PG 11 days apart (24) ²			2PG 14 days apart (20)			P
		≤3.0	3.1-5.0	≥5.1	≤3.0	3.1-5.0	≥5.1	
Days prior to 2nd PG injection								
- 7	n				15	3	2	
	CR%				60%	100%	100%	N.S.
- 4	n	14	4	6	5	5	10	
	CR%	50%	75%	83%	60%	40%	90%	0.12
- 2	n	9	5	10	1	5	13	
	CR%	44%	80%	70%	0%	40%	85%	0.06
- 1	n	5	4	15	2	3	15	
	CR%	0%	100%	73%	50%	33%	80%	N.S.
0	n	2	9	13	1	2	17	
	CR%	0%	56%	77%	100%	50%	71%	N.S.

¹Only cows that were inseminated following the manifestation of estrus, were included in the analysis.

²Number of cows in parentheses.

The shorter interval from the second PG injection to estrus appearance in the 11-day group is in agreement with the findings by various authors that when PG is given on day 7 of the estrous cycle, the interval is shorter than on days 10-13 of the cycle (20,22,25,28,36). Most cows that responded to the first PG injection were administered the second injection, on day 7-8 of the cycle in the 11-day group and day 10-11 of the cycle in the 14-day group. Although conception rates were not significantly different (Table 2), significantly more cows conceived earlier after calving in the 14-day group (Tables 4-6).

Cows with a progesterone level of more than 5.0 ng/ml plasma had a higher conception rate than cows with lower progesterone levels (Table 9). Thus, the PG14/PG synchronization method seems preferable to the PG11/PG method in cows which have an estrus cycle length of 20 days or more. Out of 110 cows with known progesterone profiles which were given the PG14/PG treatment in Exps. 1 and 2, only five (4.5%) may have had a luteolysis during the three days prior to the second PG injection.

A comparison of three methods of estrus synchronization – Experiment 2

Summary

High yielding dairy cows (N=368) were allotted before their first postpartum insemination, according to parity and body condition score, into three treatment groups. Cows of the first group were given two PG injections 14 days apart (PG14/PG); cows of the second group were inserted with a PRID for 7 days and given a PG injection one day before PRID removal (PRID7/PG6); cows of the third group were given two PG injections 14 days apart and a PRID was inserted 8 days after the first injection and removed one day after the second injection (PG8-PRID7/PG6).

Observations for the detection of estrus were carried out 4 times daily during 6 days commencing two days after the second PG injection or one day after PRID removal. A.I. were carried out during the same 6 days; cows were given two fixed time A.I. and were reinseminated if seen in estrus during the following 5 days. Estrus synchronization treatments, observations for estrus detection and A.I. were carried out during 6 days out of every three weeks throughout the experiment. Cows that did not conceive following the first estrus synchronization were inseminated three or six weeks later if detected in estrus. Cows were examined for pregnancy by rectal palpation 45 days after A.I. and if diagnosed not pregnant they were resynchronized.

Manifestation of estrus following synchronization was similar in all treatments: During six days 72% of the cows were seen in standing estrus and another 6% in mounting activity. Mounting activity was encountered more in primiparous cows than in multiparous ones ($P < 0.03$). Body condition score was positively and significantly correlated with manifestation of estrus. In the PG14/PG group, but not in the PRID groups, less multiparous cows with a plasma progesterone level of < 3 ng/ml, on the day of the second PG injection, appeared in estrus than cows with higher levels of progesterone ($P < 0.04$). The interval from PG injection to beginning of estrous activity was affected by treatment and by the age of the cows. Among cows treated with PRIDs the percentage of cows manifesting estrus later than 84 hr after the second PG injection was 73% in primiparous cows, 59% in cows in their second or third lactation and 39% in cows in their 4th or later lactation ($P < 0.05$).

Plasma progesterone levels, during 14 days prior to the first A.I., differed significantly between treatments; primiparous cows had higher progesterone levels than multiparous ones and progesterone levels of cows that subsequently conceived were higher than those of cows that did not conceive.

Reproductive performance of primiparous cows was similar in all treatments; conception rates after the first and second A.I. of cows in estrus were 54% in the PG14/PG group and 44% in the PRID groups. In multiparous cows, conception rates following the first and second A.I. were 46% in the PG14/PG group, 50% in the

PRID7/PG6 group and 65% in the PG8-PRID7/PG6 group ($P<0.03$). Multiparous cows of the same groups had 113, 111 and 97 open days, respectively. Ninety days after calving the percent of multiparous cows pregnant in the same groups was 37%, 43% and 58%, respectively ($P<0.02$).

Three factors significantly affected the conception rate of cows in estrus following the first A.I. Cows of the PG14/PG group, but not of the PRID groups, that appeared in estrus 84 hr or later after the second PG injection had a significantly higher conception rate than cows that manifested estrus earlier. Among cows given the PG14/PG and PRID7/PG treatments conception rate of cows of the first three parities was 54% vs. 28% for cows of the fourth or later parity ($P<0.01$). In cows synchronized with the PG8/PRID7/PG6 treatment, on the other hand, the conception rate of cows of the 4th or later parity was 61% and similar to that of cows of the first three parities which reached 60%. In cows of the PG14/PG6 group, progesterone levels before A.I. were positively related to conception rate; cows with progesterone levels of <3.0 ng/ml, four days before the second PG injection, had a conception rate 33%, vs. 73% for cows with plasma progesterone of >5.1 ng/ml ($P=0.053$). In the PG8-PRID7/PG6 group, on the other hand, cows with progesterone levels of <3.0 ng/ml, four days before the second PG injection, had a conception rate of 71%. In the PG8-PRID7/PG6 group, plasma progesterone levels were not related to conception.

It is concluded that the positive effects on fertility of the PG8-PRID7/PG6 treatment is not the result of the PRID's contribution to peripheral plasma levels of progesterone.

It is suggested that (a) PRID has a direct, possibly local, effect on fertility; (b) synchronization agents should be classified according to their ability to affect fertility in addition to their ability to synchronize estrous cycles; (c) the efficacy of estrus synchronization methods depends on the levels of endogenous progesterone; and (d) it is impossible to recommend a "synchronization method of choice" which should be applied to all animals; a synchronization method should be chosen according to the level of progesterone in plasma.

Introduction

It was previously shown that the conception rate of cows synchronized by inserting a PRID for 7 days and administering PG one day prior to PRID removal (PRID7/PG6) was similar to that of untreated controls (9,16,29,35). It was also shown that when PRIDs are inserted at the beginning of the estrous cycle, the conception rate is higher than when PRIDs are inserted during the second part of the estrous cycle (9). Cows which were treated by two injections of PG and that were inseminated

after the detection of estrus were reported to have conception rates which were higher than, or equal to, those of untreated animals (24,27). The objective of experiment 2 was to compare three methods of estrus synchronization: (A) two injections of PG given 14 days apart; (B) PRID7/PG6; (C) two injections of PG given 14 days apart and a PRID inserted 8 days after the first PG and removed one day after the second PG injection. Thus, the difference between treatments A and C is the insertion of a PRID for 7 days, whereas the difference between treatments B and C is the first PG injection.

Experimental

High yielding dairy cows (N=368) were allotted into three treatment groups according to parity, body condition score determined 6 to 8 weeks after calving and calving date. The three groups of cows received the following estrus synchronization treatment.

(A) Two PG injections given 14 days apart; this group is designated PG14/PG or 14PG.

(B) A PRID inserted for 7 days and PG injected one day prior to PRID removal; this treatment is designated PRID7/PG6 or 7/6.

(C) Two PG injections given 14 days apart and a PRID inserted 8 days after the first PG and removed one day after the second PG; this treatment is designated PG8-PRID7/PG6 or 8-7/6.

Cows of treatment A received two fixed-time inseminations 72 and 96 hr following the second PG injection; cows of treatments (B) and (C) received two fixed-time inseminations 56 and 72 hr after PRID removal (80 and 96 hr after the second PG injection). Cows that were detected in estrus 6 hr or more prior to the first fixed-time insemination were not given the second fixed-time insemination. Cows that were diagnosed as not pregnant and cows that were occasionally seen in estrus outside the EDI weeks were resynchronized using, in all cows, the 7/6 method with a used PRID.

Results

Manifestation of estrus. During the EDI week, 72.3% of the cows given estrus synchronization treatment were detected in standing estrus. Another 5.7% were seen mounting other cows twice or more during a single observation session or once or more

Table 10. Percent of cows detected in estrus during Days 1-6¹ following the first postpartum estrus synchronization in Exp. 2.

Treatment Parity	PG14/PG		PRID7/PG6		PG8-PRID7/PG6	
	Primiparous (43) ²	Multiparous (81) ²	Primiparous (43) ²	Multiparous (80) ²	Primiparous (42) ²	Multiparous (79) ²
Type of estrus behavior	Percent in estrus					
Standing estrus	69.8	72.8	62.8	73.8	71.4	77.2
Mounting twice or more ³	9.3	3.7*	11.6	2.5*	7.1	5.1*
Mounting once during a single observation	4.6	4.9	4.6	3.8	7.1	6.3
No estrus behavior	16.3	18.5	20.9	20.0	14.3	11.4
% detected in estrus	79.1	76.5	74.4	76.3	78.6	82.3
% not detected in estrus	20.9	23.5	25.6	23.8	21.4	17.7

¹The 24 hr following PRID removal are regarded as Day 0.

²No. of cows in parentheses.

³Mounting twice or more during a single observation or once or more during two consecutive observations.

*Significantly lower than in primiparous cows P<0.03.

Table 11. Conception rate (%) of cows according to the type of estrus manifestation following the first estrus synchronization in Exp. 2.

Type of estrus manifestation	Primiparous cows (128) ¹	Multiparous cows (240) ¹	Total (368) ¹	P
----- Conception rate, % -----				
Standing estrus	49.4 (87)	54.2 (179)	52.6 (266)	N.S.
Mounting twice or more ²	58.3 (12)	66.7 (9)	61.9 (21)	N.S.
Mounting once	28.6 (7)	25.0 (12)	26.3 (19)	N.S.
No estrus behavior	13.6 (22)	15.0 (40)	14.5 (62)	N.S.
P	0.02	0.001	0.001	
Manifesting estrus (1+2)	50.5 (99)	54.8 (188)	53.3 (287)	N.S.
Not manifesting estrus (3+4)	17.2 (29)	17.3 (52)	17.3 (81)	N.S.

¹No. of cows in parentheses.

²Mounting twice more during a single observation or once or more during two consecutive observations.

during two successive observation sessions (Table 10). More primiparous cows manifested mounting estrus behavior than multiparous ones ($P < 0.03$). The conception rate of cows manifesting standing estrus and those manifesting several mountings during one or two consecutive sessions was higher than 50% (Table 11). On the other hand, cows that manifested a single mounting during one observation had, following the fixed-time insemination, a conception rate of 26% and those showing no estrus behavior had a conception rate of 15%. A cow which was observed to mount only once was, therefore, regarded as showing no estrus behavior.

Table 12. The relationship between plasma progesterone concentration on the day of the second PG injection, and manifestation of estrus following estrus synchronization in Exp. 2.

Treatment	Plasma progesterone level (ng/ml)						P
	≤3.0		3.1-5.0		≥5.1		
	n	% in estrus	n	% in estrus	n	% in estrus	
<u>PG14/PG</u>							
Primiparous cows	6	83	5	100	20	90	N.S.
Multiparous cows	16	56	17	94	21	76	0.04
<u>PRID7/PG6</u>							
Primiparous cows	8	88	4	100	14	79	N.S.
Multiparous cows	26	81	15	60	17	82	N.S.
<u>PG8-PRID7/PG6</u>							
Primiparous cows	1	100	8	88	25	76	N.S.
Multiparous cows	16	94	20	85	19	74	N.S.

In the 14PG group, only 56% of the multiparous cows which had a plasma progesterone level of 3 ng/ml or less, on the day of the second PG injection, manifested estrus following the first postpartum synchronization vs. 94% and 76% among cows with plasma progesterone level of 3.1-5.0 and >5.1 ng/ml, respectively ($P<0.04$). In primiparous cows of the 14PG group, the trend was similar, but the percent of cows that appeared in estrus in the low progesterone category was 83% (Table 12). In the 8-7/6 group, the relationship between plasma progesterone and manifestation of estrus, following synchronization, was different (Table 12), cows with low plasma progesterone levels had the highest rate of estrus manifestation (94%) and cows with high progesterone levels had the lowest rate of estrus manifestation (75%).

Table 13. Frequency distribution (%) of the interval between PG administration and estrus appearance¹ following the first synchronization treatment.²

	Primiparous cows				Multiparous cows			
	PG14/PG	PRID7/PG6	PG8-PRID7/PG6		PG14/PG	PRID7/PG6	PG8-PRID7/PG6	
Cows in estrus	34	32	33		62	61	65	
Hours following PG administration	----- Frequency distribution (% of cows in estrus) -----							
19 - 42	2.9	0	0		1.6	0	0	
43 - 66**	29.4	6.3	3.0		35.5	27.9	20.0	
67 - 90	52.9	59.4	48.5		43.5	52.5	43.1	
91 - 114	8.8	12.5	27.3		8.1	16.4	15.4	
115 - 138	2.9	12.5	18.2		1.6	0	10.8	
139 - 162	2.9	9.4	3.0		6.5	3.3	6.2	
163 - 186	0	0	0		3.2	0	3.1	
187 - 192	0	0	0		0	0	1.5	
49 - 96	82.4	65.6	63.6		74.2	86.9	67.7	

¹Cows standing when mounted, or mounting twice or more during a single observation, or once or more during two consecutive observations.

²In treatment PRID7/PG6 and PG8-PRID7/PG6, the PRID was removed 24 hr after PG administration.

**Factorial analysis of variance revealed a significant treatment effect ($P < 0.003$) and a significant parity effect ($P < 0.003$). The treatment x parity interaction was not significant.

Body condition score determined two weeks before insemination positively affected the manifestation of estrus following the first postpartum synchronization ($P < 0.04$, Table 25).

Multiparous cows appeared in estrus earlier, following PRID removal than primiparous cows (Table 13). However, within cows of the 14PG treatment, parity had only a slight effect on the interval to estrus appearance. On the other hand, within the two groups treated with PRIDs, the percentage of cows that appeared in estrus later than 84 hr after the PG injection was 73% in primiparous cows, 59% in cows in their 2nd or 3rd lactation, and 39% in cows in their 4th or later lactation (Fig. 2; $P < 0.05$). The percentage of cows that manifested estrus 49 to 96 hr (8 observation sessions) varied, in the different groups, between 64% and 87% (Table 13). In primiparous cows, the 14PG treatment caused the highest concentration of estrus manifestation -82%, whereas among multiparous cows, 87% of those given the 7/6 treatment manifested estrus within 48 hours.

Plasma progesterone levels. The plasma progesterone levels during 17 days prior to the first postpartum fixed-time A.I. are shown in Table 14 and Fig. 3. In cows given the 14PG treatment, progesterone levels which dropped following the first PG injection, started to increase 5 days after the first injection and reached a peak on the day of the second PG injection. In cows given the 8-7/6 treatment, progesterone levels were similar to those in the 14PG group during the first 8 days following the first PG injection; however, following PRID insertion the levels of progesterone doubled in two days and reached a plateau four days before the second PG injection. In cows given the 7/6 treatment mean progesterone levels increased slowly during the period described and reached a peak two days before the single PG injection; during these last two days, progesterone decreased slightly. One day after the PG injection, prior to PRID removal, plasma progesterone levels in primiparous cows with and without PRIDs were, respectively, 1.9 and 0.8 ng/ml, and in multiparous cows 1.5 and 0.8 ng/ml ($P < 0.02$).

Plasma progesterone levels differed significantly between years and in cows that conceived progesterone levels, 4 and 2 days prior to the second PG injection were 5.2 vs. 4.0 ($P < 0.02$) and 5.4 vs. 4.2 ($P < 0.05$) during year 2 vs. years 1+3, respectively.

The factorial analysis of progesterone levels reveals a significant difference between treatments during most of the preinsemination period, and a significant effect of parity during four days before the second PG injection. Between 9 and 2 days prior to insemination, the mean progesterone levels of cows that conceived were higher than those of cows that did not conceive (Table 14).

FIGURE 2

The Interaction between Parity and the Interval
between PG Injection and the Onset of Estrus

Table 14. Mean plasma progesterone concentrations (ng/ml) during the first synchronization treatment in Exp. 2.

Treatment	Days preceding the fixed-time A.I.								
	17 ²	14	12	9	7	5	3 ³	2	1
<u>Primiparous cows</u>									
<u>P614/P6</u>									
Cows that conceived (17) ¹	3.6	0.7	0.9	2.3	4.1	5.3	5.3	1.1	0.6
Cows that did not conceive (17)	3.4	0.8	0.8	2.1	3.3	4.2	5.0	0.6	0.4
<u>PRID7/P66</u>									
Cows that conceived (15)	3.6	4.2	3.7	4.4	6.4	6.1	5.2	1.8	-
Cows that did not conceive (16)	3.3	3.0	3.0	2.9	5.5	5.2	5.0	2.3	-
<u>P68-PRID7/P66</u>									
Cows that conceived (15)	3.3	0.4	1.0	2.5	5.7	5.7	6.2	2.1	0.5
Cows that did not conceive (20)	2.7	1.5	1.5	2.7	5.7	5.0	6.6	1.6	0.5
<u>Multiparous cows</u>									
<u>P614/P6</u>									
Cows that conceived (20)	2.7	0.8	1.0	2.5	4.0	4.7	5.6	1.0	0.7
Cows that did not conceive (34)	3.2	0.6	0.7	1.9	2.8	3.4	4.0	0.6	0.5
<u>PRID7/P66</u>									
Cows that conceived (29)	3.3	2.2	2.6	3.5	4.9	4.5	3.7	1.4	0.7
Cows that did not conceive (32)	2.2	2.4	2.6	3.0	4.2	3.9	4.0	1.5	0.5
<u>P68-PRID7/P66</u>									
Cows that conceived (31)	3.0	1.1	1.5	2.4	4.1	4.4	4.2	1.6	0.5
Cows that did not conceive (27)	3.1	1.0	1.3	2.2	4.3	4.9	5.0	1.5	0.5
<u>Significance of effects</u>									
Treatment	N.S.	0.0001	0.0001	0.0001	0.0001	0.07	0.02	N.S.	N.S.
Conception	N.S.	N.S.	N.S.	0.07	0.05	0.09	N.S.	N.S.	N.S.
Parity	N.S.	0.07	N.S.	N.S.	0.0001	0.0002	0.0001	0.01	N.S.

¹Number of cows in parentheses.

²Day of first PG injection in treatments P614/P6 and P68-PRID7/P66.

³Day of second PG injection.

FIGURE 3

Primiparous Cows

Multiparous Cows

Legend of Figure 3

Plasma progesterone concentrations of cows following the first postpartum synchronization treatment.

———— o ————— PG14/PG cows that conceived.

- - - - - o - - - - - PG14/PG cows that did not conceive.

———— o ————— PG8-PRID7/PG6 cows that conceived.

- - - - - o - - - - - PG8-PRID7/PG6 cows that did not conceive.

Table 15. Frequency distribution (%) of cows of various parities according to their plasma progesterone level 4 days prior to the second PG administration in Exp. 2¹.

Parity	1		2 & 3		4 and more		Difference between parities
	≤3.0	>3.1	≤3.0	>3.1	≤3.0	>3.1	
Plasma progesterone (ng/ml)	Frequency distribution %						P
PG14/PG	44	56 (34)	43	57 (44)	73	27 (15)	0.107
PRID7/PG6	11	89 (27)	29	71 (45)	73	27 (15)	0.001
PG8-PRID7/PG6	0	100 (34)	33	67 (43)	33	67 (15)	0.001
Difference between treatments, P	0.036		0.001			N.S.	

¹No. of cows in parentheses.

The effect of the synchronization treatments on plasma progesterone concentrations, 4 days prior to the second PG injection, varied between cows of different parities (Table 15). In the 14PG groups, 43% of the younger cows (first to third lactations) had plasma progesterone concentrations that were lower than 3 ng/ml, while 73% of the older cows had low progesterone levels. In the 7/6 group, 78% of the younger cows had a progesterone level higher than 3 ng/ml vs. only 27% of the older cows ($P < 0.001$). Within the 8-7/6 group, 67% of the multiparous cows had a progesterone level of more than 3 ng/ml vs. 100% in the primiparous cows ($P < 0.001$). The frequency distribution, between low and high progesterone levels, was significantly different in younger cows, but not in the older ones (Table 15).

Plasma progesterone levels during 9 days after the post-synchronization estrus did not differ between treatments.

Table 16. Frequency distribution (%) of the time of the LH peak in relation to the interval from the second PG administration to estrus in Exp. 2.

Time of LH peak in relation to onset of estrus	<u>Interval from 2nd PG to estrus, hr</u>			P
	48-72	73-90	91-156	
	16 cows	13 cows	15 cows	
--- Frequency of distribution, % ---				
LH before estrus	12.5	15.4	66.7	0.005
LH at estrus	37.5	53.8	26.7	NS
LH after estrus	50.0	30.8	6.7	0.03
P	0.1	NS	0.008	

Timing of the LH peak. In cows which manifested estrus within 90 hr following the second PG injection, more than 80% of the LH peaks occurred at estrus or after estrus (Table 16). In cows which manifested estrus later than 90 hr after the second PG injection only 33% of the LH peaks occurred at or after estrus and 67% appeared before estrus ($P < 0.008$).

Conception rate. During the first EDI week between 42% and 44% of the primiparous cows in the three groups conceived (Table 17). However, whereas in the 14PG and 7/6 groups conception rate from the fixed-time A.I. was similar to the conception rate from the later inseminations, in the 8-7/6 group conception rate was only 24% following the fixed-time A.I. but 62% following the later inseminations. Following the second and all inseminations conception rate was approximately 10 percentage points higher in the 14PG group than in the two other groups. When only inseminations following the detection of estrus are considered, primiparous cows attained a conception rate which was 16 percentage points higher than that of the other groups - 58% vs. 42%.

Among multiparous cows, the effect of the three synchronization treatments on the conception rate was diametrically opposed to their effect in primiparous ones (Table 18). During the first EDI week, conception rate of cows in the 8-7/6 group was 58% vs. 36% in the 14PG group ($P < 0.02$); the conception rate of cows detected in estrus was 66% and 42% for the same groups, respectively ($P < 0.02$). Following the second insemination, the conception rate in the 8-7/6 group was still the highest; following all second A.I., the conception rate in this group was 58% vs. 34% in the 7/6 group ($P < 0.05$). Following all inseminations, the conception of cows given the 8-7/6 treatment remained significantly higher ($P < 0.03$), in comparison with that of the other two treatments.

Breeding interval, open days and pregnancy rates. In primiparous cows, the average breeding interval and number of open days are the smallest in the 14PG group and the largest in the 7/6 group. The differences, however, are not statistically significant (Table 19). In multiparous cows the mean breeding interval and the number of open days are lowest in the 8-7/6 group. Multiparous cows given the 14PG treatment had significantly longer breeding intervals and open days.

In multiparous cows, the number of synchronizations and the number of inseminations required per conception were lower in the 8-7/6 group, but the difference was not statistically significant. In primiparous cows, the opposite occurred, but again the differences were not statistically significant (Table 19).

Table 17. Conception rate (%) of primiparous cows in Exp. 2.

Treatment	PG14/PG	PRID7/PG6	PG8-PRID7/PG6	P
No. of cows	43	43	42	
----- Conception rate % -----				
Following the first postpartum A.I.				
of cows that:				
Conceived during EDI ² week	44.2 (43) ¹	41.9 (43)	42.9 (42)	N.S.
Conception of cows in estrus	55.9 (34)	46.9 (32)	48.5 (33)	N.S.
Conceived from fixed-time A.I.	39.5 (43)	30.2 (43)	23.8 (42)	N.S.
Conceived from A.I. during Days 4-6	33.3 (6)	41.7 (12)	61.5 (13)	N.S.
Following the second postpartum A.I.				
of cows that:				
Returned in estrus 3 wk after first A.I.	66.7 (9)	44.4 (9)	50.0 (12)	N.S.
Returned in estrus later	50.0 (4)	60.0 (5)	0.0 (1)	N.S.
Were resynchronized and manifested estrus	20.0 (5)	20.0 (10)	25.0 (8)	N.S.
Were resynchronized and did not manifest estrus	33.3 (3)	0.0 (1)	0.0 (1)	N.S.
All second A.I.	47.6 (21)	36.0 (25)	36.4 (22)	N.S.
All second A.I. of cows in estrus	50.0 (18)	37.5 (24)	38.1 (21)	N.S.
First and second A.I. of cows in estrus	53.8 (52)	42.9 (56)	44.4 (54)	N.S.
All A.I.				
All cows	50.0 (76)	39.4 (99)	39.8 (88)	N.S.
Cows in estrus	57.8 (64)	41.7 (84)	42.3 (78)	0.099
No. culled after 1st A.I.	3	0	2	

¹Number of inseminated cows in parentheses.

²EDI-estrus detection and insemination.

Table 18. Conception rate (%) of multiparous cows in Exp. 2.

Treatment	PG14/PG	PRID7/PG6	PG8-PRID7/PG6	P
No. of cows	81	80	79	
----- Conception rate % -----				
Following the first postpartum A.I.				
of cows that:				
Conceived during EDI ² week	35.8 (81) ¹	46.3 (80)	58.2 (79)	0.02
Conception of cows in estrus	41.9 (62)	55.7 (61)	66.2 (65)	0.02
Conceived from fixed-time A.I.	25.9 (81)	36.3 (80)	36.7 (79)	N.S.
Conceived from A.I. during Days 4-6	50.0 (16)	61.5 (13)	68.0 (25)	N.S.
Following the second postpartum A.I.				
of cows that:				
Returned in estrus 3 wk after first A.I.	55.6 (18)	47.6 (21)	72.7 (11)	N.S.
Returned in estrus later	42.9 (7)	0.0 (3)	50.0 (6)	N.S.
Were resynchronized and manifested estrus	52.2 (23)	33.3 (9)	54.6 (11)	N.S.
Were resynchronized and did not manifest estrus	0.0 (2)	12.5 (8)	33.3 (3)	N.S.
All second A.I.	50.0 (50)	34.1 (41)*	58.1 (31)	0.11
All second A.I. of cows in estrus	52.1 (48)	39.4 (33)	60.7 (28)	N.S.
First and second A.I. of cows in estrus	46.4 (110)	50.0 (94)	64.5 (93)	0.03
All A.I.				
All cows	39.4 (170)	44.5 (155)	55.1 (127)	0.03
Cows in estrus	47.4 (133)	52.9 (123)	61.1 (108)	0.10
No. culled after 1st A.I.	2	2	2	

¹Number of inseminated cows in parentheses.

²EDI-estrus detection and insemination.

*Significantly lower than that of the PG8-PRID7/PG6 group (P<0.05).

Table 19. Mean interval from calving to first postpartum A.I., breeding interval, open days and no. of A.I. per conception in Exp. 2.

Parity	Primiparous cows				Multiparous cows			
Treatment	PG14/PG	PRID7/PG6	PG8-PRID7/PG6	SE	PG14/PG	PRID7/PG6	PG8-PRID7/PG6	SE
No. of cows	43	43	42		81	80	79	
No. of cows culled	5	4	7		14	11	9	
Interval from calving to first A.I., days								
All cows	95.4	94.7	94.6	±1.4	74.8	74.7	75.2	±1.1
Pregnant cows	94.9	94.8	93.0	±1.3	74.9	75.1	75.5	±1.2
Breeding interval, days								
All cows	38.6	54.4	55.1	±9.2	58.1 ^A	48.5 ^{AB}	34.1 ^B	±6.9
Pregnant cows	28.2	46.4	36.2	±8.0	38.1 ^A	35.3 ^{AB}	21.7 ^B	±5.5*
Open days								
All cows	140.0	149.1	149.4	±9.4	132.9 ^A	123.3 ^{AB}	109.3 ^B	±6.9
Pregnant cows	123.0	141.3	129.2	±8.1	113.0	111.0	97.1	±5.6*
No. of synchronizations/cow								
All cows	1.30	1.47	1.45	±0.10	1.49	1.45	1.27	±0.08*
Pregnant cows	1.26	1.43	1.31	±0.10	1.38	1.43	1.20	±0.08*
No. of EDI weeks/conception								
All cows	1.77	2.30	2.10	±0.20	2.10 ^A	1.94 ^{AB}	1.61 ^B	±0.13
Pregnant cows	1.71	2.10	1.86	±0.18	1.86 ^A	1.90 ^{AB}	1.49 ^B	±0.12
No. of A.I./conception								
All cows	3.09	4.02	3.90	±0.32	3.72	3.41	3.09	±0.21
Pregnant cows	2.97	3.72	3.54	±0.28	3.45	3.30	2.90	±0.21

A,B Means having different superscripts are significantly different $P \leq 0.05$.

*Significance of difference between means: $0.05 < P < 0.01$.

The frequency distribution of the breeding intervals of the pregnant cows is presented in Table 20, and the frequency of open days in Table 21. In primiparous cows, the frequency distribution of open days was significantly different between the 14PG group and the PRID7/PG group ($P < 0.002$), between the 8-7/6 group and the 7/6 group ($P < 0.05$) but not between the 14PG and 8-7/6 groups. The 120- and 150-day pregnancy rate is similar for primiparous cows of all groups (Table 22), however the 180- and 210-day pregnancy rate is considerably better in the 14PG group.

The number of multiparous cows with a breeding interval of 30 days or less was significantly larger in the 8-7/6 treatment group than in the 14PG group (Table 20); 66% of the cows of the 8-7/6 treatment conceived within 90 days of calving vs. 45% of the 14PG group (Table 21). The frequency distribution of open days is significantly different between the 8-7/6 group and the two other groups ($P < 0.05$). In the 8-7/6 group, 58% of the cows were pregnant 90 days after calving (Table 22) vs. 37% in the 14PG group ($P < 0.02$). The respective figures 120 days after calving are 68% and 49% ($P < 0.05$). The performance of cows of the 7/6 group was intermediate between that of the two other groups.

Factors affecting conception rate

Interval to estrus. The conception rates of cows treated with PRIDs were not related to the interval between PG injection and the beginning of estrous behavior (Table 23). On the other hand, the conception rates of cows and heifers treated with two injections of PG in Experiments 1, 2 and 4 were significantly higher in animals which manifested estrus 84 or more hours after the second PG injection than in animals with shorter intervals between PG injection and estrous behavior. The data in Table 23 present conception rates of cows following the first synchronization only; subsequent estrus synchronizations were carried out by the 7/6 method. In heifers, subsequent synchronizations were carried out also by two injections of PG. Thus, the results presented in Table 23 are, in the case of heifers, for all synchronized inseminations.

Parity. Among cows given the 8-7/6 treatment, parity had no effect on conception rate (Table 24). On the other hand, in the two other groups, conception rate of cows in their 4th or later lactations was significantly lower (28%) than of cows in their first or second and third lactation (54%; $P < 0.01$). A CATMODE analysis of all the data also reveals that the effect of parity is significant ($P < 0.05$). Parity did not affect the time interval between PG injection and the appearance of estrus.

Table 20. Frequency distribution (%) of the breeding interval of pregnant cows in Exp. 2

Parity	Primiparous cows				Multiparous cows			
	Treatment		No. of pregnant cows		Treatment		No. of pregnant cows	
	PG14/PG	PRID7/PG6	PG8-PRID7/PG6		PG14/PG	PRID7/PG6	PG8-PRID7/PG6	
	38	39	35		67	69	70	
Breeding interval, days	Frequency distribution, %							
≤ 30*	65.8	56.4	68.6	58.2	68.1	77.1		
31 - 60	7.9	7.7	0.0	7.5	5.8	4.3		
61 - 90	21.1	15.4	20.0	22.4	13.0	11.4		
91 - 120	0.0	2.6	0.0	3.0	2.9	1.4		
121 - 150	5.3	12.8	5.7	7.5	2.9	5.7		
≥ 151	0.0	5.1	5.7	1.5	7.2	0.0		

* χ^2 analysis revealed a significant difference in multiparous cows only ($P < 0.06$).

Table 21. Frequency distribution (%) of open days of pregnant cows in Exp. 2.

Parity	Primiparous cows ¹				Multiparous cows ²			
	PG14/PG	PRID7/PG6	PG8-PRID7/PG6	PG14/PG	PRID7/PG6	PG8-PRID7/PG6		
Treatment								
No. of pregnant cows	38	39	35	67	69	70		
	----- Frequency distribution, % -----							
≤ 90	21.0	15.4	17.1	44.7	49.3	65.7		
91 - 120	39.5	35.9	48.6	14.9	21.7	11.4		
121 - 150	10.5	12.8	5.7	19.4	8.7	8.6		
151 - 180	18.4	5.1	11.4	10.4	10.1	8.6		
181 - 210	5.3	12.8	5.7	4.4	1.4	4.3		
≥ 211	5.3	17.9	11.4	6.0	8.7	1.4		

^{1,2}The distribution of open days is significantly different between treatments ($P < 0.006$ and $P < 0.02$ for primiparous and multiparous cows, respectively).

Table 22. Pregnancy rate¹ (%) at various intervals after calving in Exp. 2.

Parity	Primiparous cows ¹				Multiparous cows ²			
	PG14/PG	PRID7/PG6	PG8-PRID7/PG6		PG14/PG	PRID7/PG6	PG8-PRID7/PG6	
Treatment								
No. of cows	43	43	42		81	80	79	
Interval after calving, days	Percent pregnant							
90**	18.6	14.0	14.3		37.0	42.5	58.2	
120*	53.5	46.5	54.8		49.4	61.3	68.4	
150	62.8	58.1	59.5		65.4	68.8	75.9	
180	79.1	62.8	69.0		74.0	77.5	83.5	
210	83.7	74.4	73.8		77.8	78.8	87.3	
≥ 211	88.4	90.7	83.3		82.7	86.3	88.6	
Percent culled	11.6	9.3	16.7		17.3	13.8	11.4	

¹Percent of cows pregnant.

*,**x² analysis revealed a significant difference between treatments in multiparous cows only.
(*P<0.05, **P<0.02).

Table 23. The relationship between the interval from the time of PG injection to estrus appearance and conception rate in cows and heifers treated with either PRID and PG vs. PG only in Exps. 1, 2 and 4^{1,2}.

Synchronization treatment	Interval from PG injection to estrus, hr					
	≤ 66		72 - 78		≥ 84	
	No. of animals	Conception rate, %	No. of animals	Conception rate, %	No. of animals	Conception rate, %
<u>Cows</u>						
PRID7/PG6 and PG8-PRID7/PG6 (Exp.2)	33	57.6	42	64.3	116	53.4
						N.S.
<u>Heifers</u>						
PG11/PG and PG14/PG (Exps.1 & 2)	62	40.3	39	53.8	62	64.5
						0.05
PG12/PG (Exp.4)	342	57.6	69	56.5	103	74.8
						0.005

¹In cows following the first postpartum synchronization only, in heifers following all synchronizations.

²SAS Catmode analysis indicates a parity effect ($P < 0.03$) and a treatment x interval interaction ($P < 0.07$).

Table 24. The relationship between parity, synchronization treatment and conception rate¹ in Exp. 2².

Treatment	PG14/PG		PRID7/PG6		PG8-PRID7/PG6	
	No. of cows	Conception rate, %	No. of cows	Conception rate, %	No. of cows	Conception rate, %
<u>Parity</u>						
1	34	58.8	32	46.9	33	48.5
2 and 3	48	45.8	46	65.2	47	68.1
4 and more	24	28.6	25	26.7	18	61.1

¹Percent of cows pregnant after insemination following the manifestation of estrus.

²SAS Catmode analysis indicates a parity effect ($P<0.05$) and a treatment x parity interaction ($P<0.08$).

Body condition score. No significant differences were found between conception rates of cows in estrus which had different body condition scores (Table 25). However, the conception rate of all cows with a body condition score of 1.75 was significantly lower than that of cows with a body condition score of 2.50 or more ($P<0.02$).

Plasma progesterone. As already mentioned, plasma progesterone levels during days 7 to 3 before A.I. were higher in cows that conceived than in cows that did not conceive. Cows of the 14PG group which had plasma progesterone levels of 3.0 ng/ml or less two or four days before the second PG injection had a conception rate of 39% and 33%, respectively, whereas cows with progesterone levels of more than 5.0 ng/ml had a conception rate of 76% and 73%, respectively ($P<0.01$ and $P=0.05$)(Table 26). However, out of 18 cows which reached a ≥ 5.1 ng/ml level only on the day of the second PG injection only 5 (27%) conceived. Among cows which had a plasma progesterone level of <3.0 ng/ml four days before the second PG injection, cows of the 8-7/6 group had a significantly higher conception rate than cows of the 14PG group ($P<0.05$). In the 8-7/6 treatment, cows with a higher progesterone level did not have a higher conception rate (Table 26). Cows of both PRID treatments with a medium level of

Table 25. The relationship between body condition score, the manifestation of estrus and conception following the first synchronization in Exp. 2.

Body condition score	No. of cows	Manifestation of estrus (%)	Conception rate	
			% of all cows ¹	% of estrous cows
< 1.75	162	72.8	40.1*	51.7
2.00 - 2.25	241	79.7	46.5	55.2
2.50 - 2.75	108	80.6	52.8	59.8
> 3.00	42	92.9	54.8	56.4
P		<0.04	N.S.	N.S.

¹Sixteen cows, not seen in estrus, which conceived following a fixed-time A.I. are included in the results.

*Conception rate of cows with a score of <1.75 is significantly lower than that of cows with a score of >2.50 ($P<0.02$).

progesterone four days prior to the second PG injection had a conception rate of only 38% vs. more than 60% in cows with low or high progesterone ($P<0.005$). The data presented in Table 27 indicate that 33 cows of the two PRID treatments which, during the four days before the PG injection, changed their plasma progesterone concentration either from low levels to medium or high levels, or from high levels to medium or low levels, had a conception rate of 91%; the equivalent 23 cows in the 14PG group had a conception rate of only 35% ($P<0.005$).

Conception rates of primiparous cows and cows in their 2nd or 3rd lactation treated with PRIDs that had, 4 days prior to the second PG, a plasma progesterone level lower than 3 ng/ml, were higher than those of cows of the same parities treated with PG only. In cows in their 4th or later lactation, only cows given the 8-7/6 treatment had a high conception rate (Table 28).

Effect of year. It was previously mentioned that plasma progesterone levels during the second year of the experiment were significantly higher than those of the two other years. The results in Table 29 indicate that in multiparous cows, the effect of the synchronization treatments during the second year of the experiment were

Table 26. The relationship between plasma progesterone concentration, prior to the first postpartum A.I., and conception rate (%) in cows that manifested estrus within three days following estrus synchronization in Exp. 2.

Days prior to second PG administration	Plasma progesterone level (ng/ml)			P
	≤3.0	3.1 - 5.0	≥5.1	
----- Conception rate, % -----				
<u>On day of PG administration</u>				
PG14/PG	43 (14)	43 (21)*	53 (34)	N.S.
PRID7/PG6	50 (28)	77 (13)	48 (25)	N.S.
PG8-PRID7/PG6	56 (16)	75 (24)	45 (33)	0.08
<u>Two days before PG administration</u>				
PG14/PG	39 (18)	34 (32)	76 (21)	0.01
PRID7/PG6	48 (23)	61 (18)	61 (28)	N.S.
PG8-PRID7/PG6	58 (19)	59 (22)	55 (33)	N.S.
<u>Four days before PG administration</u>				
PG14/PG	33 (36)**	52 (27)	73 (11)	0.053
PRID7/PG6	52 (21)	31 (16)	68 (31)	0.06
PG8-PRID7/PG6	71 (17)	42 (26)	63 (30)	N.S.

¹Number of inseminated cows in parentheses.

*Significantly lower than cows of the PG8-PRID7/PG6 treatment, $P < 0.05$; ** $P < 0.02$.

diametrically opposed to that of the two other years. In the 14PG treatment, the conception rate, following the first synchronization, was almost twice as high and the percent of negative pregnancy diagnoses twice as low during the second year, in comparison with the two other years. In the two PRID treatments, the opposite was true: conception rate was significantly higher and the percent of negative pregnancy diagnoses significantly lower during years 1 and 3, in comparison with year 2. The conception rate of cows of the 7/6 and 8-7/6 treatment were, during the second year, 37.5% and 42.9% respectively, and during the two other years 62.2% and 72.6%, respectively. In primiparous cows, the difference between years was small.

Table 27. Conception rate (%) following the first A.I. in relation to changes in plasma progesterone levels from day 4 before to day of second PG injection in Exp.2¹.

Treatment	Type of change in plasma progesterone levels ²						P
	Low increased or High decreased		Low, Medium and High unchanged		Medium to Low and Medium to High		
	n	%	n	%	n	%	
PG14/PG	23	35	27	52	20	55	N.S.
PRID7/PG6	18	94	35	40	12	25	<0.005
PG8-PRID7/PG6	15	87	44	55	14	36	<0.04
P		0.0026		N.S.		N.S.	

¹SAS Catmode analysis indicates a significant effect of the type of change in plasma progesterone ($P < 0.004$) and a significant treatment x progesterone change interaction ($P < 0.002$)

²Low - ≤ 3.0 ng/ml; Medium - 3.1-5.0 ng/ml; High - ≥ 5.1 ng/ml.

Table 28. Conception rate (%) of cows¹ of different parities in relation to their plasma progesterone level 4 days before the second PG administration in Exp. 2.

Parity	<u>1</u>		<u>2 & 3</u>		<u>4 and more</u>	
Plasma progesterone (ng/ml)	≤3.0	≥3.1	≤3.0	≥3.1	≤3.0	≥3.1
<u>Treatment</u>	----- Conception rate, % -----					
PG14/PG	38(13) ²	67(18)	27(15)	50(18)	38(8)	50(2)
PRID7/PG6	67(3)	47(19)	70(10)	62(26)	25(8)	50(2)
PG8-PRID7/PG6	-	50(26)	75(12)	57(21)	60(5)	56(9)
P between treatments	-	N.S.	0.03	N.S.	N.S.	N.S.

¹Only cows inseminated following estrus were included in the analysis.

²No. of cows in parentheses.

Table 29. Conception rate of multiparous cows¹ following the first postpartum synchronization in different years of Exp. 2.

Treatment Year	<u>PG14/PG</u>			<u>PRID treatments²</u>		
	1+3	2	P	1+3	2	P
No. of cows	46	16		96	30	
Conception rate, %	34.8	62.5	0.06	67.7	40.0	0.01
Returned in estrus, %	32.6	18.8	N.S.	19.8	23.3	N.S.
Negative P.D. ³ , %	32.5	18.8	N.S.	12.5	36.7	0.01

¹Only cows that were inseminated following estrus were included in the analysis.

²The results of the PRID7/PG6 and the PG8-PRID7/PG6 treatments were similar and were, therefore, combined.

³Negative P.D. - cows that did not return in estrus during the EDI weeks, but were found non-pregnant by rectal palpation.

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The processing of the data was completed on 12/12/70. The data was processed with the same program as was used for the 11/12/70 data. The data was processed with the same program as was used for the 11/12/70 data. The data was processed with the same program as was used for the 11/12/70 data.

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Discussion

The percentage of cows that appeared in estrus following synchronization (Table 10) is in agreement with other studies where one injection of PG during the luteal phase, two injections of PG or PRID in conjunction with a luteolytic agent, were used to synchronize estrous cycles (25,30,38).

The data presented in Table 12 indicate that appearance in estrus of multiparous cows was significantly decreased in cows with low plasma progesterone levels which were treated with PG alone, but not in the groups treated with PRIDs. Furthermore, in the 8-7/6 group, more cows with a low level of progesterone appeared in estrus than cows with a high level of progesterone. This difference between treatments may suggest that treating cows with PRIDs may have additional effect(s) to that of increasing plasma progesterone levels. Graves et al. (13) have previously reported that heifers with low progesterone levels on the day of the second PG injection have a significantly lower rate of estrus manifestation.

The reason why PRID insertion delayed the appearance in estrus of younger, mainly primiparous, cows (Table 13; Fig. 2) is at present unknown. This difference between parities did not occur among cows given the 14PG treatment. In this treatment, the interval to estrus is slightly shorter than in the primiparous cows of Exp. 1 given the 14PG treatment. As 66% of the heifers in Exp. 4 appeared in estrus within 66 hr and 58% of the primiparous cows in Exp. 1 given the PG11/PG treatment appeared in estrus during the same period vs. only 35% of the cows given the 14PG treatment, it is plausible to conclude that the data collected in this report do not indicate that parity has an effect on the interval to estrus in cows treated with PG only.

It was previously reported that inseminations given later than 24 hr after the onset of estrus or more than 4 h prior to estrus resulted in low conception rates (15,35). From the distribution of the interval from PG administration to estrus appearance (Table 13), it is evident that if only two fixed-time inseminations are given, about 25% and 30% of the cows in the 14PG and PRID-treated groups, respectively, must be expected to attain low conception rates. Therefore, carrying out visual observations of cows for signs of estrus will increase the percentage of cows that will conceive during the immediate post-synchronization period. Whether cows should also be given a fixed-time insemination, depends on economic considerations. In the present experiment, only 17% of the cows not detected in estrus conceived (Table 11). This result should be weighed against the additional expense resulting from carrying out fixed-time inseminations.

Significantly more multiparous cows of the 8-7/6 treatment conceived than cows of the 14PG treatment both following the first and all A.I. (Table 18). Following the second A.I., more cows of the 8-7/6 group conceived than cows of the PRID7/PG group ($P < 0.05$). This occurred both after spontaneously returned estrus and resynchronization. In primiparous cows the conception rate in the 14PG group were higher than those of the other two groups, but the differences were not statistically significant. Thus, the 14PG treatment gave satisfactory conception rates in primiparous but not in multiparous cows, whereas the 8-7/6 treatment gave good results in multiparous but not in primiparous cows. The greatest difference between treatments was in cows in their 4th or later parity where first A.I. conception rate of cows in estrus given the 8-7/6 treatment was 61.1% vs. less than 30% in the two other treatments (Table 24). Older cows of the 14PG and 7/6 groups had a significantly lower ($P < 0.01$) conception rate (27.6%) than younger cows (54.4%) of the same treatments.

Very few comparisons were previously carried out between synchronization methods based on PG only vs. progesterone or progestagen, in conjunction with PG (5,6,14,29,35,37). Studies in which only fixed-time inseminations were carried out are difficult to interpret since the fertility results may reflect the variation in the appearance of estrus (6,14,29,35). In one experiment (5), in which dairy cows were treated with norgestomet and PG vs. two PG injections and inseminated following estrus detection, conception rates were 35.6% and 45.9%, respectively (N.S.).

It was previously shown that in unsynchronized cows the preovulatory LH surge appears prior to the onset of estrus only in 11% of the animals (32). In another study, the range of the interval between the onset of estrus and the beginning of the LH surge was between -8 and +9 hr (3). In another, very precise study the onset of the LH surge after PG treatment always followed the onset of estrus by 1 to 2 hr (40). Similar results were obtained in the present experiment for cows which appeared in estrus up to 90 hr following the second PG injection (Table 16). However, in 67% of the cows, which appeared in estrus later than 90 hr after the PG injection, the LH surge appeared prior to the onset of estrus. This may suggest that less follicular development is required for the induction of the LH surge than for the appearance of estrus. Thus, in some synchronized animals, the full coincidence of the LH surge and onset of estrus may be disturbed.

The continuous increase in plasma progesterone levels during 9 days prior to the second PG injection, in cows given the 14PG treatment, reflects the growth of the corpus luteum and its increased progesterone secretion. In cows which were inserted a PRID 8 days after the first PG, progesterone levels increased considerably during the two days following PRID insertion reaching a plateau four days before the second PG. The further increase in progesterone levels was possibly prevented by a feedback mechanism caused by the high level obtained in plasma on or prior to Day 10 (2,12,39). In cows given the 7/6 treatment the PRID was inserted into cows at various stages of the estrous cycle, and its effect on plasma progesterone concentrations varied accordingly. In cows which were on Day 5 to 11 of the cycle on the day of insertion, progesterone levels were increased while cows which were on Days 13 to 18 underwent luteolysis, following PRID insertion, and their progesterone levels decreased. Thus, the mean progesterone profile of cows in this group is the result of cows being at different stages of the estrous cycle.

The reason for more younger cows having higher progesterone levels than older cows (Tables 14 and 15) is at present unknown. Younger cows may have either a higher progesterone production, a lower progesterone clearance, or both.

In agreement with previous studies (10,11,18,33), mean plasma progesterone levels prior to the first A.I. were higher in cows that conceived than in cows that did not conceive (Table 14). In the 14PG treatment, cows with progesterone levels of more than 5.0 ng/ml two and four days prior to the second PG injection attained a higher conception rate than cows with low progesterone levels (Table 26). Cows of the 14PG group which reached a high progesterone level only within the last two days prior to the second PG injection had a conception rate of only 28%, whereas cows which reached the high progesterone levels between day 4 and day 2 prior to the PG injection had a conception rate of 78% ($P < 0.02$). Maximal progesterone levels coincided with maximal conception rate in the 14PG group, but not in the 8-7/6 group (Table 26). This result, as well as the fact that cows of the 8-7/6 group with lower than 3.0 ng/ml plasma progesterone levels had a higher conception rate than cows of the 14PG group with the same progesterone values, suggests again that, in addition to increasing peripheral plasma progesterone levels, PRID is affecting another mechanism. One possibility is that PRID directly affects the reproductive tract. Another difference between the PRID and PG only treatments is that in the PRID treatments the decrease in progesterone levels following the second PG injection was slower (Fig. 3 and Table 14).

The data in Table 14 indicate that seven days after PRID insertion the level of progesterone in cows with PRID is less than 1.0 ng/ml plasma higher than in cows without PRIDs. A further support for the contention that cows with PRIDs differ from cows without PRIDs with the same progesterone levels is the data shown in Table 27 which indicates that cows with PRIDs have the best conception rate (91%) when their plasma progesterone concentration, during the four days prior to the PG injection, decreases or increases. Similar changes in plasma progesterone levels in the 14PG group resulted in a conception rate of 35% only. The similarity between the two PRID groups in conception rates in relation to plasma progesterone levels (Tables 26 and 27) and in relation to year of experiment (Table 29), as opposed to the very different conception rate of the 14PG group in relation to the same factors, further supports this contention. It is not yet clear why cows of the PRID groups with medium levels of progesterone four days prior to the second PG injection have a significantly lower conception rate than cows with low and high levels.

The results of Exp. 2, therefore, indicate that inserting PRIDs increased the conception rate of cows with low levels of progesterone but not that of cows with high levels of progesterone. Conception rates of cows in the PRID groups which had high levels of progesterone were lower than those of cows in the 14PG group with the same levels of progesterone. Conception rates of cows in the 14PG group which had a high levels of progesterone two days before the second PG injection were 76% (n=21). Thus, the efficacy of an estrus synchronization method depends on the level of endogenous progesterone. The method based on two injections of PG gives very good results in cows with high progesterone levels. In Table 30, the results of the 14PG treatment were pooled with the data from Exp. 1 in which cows were given either a PG11/PG or a 14PG treatments. A Catmode analysis on more than 110 cows given two PG injections revealed that progesterone levels had a highly significant ($P < 0.0001$) effect on conception rate which was approximately 80% in cows with more than 5.0 ng/ml of progesterone two and four days before the second PG injection. However, the two PG methods give poor results in cows with low progesterone levels. In these cows, methods based on PRIDS, significantly increased conception rate to approximately 60%. The advantage of the 8-7/6 method over the 7/6 method probably results from the fact that the 8-7/6 method prevents the occurrence of luteolysis during the period of PRID insertion. In primiparous cows which had higher progesterone levels than multiparous ones, the reproductive performance of the 14PG group was better than that of the two PRID-treated groups. The different conception rates between treatment groups in different years, was also related to plasma progesterone concentrations. The conception rate of multiparous cows given the two PRID treatments was significantly lower during the second year of the experiment than that of the two

Table 30. Relationship between plasma progesterone concentration prior to the first postpartum A.I. and conception rate in cows which were synchronized with two PG injections¹ (summary from Exps.1 and 2)².

Days prior to second PG administration	Plasma progesterone level (ng/ml)		
	≤3.0	3.1 - 5.0	≥5.1
----- Conception rate, % -----			
<u>On day of PG administration</u>			
Exp. 1	33.3 (3) ³	54.5 (11)	73.3 (30)
Exp. 2	42.9 (14)	42.9 (21)	52.9 (34)
Total	41.2 (17)	46.9 (32)	62.5 (64)
<u>Two days before PG administration</u>			
Exp. 1	40.0 (10)	60.0 (10)	78.3 (23)
Exp. 2	38.9 (18)	34.4 (32)	76.2 (21)
Total	39.3 (28)	40.5 (42)	77.3 (44)
<u>Four days before PG administration</u>			
Exp. 1	52.6 (19)	55.5 (9)	87.5 (16)
Exp. 2	33.3 (36)	51.9 (27)	72.7 (11)
Total	40.0 (55)	52.8 (36)	81.5 (27)

¹Only cows that were inseminated following detection of estrus were included in the analyses.

²SAS Catmode analysis indicated a significant effect of plasma progesterone concentration ($P<0.0001$) and no progesterone x day interaction.

³No. of cows in parentheses.

other years. In the 14PG treatment the opposite was true, conception rate was almost twice as high during the second year of the experiment. In cows that conceived, plasma progesterone levels 4 and 2 days prior to the second PG injection were, during year 2 vs. years 1+3, 5.2 vs. 4.0 ($P<0.02$) and 5.4 vs. 4.2 ($P<0.05$), respectively.

The above mentioned discussion leads to the conclusion that as far as PG and PRID synchronization methods are concerned, the merit of any method is not absolute

but depends on environmental conditions for the population as a whole and for the individual cow. Our data suggest that plasma progesterone level prior to A.I. is the most important condition in determining the type of synchronization method required.

The data of this experiment suggest that PRIDs have a direct effect on conception not related to its contribution to the concentration of peripheral plasma progesterone which is rather small. It is therefore suggested that estrus synchronizing agents may have two different effects on the reproductive system of the cow: (a) a synchronization effect only, by which the administration of an agent causes the synchronization of estrous cycles; and (b) a direct effect on fertility not related to its effect on synchronization. $\text{PGF}_{2\alpha}$ is an 'a' type agent, whereas PRID is a 'b' type agent. The 'b' type agent can act under certain conditions as an 'a' agent as well. It is not yet known whether $\text{PGF}_{2\alpha}$ or norgestomet can act as 'b' type agents (24,27). The ability of a compound to act as a 'b' type agent may depend on its mode and site of administration.

The effect of preceding a single PG injection to the PG8-PRID7/PG6 treatment on reproductive performance of multiparous dairy cows - Experiment 3

Summary

Group I of multiparous dairy cows was given the full PG8-PRID7/PG6 treatment, as described in Exp. 2. A second group of cows (group II) was given a single PG injection. Cows of group II, which appeared in estrus following the single PG injection, were inseminated; whereas cows that did not manifest estrus were then given the PG8-PRID7/PG6 treatment and inseminated the following EDI week. Forty-two percent of the cows of group II did not manifest estrus following the first PG injection and were, consequently, given the PG7-PG8-PRID7/PG6 treatment. Ninety-three percent of these cows were detected in estrus vs. 70% of cows in group I.

The variation in estrus appearance was smallest in cows of group II that did not respond to the first PG injection. All cows that manifested estrus in this group were detected in estrus on days 3 to 6 after PG. Conception rate of cows in estrus, following the first A.I., was 39.4% in cows treated with a single PG and 68.9% in cows given the PRID treatment ($P < 0.05$). The mean breeding interval was 29 and 22 days for groups I and II, respectively, and the percent of cows pregnant 90 days after calving 46% and 30%, respectively ($P < 0.08$).

It is concluded that despite the low conception rate following the single PG injection, the combined PG7-PG8-PRID7/PG6 treatment gives similar results to the PG8-PRID7/PG6 treatment at a lesser expense on materials and labor.

Introduction

The data of Exp. 2 indicate that, in multiparous cows, the estrus synchronization method PG8-PRID7/PG6 results in a better reproductive performance than the PG14/PG and PRID7/PG6 methods. The method is, however, rather expensive in materials and labor as it requires two injections of PG and the insertion and removal of a PRID.

The objective of Exp. 3 was to determine whether a single PG followed by PG8-PRID7/PG6 will render similar results at reduced expenses on materials and labor.

Experimental

Multiparous dairy cows (N=116) were allotted into two estrus synchronization treatment groups, according to parity, body condition score and calving date. The first group of cows, designated group I, were given the PG8-PRID7/PG6 treatment, as described in Exp. 2; these cows were first inseminated 60 to 80 days after calving. The second group of cows, designated group II, were given a single PG injection prior to the first post-partum EDI week. Cows that were detected in estrus were inseminated 60 to 80 days after calving. Cows that were not detected in estrus were then given the PG8-PRID7/PG6 treatment and inseminated the following EDI week. Cows, of both groups, which received the full treatment were given two fixed-time inseminations 56 and 72 hr following PRID removal, as described in Exp. 2. Cows that appeared in estrus following the fixed-time A.I. were reinseminated. All other experimental details are as described in Exp. 2.

Results

Following a single PG injection, 58% of the cows of group II were detected in

Table 31. Percent of cows detected in estrus during Days 1-6 following the first postpartum synchronization in Exp. 3.

Treatment	PG8-PRID7/PG6	PG7-PG8-PRID7/PG6 ¹
No. of cows	59	24
Type of estrus behavior	Percent	Percent
Standing estrus	67.8	83.3
Mounting twice or more ²	1.7	0
Mounting once during a single observation	5.1	0
No estrus behavior	25.4	16.7
Percent detected in estrus	69.5	83.3
Percent not detected in estrus	30.5	16.7

¹Only cows that were not detected in estrus after the first PG injection, were given this treatment.

²Mounting twice or more during a single observation, or once or more during two consecutive observations.

Table 32. Frequency distribution (%) of the interval between PG administration and estrus appearance following the first postpartum synchronization treatment in Exp. 3¹.

Treatment	<u>PG8-PRID7/PG6</u>		<u>PG7-PG8-PRID7/PG6</u>	
			<u>Single PG</u>	<u>PG8-PRID7/PG6</u>
No. of cows in estrus	41		33	20
Hours following PG administration	----- Frequency distribution, % -----			
≤ 42	0		3.0	0
43 - 66	7.3		36.4	20.0
67 - 90	46.3		36.4	45.0
91 - 114	17.1		15.2	25.0
115 - 138	7.3		3.0	10.0
139 - 162	17.1		6.0	0
163 - 186	2.4		0	0
187 - 192	2.4		0	0
49 - 96	58.5		69.7	65.0

¹The frequency distribution is significantly different between treatments ($P < 0.001$).

estrus. Of the remaining cows of this group, which received the full 7-8-7/6 treatment, 83% were detected in estrus vs. only 70% of group I (Table 31). Cows detected in estrus following a single PG appeared in estrus earlier after PG than cows given the PRID treatments. Manifestation of estrus of the PRID-treated cows of group II was concentrated within the time period of 43 - 138 h following PG injection (Table 32). This was probably due to the fact that most cows in this group were inserted with the PRID on days 3-6 of the estrous cycle (Table 32).

Due to the great variation in the time of estrus appearance in cows of group I, conception rate from the fixed-time A.I. was significantly lower than in cows of group II given the 8-7/6 treatment 21 days later. Conception rate of cows in estrus inseminated following a single PG injection was significantly lower than that of cows in the PRID treatments (Table 33).

Table 33. Conception rate (%) of multiparous cows in Exp. 3¹.

Treatment	PG8-PRID7/PG6	PG7-PG8-PRID7/PG6 ²		
		Single PG	PG8-PRID7/PG6	Total
No. of cows	59	33	24	57
Following the first postpartum A.I.				
Conception during EDI week	47.5 (59)	39.4 (33)	66.7 (24)	50.9 (57)
Conception from A.I. during Days 4-6	73.7 (19)	-	60.0 (5)	60.0 (5)
Conception of cows in estrus	65.9 (41)	39.4 (33)*	75.0 (20)	52.8 (53)
Conception from fixed time A.I.	23.7 (59)**	-	54.2 (24)	54.2 (24)
Following the second postpartum A.I.				
of cows that:				
Returned in estrus 3 wk after 1st A.I.	73.3 (15)	54.5 (11)	50.0 (21)	53.8 (13)
Returned in estrus later	40.0 (5)	66.7 (3)	0.0 (1)	50.0 (4)
Were resynchronized and manifested estrus	37.5 (8)	40.0 (5)	75.0 (4)	55.6 (9)
Were resynchronized and did not manifest estrus	50.0 (2)	-	-	-
All second A.I.	56.7 (30)	52.6 (19)	57.1 (7)	53.8 (26)
All second A.I. of cows in estrus	57.1 (28)	52.6 (19)	57.1 (7)	53.8 (26)
First and second A.I. of cows in estrus	62.3 (69)	44.2 (52)*	70.4 (27)	53.2 (79)
All A.I.				
All cows	49.1 (112)	46.8 (62)	63.6 (33)	52.6 (95)
Cows in estrus	57.0 (93)	47.5 (61)	71.4 (28)	55.1 (89)

¹Number of inseminated cows in parentheses.

²Cows were given a single PG and those not in estrus were given the PG8-PRID7/PG6 treatment and inseminated 21 days later.

*Significantly lower than cows treated with PG8-PRID7/PG6 in both groups ($P < 0.05$).

**Significantly lower than cows treated with PG8-PRID7/PG6 in the other group ($P < 0.01$).

Table 34. Interval from calving to first postpartum A.I., breeding interval, open days and no. of A.I. per conception in Exp. 3.

Treatment	PG8-PRID7/PG6	PG7-PG8-PRID7/PG6			S.E.	P
		Single PG	PG8-PRID7/PG6	Total		
No. of cows	59	33	24	57		
No. of cows culled	4	4	3	7		
Interval from calving to first A.I., days						
All cows	80.6	78.5	97.9	86.6	1.16	0.0001*
Pregnant cows	80.5	79.6	97.5	87.1	1.26	0.0001
Breeding interval, days						
All cows	38.1	38.4	18.5	30.0	4.78	N.S.
Pregnant cows	28.7	28.6	12.0	21.6	3.95	N.S.
Open days						
All cows	118.8	116.8	116.4	116.6	4.90	N.S.
Pregnant cows	109.2	108.2	109.5	108.8	4.17	N.S.
No. of synchronizations/cow						
All cows	1.25	1.30	1.17	1.25	0.05	N.S.
Pregnant cows	1.22	1.21	1.19	1.20	0.05	N.S.
No. of EDI weeks/conception						
All cows	1.89	1.94	1.38	1.70	0.10	N.S.
Pregnant cows	1.76	1.87	1.33	1.65	0.09	N.S.
No. of A.I./conception						
All cows	2.95	2.50	2.71	2.59	0.15	N.S.
Pregnant cows	2.88	2.43	2.67	2.53	0.16	N.S.

*The mean interval from calving to first A.I. for all cows of the PG7-PG8-PRID7/PG6 treatment was significantly greater than in the PG8-PRID7/PG6 group ($P < 0.05$).

Table 35. Frequency distribution (%) of the breeding interval of pregnant cows in Exp. 3¹.

Treatment	PG8-PRID7/PG6	PG7-PG8-PRID7/PG6		
		Single PG	PG8-PRID7/PG6	Total
No. of pregnant cows	55	29	21	50
<u>Breeding interval, days</u>	----- Frequency distribution, % -----			
≤ 30	72.7	65.5	85.7	74.0
31 - 60	7.3	17.2	0.0	10.0
61 - 90	14.5	10.3	14.3	12.0
≥ 91	5.5	6.9	0.0	4.0

– ¹Differences in the frequency distribution of the breeding interval are not statistically significant.

Table 36. Frequency distribution (%) of open days in pregnant cows in Exp. 3¹.

Treatment	PG8-PRID7/PG6	PG7-PG8-PRID7/PG6		
		Single PG	PG8-PRID7/PG6	Total
No. of pregnant cows	55	29	21	50
<u>Open days</u>	----- Frequency distribution, % -----			
≤ 90	49.1	44.8	19.0	34.0
91 - 120	21.8	24.1	57.1	38.0
121 - 150	14.5	17.2	9.5	14.0
151 - 180	9.1	6.9	9.5	8.0
181 - 210	0.0	3.4	4.8	4.0
≥ 211	5.5	3.4	0.0	2.0

– ¹The frequency distribution is significantly different when the PG8-PRID7/PG6 group and the two subgroups of the PG7-PG8-PRID7/PG6 group are compared ($P < 0.001$), but not when the two main groups are compared.

Table 37. Pregnancy rate (%) at various intervals after calving in Exp. 3.

Treatment	PG8-PRID7/PG6	PG7-PG8-PRID7/PG6		
		Single PG	PG8-PRID7/PG6	Total
No. of pregnant cows	59	33	24	57
- Interval after calving, days	Percent pregnant			
90	45.8 ¹	39.4 ¹	16.7 ¹	29.8 ¹
120	66.1	60.6	66.7	63.2
150	79.7	75.8	75.0	75.4
180	88.1	81.8	83.3	82.5
210	88.1	84.8	87.5	86.0
≥ 211	93.2	87.9	87.5	87.7
Percent culled	6.8	12.1	12.5	12.3

¹The difference in pregnancy rate at 90 days is $P < 0.06$ between the PG8-PRID7/PG group and the subgroups of the PG7-PG8-PRID7/PG6 group and $P < 0.08$ between the two main groups.

The breeding interval of cows in group II treated with PRIDs was considerably lower than that of cows of group I treated with PRIDs or cows treated with a single injection of PG (Table 34). However, due to their late first A.I., the average number of open days was similar for all treatments. Nevertheless, the percent of cows pregnant within 90 days of calving was higher in group I (Table 37). The number of synchronizations/cows was similar in all groups, but 58% of the cows of group II required only one PG injection for synchronization of the estrous cycle.

Discussion

Insemination of cows that manifested estrus following the single PG injection left for the full treatment mainly cows which were on day 0 to 6 of the estrous cycle on the day of the first PG. Thus, the second PG was given on days 7 to 13 of the cycle. Assuming that all cows responded to this PG injection, the PRID was inserted in almost all cows on days 3 to 5 of the following cycle. This special situation may have caused all the cows in estrus to appear within four days (Table 32). It is also important that in the combined PG7-PG8-PRID7/PG6 group only 4 cows (7.0%) did not manifest estrus. This is the lowest percentage of cows not manifesting estrus following synchronization treatment throughout this report.

The conception rate obtained following the insemination of cows in estrus given the PG8-PRID7/PG treatment is almost identical to that obtained in Exp. 2 (Table 33 and 18). Various earlier studies have indicated that the conception rate of cows that appeared in estrus and were inseminated following a single PG injection, was higher than that obtained after two injections or in untreated cows (26,30). Contrary to these findings, the conception rate of cows in estrus inseminated following a single PG injection is also very similar to that obtained in Exp. 2 in the PG14/PG treatment. The significant difference in conception rate between cows given PRID vs. PG only again indicates that in multiparous cows the PRID is favorably affecting conception rate.

Combining a single PG injection with the PG8-PRID7/PG6 treatment resulted in a similar reproductive performance as the full treatment. The advantage of the combined method is that 60% of the animals get only one PG injection, thus saving labor and expense. The disadvantage of the combined method is the delay in conception of 40% of the group. This disadvantage may be overcome by administering the first PG 50 to 70 days postpartum.

Management of reproduction of heifers treated with two PG injections given 12 days apart - Experiment 4

Summary

Four hundred and twenty-four dairy heifers, were given two injections of PG 12 days apart. The heifers were allotted at random into two groups. In one group (A.I. at estrus) heifers were inseminated following the detection of estrus only. In the second group (fixed-time A.I.), heifers were given two fixed-time inseminations 72 and 96 hr after the second PG injection; heifers seen in estrus outside the 49 to 96-hr post-PG period were inseminated following its detection. Observations for the detection of estrus were carried out four times daily during 6 days out of each three weeks. Inseminations were also carried out during the same six days. Heifers of the first group that did not appear in estrus were resynchronized and so were heifers of both groups that were diagnosed as not pregnant.

During 5 days, following the second PG, 83% of the heifers manifested standing estrus and another 6% manifested mounting behavior. Twenty-one percent of the heifers appeared in estrus within 48 hr after the PG injection, 70% between 49 and 96 hr and 9% between 97 and 126 hr.

For heifers of the 'A.I. at estrus' and 'fixed-time A.I.' groups, average age at first A.I. was 436 and 427 days, respectively. Number of A.I./conception for heifers of the two groups were 1.99 and 2.82, respectively ($P < 0.0001$), and conception rates following all inseminations were 58.7% and 51.2%, respectively ($P < 0.05$). It is concluded that inseminating heifers following estrus detection and resynchronization of those not detected in estrus is an efficient way for managing reproduction of estrus synchronized heifers.

Introduction

Treating heifers with PG is the easiest and least expensive way for the synchronization of their estrous cycles. However, the variation in estrus appearance is rather large and fixed-time inseminations decrease conception rate in comparison with untreated controls (4,8,17,21,28,35,36). The objective of the present experiment was to attempt to maximize fertility by supplementing fixed-time inseminations with additional breeding of heifers detected in estrus outside the fixed-time insemination period.

Experimental

All the heifers that were raised during three years on a kibbutz dairy farm were included in the experiment. The management of reproduction was based on estrus synchronization and heifers were treated every three weeks in clusters. Visual detection of estrus and inseminations were carried out during six days out of each three weeks. Heifers that reached the age of 13 months were included in a cluster provided they reached a body weight of 330 kg. The heifers in each cluster were given two injections of PG, 12 days apart. The second injection was given on the Sunday of each EDI week. The heifers in each cluster were allotted at random into two groups. Heifers of one group were inseminated during the EDI week following their detection in estrus. Heifers manifesting standing estrus and heifers mounting twice or more during two subsequent estrus observation sessions were regarded as being in estrus. Heifers of the first group that were not detected in estrus during the EDI week were resynchronized by two PG injections. Heifers of the second group were given two fixed-time inseminations, 72 and 96 hr after the second PG injection. Heifers of this group that appeared in estrus earlier than 48 hr following the PG injection were inseminated after the detection of estrus only. Heifers that were detected in estrus between 49 and 72 hr following the PG injection were given only one fixed-time insemination at 72 hr, and heifers that were detected in estrus later than 96 hr were reinseminated 126 hr following the PG injection. Heifers of both groups that were diagnosed as not pregnant, or that were noticed in estrus outside the EDI week, were resynchronized with two PG injections.

Results

Manifestation of estrus. About 82% of the synchronized heifers were detected to manifest standing estrus (Table 38). Another 3 to 6% manifested mounting activity. The conception rate following 481 synchronizations in which standing estrus was detected was 62.0%. In contrast, the conception rate following 32 synchronizations in which only mounting activity was detected was 43.8% ($P < 0.05$). This comparison included the first three inseminations. Ten heifers (2.4%) did not manifest estrus following two or more successive synchronizations; three of these were eventually culled.

The frequency distribution of 547 intervals from the second PG administration to estrus appearance is presented in Table 39. Within 96 hr after the second PG injection, estrus appearance reached 90.9%. However, 20.5% appeared up to 48 hr and only 70.4% appeared in estrus within the 48 hr period from 49 to 96 hr.

Table 38. Percent of heifers detected in estrus following two PG injections given 12 days apart to heifers in Exp. 4.

Type of estrus behavior	<u>First synchronization</u> 424 heifers	<u>Further synchronizations</u> 202 heifers
Standing estrus	82.5%	81.7%
Mounting during two observation sessions	6.4%	2.5%
No estrus behavior	11.1%	15.8%

Table 39. Frequency distribution of the interval from the second PG injection to estrus appearance in heifers - Exp. 4.

Interval from PG injection to estrus, hr	<u>First year</u>		<u>Second year</u>		<u>Third year</u>		<u>Total</u>	
	n	%	n	%	n	%	n	%
≤ 42	10	5.9	6	3.3	9	4.6	25	4.6
43 - 54	67	39.4	68	37.8	71	36.1	206	37.6
55 - 66	46	27.1	44	24.4	38	19.3	128	23.4
67 - 78	14	8.2	28	15.6	29	14.7	71	13.0
79 - 90	12	7.1	18	10.0	17	8.6	47	8.6
91 - 102	14	8.2	6	3.3	16	8.1	36	6.6
103 - 126	7	4.1	10	5.6	17	8.6	34	6.2
≤ 48	40	23.5	37	20.6	35	17.8	112	20.5
49 - 96	121	71.2	129	71.7	135	68.5	385	70.4
≥ 97	9	5.3	14	7.8	27	13.7	50	9.1

Table 40. Frequency distribution (%) of the appearance of standing estrus in heifers - Exp. 4.

Observation session	Synchronized	Spontaneous	P
	<u>estrus</u>	<u>estrus</u>	
	515 ¹	139 ¹	
--- Frequency distribution, % ---			
Morning	29.1	38.8	0.05
Noon	33.2	18.7	0.001
Evening	24.5	31.7	N.S.
Night	13.2	10.8	N.S.

¹No. of heifers.

The majority of spontaneous estruses were detected in the morning observation session, while most of the synchronized estruses started at noon (Table 40). When estruses following a second or later synchronization only are compared, the difference against spontaneous estruses is even larger.

Reproductive performance. Inseminating heifers, following estrus only, significantly increased the average age at first A.I., in comparison with the fixed-time A.I. management (Tables 41 and 42). However, age at conception was almost identical for the two systems of management. As a result of higher conception rates in the 'A.I. at estrus' system (Table 44), the breeding interval of heifers that conceived is significantly shorter in this group than in heifers of the 'fixed-time A.I.' system (Tables 41 and 42). In the 'A.I. at estrus' system 76.6% of the heifers conceived within 60 days of the first A.I. vs. 69.7% in the 'fixed-time A.I.' system (Table 43). The number of A.I./EDI week, the number of EDI weeks required for conception and the number of A.I./conception are also significantly greater in the 'fixed-time A.I.' system (Table 42).

Table 41. System of A.I. and its effect on age at first A.I., age at conception and breeding interval in heifers synchronized with two PG injections¹ - Exp. 4.

System of A.I. Year of experiment	A.I. at estrus			Fixed-time A.I. ²			Significance p ³		
	First	Second	Third	First	Second	Third	S.E.	System of AI	Year
Total no. of heifers	72	62	77	70	62	81			
No. of heifers culled	3	2	1	1	2	2			
Age at first A.I., days	427	444	438	423	427	430	3.4	0.002	0.005
Age at conception, days									
Pregnant heifers	450	478	459	462	474	457	6.9	N.S.	0.02
All heifers	459	484	461	463	483	463	8.0	N.S.	0.01
Breeding interval, days									
Pregnant heifers	23	36	21	39	48	27	6.3	0.04	0.03
All heifers	32	40	24	40	56	32	7.3	N.S.	0.03

¹PG injections were given 12 days apart.

²Two fixed-time A.I.'s at 72 and 96 hr after the 2nd PG injection, if estrus appeared 6 or more hours prior to the first A.I. the second A.I. was not given; if estrus appeared after the 2nd A.I. a third A.I. was given.

³Factorial ANOVA - interaction between system of A.I. and year are not statistically significant.

Table 42. The effect of system of A.I. on reproductive performance of heifers during three years in Exp. 4.

System of A.I.	<u>A.I. at estrus</u>	<u>Fixed-time A.I.</u>	Statistical significance P
No. of heifers	211	213	
No. of heifers culled	6	5	
Age at first A.I., days	436 $\pm$ 2.3	427 $\pm$ 1.7	0.005
Age at conception			
Pregnant heifers	462 $\pm$ 3.7	464 $\pm$ 4.4	N.S.
All heifers	467 $\pm$ 4.4	467 $\pm$ 4.9	N.S.
Breeding interval			
Pregnant heifers	26 $\pm$ 3.1	37 $\pm$ 4.2	0.04
All heifers	31 $\pm$ 3.8	42 $\pm$ 4.6	N.S.
No. of A.I./heifer during EDI week following estrus synchronization			
Pregnant heifers	1.31 $\pm$ 0.03	1.64 $\pm$ 0.04	0.0001
All heifers	1.31 $\pm$ 0.03	1.65 $\pm$ 0.04	0.0001
No. of EDI weeks/conception			
Pregnant heifers	1.57 $\pm$ 0.065	1.84 $\pm$ 0.090	0.02
All heifers	1.66 $\pm$ 0.081	1.91 $\pm$ 0.094	0.05
No. of A.I./conception			
Pregnant heifers	1.99 $\pm$ 0.087	2.82 $\pm$ 0.131	0.0001
All heifers ¹	2.10 $\pm$ 0.108	2.92 $\pm$ 0.140	0.0001
No. of synchronizations/conception			
Pregnant heifers	1.41 $\pm$ 0.049	1.46 $\pm$ 0.057	N.S.
All heifers	1.45 $\pm$ 0.054	1.50 $\pm$ 0.060	N.S.

¹The number of A.I. of culled heifers was the actual number of A.I. + 1.

Table 43. Frequency distribution (%) of the breeding interval in pregnant heifers synchronized with two PG injections in Exp. 4.

System of A.I.	A.I. at estrus				Fixed-time A.I.			
	First	Second	Third	All	First	Second	Third	All
Year of experiment								
Breeding interval, days ¹	Frequency distribution, %							
0 - 30	75.4	58.3*	81.6	72.7	71.0	58.3*	70.9	67.3
31 - 60	4.3	6.7	1.3	3.9	0.0	3.3	3.8	2.4
61 - 90	11.6	21.7	7.9	13.2	14.5	20.0	17.7	17.3
91 - 120	2.9	8.3	2.6	4.4	2.9	5.0	2.5	3.4
> 120	5.8	5.0	6.6	5.8	11.6	13.3	5.1	9.6

¹Breeding interval - the interval between first A.I. and conception.

*Percent of cows with a breeding interval of 0-30 days is significantly lower in the second year of the experiment ($P < 0.003$).

Following the first synchronized A.I., conception rates are similar in both systems of management (Table 44). However, following the second synchronized A.I. and following all A.I. in the experiment, conception rates in the 'A.I. at estrus' group are significantly higher. In the 'fixed-time A.I.' group, 41 inseminations of heifers not seen in estrus were carried out following estrus synchronization; only 6 of these heifers conceived (14.6%). When these inseminations are excluded, the conception rate of all A.I. is 58.7% and 55.3% for the 'A.I. at estrus' and 'fixed-time A.I.' groups, respectively (N.S.).

Second and third inseminations were carried out following both synchronized and spontaneous estruses (Table 44). The conception rate following the synchronized estruses was 55.9%, as opposed to 50.8% in heifers of both treatments which appeared in estrus spontaneously (N.S.).

Table 44. System of A.I. and its effect on conception rate (%) in heifers synchronized with two PG injections in Exp. 4.

System of A.I.	A.I. at estrus				Fixed-time A.I.				P ¹
	First	Second	Third	All	First	Second	Third	All	
<u>Conception rate, %</u>									
First A.I.	62.5(72) ²	50.0(62)	70.1(77)	61.6(211)	62.9(70)	45.2(62)	63.0(81)	57.7(213)	N.S.
Second and Third A.I.									
Following estrus									
synchronization	63.6(11)	63.6(22)	66.7(18)	64.7(51)	31.6(19)	46.7(30)	44.8(29)	42.3(78)	0.02
Following									
spontaneous estrus	61.9(21)	55.0(20)	50.0(18)	55.9(59)	44.4(18)	48.2(27)	44.4(18)	46.0(63)	N.S.
Total	62.5(32)	59.5(42)	58.3(36)	60.0(110)	37.8(37)	47.4(57)	44.7(47)	44.0(141)	0.02
All A.I.	58.4(113)	51.3(113)	65.9(123)	58.7(349)	54.0(113)	45.5(145)	54.7(148)	51.2(406)	0.05

¹Significance between all A.I. of both groups.

²No. of A.I. in parentheses.

Table 45. The effect of season on conception rate (%) of heifers inseminated after the first synchronized standing estrus in Exp. 4.

Season	Number of heifers	Conception rate, %
Dec. - Feb.	78	61.5
March - May	110	66.4
June - August	98	53.1
Sept. - Nov.	82	74.4
P		0.05

Effect of year. The reproductive performance of heifers first inseminated during the second year of the experiment is significantly lower than that of heifers first inseminated during the first and third year of the experiment (Tables 41, 43 and 44). During the second year gin-trash was fed and mold was found in the gin-trash fed to heifers.

Effect of season. The conception rate following inseminations carried out during June-August was significantly lower than inseminations carried out during September-November (Table 45). There was no season x year interaction and the difference between the summer and other months were similar in all the three years studied.

PG to estrus interval and conception. The data on the relationship between the time interval from the second PG injection to estrus appearance and conception rate is presented together with that of cows in Table 23. Like in cows treated with two PG injections, the conception rate of heifers, which appeared in estrus 84 hr or later following the second PG injection, was higher than that of heifers which appeared in

estrus earlier. In addition, a year x interval interaction was found; among heifers which appeared in estrus 84 hr or later, the conception rate of heifers which were first inseminated during the first and third year of the experiment was 72.2% and those first inseminated during the second year 80.6% (N.S.). Among heifers which appeared in estrus 78 hr or earlier after the second PG injection, the conception rate of heifers of the first and third year was 68.6% and that of the second year, 44.3% ($P < 0.001$).

Discussion

Assuming that acceptable conception rates are obtained when cows or heifers are inseminated not later than 24 hr after the onset of estrus, only heifers manifesting estrus 49 to 96 hr after the second PG will have an acceptable conception rate when inseminated at 72 and 96 hr only. The data in Table 39 indicate that only 70% of the heifers appeared in estrus within 49-96 hr following PG.

That 39% of the spontaneous estruses were detected in the morning is in accordance with the study of Walton et al. (40), who reported that more estrus activity occurs during the night hours. The different frequency distribution of estrus appearance in the synchronized heifers in the present study is probably due to the synchronizing effect of the PG injection which induced the onset of estrus 48 and 54 hr (morning and noon) following PG in a large proportion of the treated heifers.

In the present experiment the 'fixed-time A.I.' system included the insemination of heifers prior to and after the fixed-time inseminations. Thus, all the heifers that manifested estrus were inseminated. In addition, however, heifers not in estrus were also inseminated. As a result, age at first A.I. was lower in the fixed-time group (Table 42); however, their breeding interval was longer. Thus, the 'improved fixed-time A.I.' system, as practised in the present experiment, is less efficient than the 'A.I. at estrus' system. Age at conception was similar in both systems, however the 'fixed-time A.I.' group required more inseminations per conception and had a longer breeding interval, as a result of the method of inseminating heifers which were not detected in estrus. There was also no saving on visual observations in this group.

The small and nonsignificant difference in conception rate between the two systems of A.I. following the first synchronization (Table 44) is the result of 26 heifers inseminated without being detected in estrus. Following the second and third synchronization, 11 heifers in the 'fixed-time A.I.' system were inseminated without being seen in estrus. This decreased conception rates accordingly. The lower reproductive performance during year 2, especially in heifers that appeared in estrus

up to 78 hr following the second PG injection, indicates that fertility of heifers can fluctuate widely even when they are kept indoors, have a well-defined reproductive management and are fed a ration which is supposed to supply the necessary amounts of energy, protein and micronutrients. It is possible that the mold found in the gin-trash fed to heifers affected feed intake, which was not recorded, or had a toxic effect.

The significantly lower conception during the three months from June to August indicated that heifers which have a relative low heat production can suffer from heat stress. The decrease in conception began and ended earlier than in milking cows in which the lowest conception rate is recorded during July to October.

In conclusion, the results of the present experiment suggest that a strict 'fixed-time A.I.' system may considerably decrease the reproductive performance of heifers appearing in estrus outside the 49-96 hr period (about 30% of the animals), while gaining the conception of only 3% of additional heifers (6 out of 213). The 'fixed-time A.I.' system will also require more inseminations/conceptions than the 'A.I. at estrus' system. The 'improved fixed-time A.I.' system, as practised in the present experiment, is also less efficient than the 'A.I. at estrus' system. Thus, it seems that, in heifers, the 'A.I. at estrus' system should be preferred to the 'fixed-time A.I.' system whenever observation of estrus can be carried out during six days out of each three weeks.

The effect of post-insemination PRID insertion after PRID7/PG6 treatment on reproductive performance of dairy cows Experiment 5 - carried out in the U.S.

Introduction

Previously described studies at Cornell demonstrated that an estrous cycle control regimen for dairy heifers and cows utilizing progesterone releasing intravaginal devices (PRID) in combination with prostaglandin $F_{2\alpha}$ (PG) provided excellent synchrony of estrus, coupled with high fertility. The best system was one in which PRID were inserted for 7 days and PG was administered 24 h prior to PRID removal. In dairy heifers, a single insemination without regard to estrous activity at approximately 60 h after PRID removal resulted in very acceptable conception rates.

Based upon these and other results, a reproductive management system for dairy herds was developed. This system (outlined in Fig. 1) permits the establishment of one week out of every three-week period as an "estrous detection and insemination week" by controlling the estrous cycles of "clusters" of cows that are 50-70 days postpartum.

Experimental

Three-hundred and fifty-nine reproductively healthy Holstein cows from four commercial dairy herds (90 cows/herd) were blocked by parity (primiparous, n=119; multiparous, n=240), and randomly assigned to three treatment groups as follows:

1. Controls. Inseminated following currently recommended practices at the first naturally occurring estrus observed after 50 days postpartum.
2. PRID-PG. PRID inserted for seven days; PG (25 mg, IM) administered on day 6 (approximately 24 h prior to PRID removal).
3. PRID-PG-PRID. PRID and PG administered as described above. PRID autoclaved and reinserted during days 12-19 following insemination at the synchronized estrus.

Cows in the PRID-PG and PRID-PG-PRID groups were inseminated based on the observation of estrus or at 78-84 hr after PG administration, if estrus was not observed. Cows observed in estrus after the "appointment" breeding were rebred. Cows in both groups that failed to conceive were rebred only when detected in estrus. Cows observed in estrus during the second post-treatment week were not inseminated. They

were retreated with the next cluster. After the two weeks post-treatment, cows were rebred whenever heat was observed.

Blood samples for progesterone analysis were obtained on the day of PRID insertion. Endocrine status at breeding and conception were monitored by obtained milk samples for progesterone analysis on the day of insemination and at 23 days post-breeding.

Time of estrus observation, signs of estrus and time of insemination were recorded by the farmers. Pregnancy status was determined by rectal palpation at 40-50 days after insemination.

Results

Reproductive performance data have been summarized (Table 46) and statistical analyses have been completed. Analyses of the data were performed using the regression model of the General Linear Model (GLM) procedure (Statistical Analysis System, 1982). The model utilized when data for primiparous and multiparous cows were analyzed separately was:

$$Y_{ijk} = \mu + T_i + F_j + T\&F_{ij} + E_{ijk},$$

where

- μ = the overall mean,
- T = the effect associated with treatment,
- F = the effect associated with farm,
- $T\&F$ = the interaction of treatment and farm,
- E = random error

The model utilized when results from primiparous and multiparous cows were pooled were:

$$Y_{ijkl} = \mu + T_i + F_j + P_k + T\&F_{ij} + T\&P_{ik} + F\&P_{jk} + E_{ijkl},$$

where

- μ = the overall mean,
- T = the effect associated with treatment,
- F = the effect associated with farm,
- P = the effect associated with parity,
- $T\&F$ = the interaction of treatment and farm,
- $T\&P$ = the interaction of treatment and parity,
- $F\&P$ = the interaction of farm and parity,
- E = random error

Table 46. Reproductive performance in lactating Holstein cows after estrous cycle control using PRID+PG.

VARIABLE	Primiparous Cows				Multiparous Cows				Total	
	Control	PRID	PRID	PRID	Control	PRID	PRID	PRID	Control	PRID
# Cows	39	40	40	80	80	80	80	119	120	120
Days Postpartum										
Treatment	-	58±1	59±1	-	59±1	59±1	59±1	-	58±1	59±1
1st service	69±2 ¹	67±2	68±2	76±1 ^b	68±1 ^a	68±1 ^a	68±1 ^a	72±1 ^b	67±1 ^a	68±1 ^a
Conception										
1st service	18(46%)	19(48%)	10(25%)	44(55%) ^b	21(26%) ^a	32(40%) ^{ab}	62(52%) ^b	40(33%) ^a	42(35%) ^a	
120 day										
postpartum	31(79%)	31(78%)	24(60%)	52(65%)	51(64%)	57(71%)	83(70%)	82(68%)	81(68%)	
Total	38(97%)	33(83%)	35(88%)	72(90%)	72(90%)	77(96%)	110(92%)	105(88%)	112(93%)	
Days Open	92±6 ^{ab}	86±6 ^a	108±6 ^b	100±4	103±4	100±4	96±4	94±4	104±4	
Services/Conception	ab	a	b	a	b	b	a	ab	b	
Pregnant cows	2.0±0.2	1.7±0.2	2.5±0.2	1.9±0.1	2.5±0.1	2.3±0.1	1.9±0.1	2.1±0.1	2.4±0.1	
All cows	2.2±0.2 ^a	2.8±0.2 ^a	3.5±0.3 ^b	2.6±0.1 ^a	3.2±0.1 ^b	2.5±0.1 ^a	2.4±0.1 ^a	3.1±0.1 ^b	2.8±0.1 ^b	
Cows culled	1	7	5	8	8	3	9(8%)	15(13%)	8(7%)	

¹ Mean ±SEM² 1st service conception for treated groups in defined as conception within the 1st insemination week post-treatment (3-9 days after PRID removal).

a,b Significant differences (P<.05).

Reproductive management and performance were excellent in cooperating herds. Intervals from calving to first service for primiparous cows were similar across treatments ($P=.08$) (Table 46). In contrast, treatment (PRID + PG or PRID + PG + PRID) reduced days from calving to first service in multiparous cows ($P=.001$). Likewise, when data from both age groups were pooled, treatment effects were significant ($P=.001$) with controls receiving their first service later than either treatment group. Farm and farm and treatment interactions were significant ($P<.05$) and apparently can be explained by the fact that on one farm, control cows were inseminated earlier in the postpartum period than called for in the experimental protocol.

First service conception rates in control and PRID + PG treated primiparous cows did not differ. Conception in PRID + PG + PRID-treated primiparous cows was lower, but not significantly so ($P=.06$). In multiparous cows, conception rates were lower ($P=.001$) in PRID + PG-treated cows than in controls and those receiving PRID + PG + PRID.

When data from parity groups were pooled, first service conception rate in controls exceeded that in both treated groups ($P=.02$). However when conception rates of cows detected in heat are compared, the results were similar for control and treated animals (Table 48). On the other hand the conception rate of synchronized cows not seen in heat was 15%. As 44% of the cows which were in estrus according to milk progesterone levels were not seen in heat, the conception rate of all treated cows was lower than that of controls. The percent of cows detected in heat is not related to plasma progesterone levels on the day of PRID insertion (Table 47).

Two factors that relate to the proper timing of insemination with respect to ovulation are likely to be important. First, is the "appointment breeding" of animals that were not seen in estrus. Conception of treated cows not seen in estrus was lower ($P=.001$) than in treated cows that had been observed in estrus. Second, is the accuracy of estrus detection and timing of insemination when large numbers of animals were in estrus in these herds. Inseminator fatigue should also be considered as up to 30 cows were inseminated by a single technician on some days during the insemination week.

Pregnancy rates within 120 days postpartum and during the entire lactation did not differ across treatment groups (Table 46). Differences in services per conception were reflective of differences in first service conception rate. Culling rates also did not differ across treatments.

Reproductive performance, as measured by days open, was excellent across all treatments. However, treatment differences were observed in the primiparous group where open intervals in controls did not differ from either PRID + PG or

Table 47. Plasma Progesterone Levels on the Day of FRID Insertion.

	Plasma P ₄ , ng/ml			
	FRID + PG		FRID + PG + FRID	
	.01 to .99	1.00 to 1.99	.01 to .99	1.00 to 1.99
Variable		2.0+		2.0 + 4/4
# cows bred	50	22	48	23
# cows observed in heat	30(60%)	12(55%)	22(46%)	12(53%)
# cows pregnant to 1st service	18(36%) ^b	4(18%) ^a	18(37%) ^b	8(35%) ^b
# cows pregnant Total	43(86%)	16(73%)	46(96%)	22(96%)
Days Open	103+7	86+10	95+ 6	111+ 7
# cows culled	7(14%)	6(27%)	2(4%)	1(4%)

a, b Significant Difference (.03)

Table 48. Estrus Response and Milk Progesterone Levels

Variable	Primiparous Cows				Multiparous Cows				Total			
	Control	PRID +PG	PRID +PG+	PRID	CONTROL	PRID +PG	PRID +PG+	PRID	CONTROL	PRID +PG	PRID +PG+	PRID
Cows Bred	39	40	40	40	80	80	80	80	119	120	120	120
Cows in Estrus by Milk P ₄	34	40	37	37	80	78	77	77	114	118	114	114
Cows not in Estrus by Milk P ₄	5	0	3	3	0	2	3	3	5	2	6	6
Cows in Estrus by Milk P ₄ and seen in heat	34	22	19	19	80	42	47	47	114	64	66	66
# Cows Preg to 1st service	17(50%)	15(68%)	8(42%)	8(42%)	42(52%)	17(40%)	26(55%)	26(55%)	59(52%)	32(50%)	34(52%)	34(52%)
Cows in Estrus by Milk P ₄ and not seen in heat	-	18	18	18	-	36	30	30	-	54	48	48
# cows Preg to 1st service	-	4(22%)	2(22%)	2(22%)	-	4(11%)	5(17%)	5(17%)	-	8(15%)	7(15%)	7(15%)
Cows not in estrus by Milk P ₄	5	-	3	3	0	2	3	3	5	2	6	6
# Cows Preg to 1st service	1(20%)	-	0	0	0	0	1(33%)	1(33%)	1(20%)	0	1(17%)	1(17%)

PRID + PG + PRID, but the two PRID-treated groups differed from each other ($P=.03$). Data from multiparous cows and data pooled across parity groups revealed no difference ($P>.14$) due to treatment.

The establishment of an estrus detection and insemination week was studied by counting the number of inseminations that occurred each week of the trial (Fig. 4). Eighty-six percent of all breedings (first and repeat) in treated cows occurred during the established insemination weeks. Inseminations of control cows were evenly distributed across weeks.

Summary

The results of this study indicate that estrous cycle control using PRID + PG effectively programs dairy herd reproduction so that heat detection and insemination can be concentrated within one week out of every three. Post-insemination reinsertion of PRID after PRID + PG treatment is not beneficial in terms of improving either conception rate or synchrony of the return to estrus in cows that fail to conceive. PRID reinsertion may, in fact, be contraindicated in primiparous cows, but this needs to be confirmed. Since possible reductions in labor associated with heat detection and insemination are at least, in part, off-set by drug costs and increased semen usage in the scheme used in this experiment, cost-benefit analysis is needed before it can be recommended. Options that should be considered in this analysis and future experiments include the elimination of "appointment breeding" for those cows that are not observed in estrus and foregoing all breedings that would fall outside the insemination week; these open cows would be retreated in the first succeeding cluster.

** LAST CLUSTER ADDED

Figure 4. Number of cows bred each week identified by treatment.

General Discussion

In view of the considerable variation in the onset of estrus, following synchronization treatment, insemination of cows at a fixed-time A.I. only cannot be expected to attain high fertility. Conception rate of cows inseminated while not in estrus, in Exps. 2 and 5, was very poor. Even in heifers which have a better synchrony of estrus (22,23), insemination following estrus detection resulted in better reproductive performance at a lower cost. It has been reported that administering PG two or three days prior to PRID or norgestomet removal considerably reduced the variation in estrus appearance (6,7,37), however, the effect of these procedures on the fertility of high-yielding dairy cows is not clear.

A review of the literature reveals that inseminating dairy cows in estrus following PG administration resulted in conception rates similar or slightly higher than those of untreated controls (24,27). The data presented in this report indicate that the conception rate, following the first postpartum A.I. of multiparous cows in estrus, synchronized by PG only, was 41.9% and 39.4% in Exps. 2 and 3, respectively. The conception rate of corresponding cows given the PG8-PRID7/PG6 treatment was 66.2% ($P<0.01$) and 65.9% ($P<0.05$) in Exps. 2 and 3, respectively. It may, therefore, be inferred that the conception rate of PG8-PRID7/PG6-treated cows is also higher than that of untreated animals. The combined PG7-PG8-PRID7/PG6 method used in Exp. 3, in which cows are treated with a single PG injection and only those not in estrus are given the PG8-PRID7/PG treatment, may render similar results to that of treating all cows with PG8-PRID7/PG6, at a much lower cost.

The significantly lower than control conception rate of cows given the PRID7/PG6 treatment in Exp. 5 is the result of a large proportion of cows not being detected in estrus. Most of these cows were presumably inseminated while not in estrus, and as a result their conception rate was 15%. Cows that were detected in estrus had a similar conception rate to that of control animals. It is plausible to assume that estrus detection and thus the timing of insemination were a problem in the herds of Exp. 5.

An analysis based on the data of more than 110 cows given two injections of PG, 11 or 14 days apart, revealed that conception rate, following the first postpartum A.I. of cows inseminated at estrus, is strongly related to peripheral plasma progesterone levels four and two days prior to the second PG injection. The conception rate of cows with plasma progesterone levels of more than 5 ng/ml was almost double that of cows with lower progesterone levels and reached approximately 80%. Contrary to the low level of conception (33%) of low progesterone cows treated with PG14/PG (Table 26), cows of the PG8-PRID7/PG6

treatment with a low progesterone level, four days prior to the second PG, had a conception rate of 71% ($P < 0.02$). As the insertion of the PRID is the only known difference between the two treatments, it is plausible to assume that PRID has a positive effect on conception rates which is not reflected in peripheral plasma progesterone levels.

As PRID insertion significantly increases conception rate of cows with low progesterone levels, two and four days prior to the second PG injection, and may decrease conception rate of cows with high levels of progesterone (Table 26), it may be concluded that the optimal estrus synchronization method should be based on progesterone concentrations. Synchronization of cows with high progesterone concentrations by means of 2 PG injections and insertion of a PRID to low progesterone cows only may achieve very high conception rates for the whole herd. The recently developed cowside progesterone tests may facilitate the development of such a system.

The experiments described in this report were carried out within the strict framework of a management system under which cows and heifers are observed in estrus and inseminated during only 6 days out of each 3 weeks. This management system has various advantages, including the saving of labor and transportation expenses. However, the system prolongs the breeding interval and the number of open days of cows that do not conceive and return in estrus between the EDI weeks. A possible variation to this system is to observe cows for estrous behavior two or three times daily and inseminate them during the period between the EDI weeks. The advent of synchronization methods, with very high conception rates, may render this variation unnecessary.

In conclusion, the results of this report indicate that although fixed-time A.I. might attain satisfactory conception rates in some cows and especially in heifers, the reproductive performance of dairy cows inseminated by "appointment breeding" is usually decreased. Agents for estrus synchronization may directly affect fertility and thus the use of hormones should be considered in relation to both reproductive management and fertility. Systems that will combine adequate management with high fertility can be adapted to a variety of practical conditions. The system based on estrus detection and insemination during 6 days out of each 3 weeks, using synchronization methods which result in high fertility, is one possibility.

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Description of Cooperation

Prior to the submission of this research proposal, researchers from the U.S. and Israel have met to review the state of the art in the field of reproduction of dairy cattle and methods of synchronization of estrous cycles. During the implementation of this project investigators from the U.S. have visited Israel and vice versa. During these visits the progress in carrying out this research project has been reviewed and the results obtained have been discussed. During March 1988, Dr. Hansel will visit Israel and the final results will be reviewed and discussed.

Evaluation of Research Achievements

The results obtained during the implementation of this project provide evidence that the management of reproduction used throughout the experiments is a feasible system which enables the insemination of cattle at a time which is optimal for the attainment of maximal milk and calf production. The system enables the farmer to carry out estrus detection and artificial insemination during 6 days out of each 3 weeks.

A new method for the synchronization of estrous cycles has been developed. In multiparous cows, the method, based on two injections of PG and an insertion of a PRID, attained significantly higher conception rates than those obtained by other synchronization methods currently in use.

The results obtained indicate that the reproductive performance obtained by different methods of estrus synchronization are related to the peripheral plasma concentration of progesterone; very high conception rates have been obtained, with the use of PG only, when endogenous progesterone levels were high and vice versa. The use of PRIDs significantly increased the conception rate of cows with low progesterone levels.

The results suggest, for the first time, that the insertion of PRIDs has a beneficial effect on fertility of cows which is not related to its augmentation of plasma progesterone concentrations. It is, thus, suggested that some reproductive hormones and methods of application have direct effects on conception, in addition to their role as estrus synchronizing agents.

The data obtained provide a basis for the future development of an estrus synchronization method which may attain conception rates of about 70%.

The management of reproduction and the method of synchronization developed in the course of this research should improve reproductive performance in high-yielding dairy cows. Future developments, based on the findings obtained, may increase fertility even further.

List of Publications

*Folman, Y., Kaim, M., Rosenberg, Miriam and Herz, Z. 1984.

Management of reproduction of dairy cattle based on synchronization of oestrous cycles. In: The Reproductive Potential of Cattle and Sheep. INRA Colloq. No. 27. INRA, Paris, pp. 71-85.

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Three treatments of estrus synchronization in dairy cows - a comparison of their effects on progesterone concentration and fertility. Proc. 10th International Congress on Animal Reproduction and Artificial Insemination. Vol. III, p. 346.

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The effect of three synchronization treatments on the fertility and plasma progesterone concentrations of dairy cows (Hebrew). Professional Meeting of Cattle Growers in Israel, Abstr. 26.

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The effect of body condition score prior to A.I. on conception of dairy cows (Hebrew). Professional Meeting of Cattle Growers in Israel, Abstr. 23.

*Herz, Z., Harel, A., Rosenberg, M., Kaim, M. and Folman, Y. 1987.

The fertility of estrus-synchronized cows compared to the fertility of untreated control cows at Kibbutz Gezer (Hebrew). Professional Meeting of Cattle Growers in Israel, Abstr. 27.

*Reprints from these meetings are not available.

Manuscripts in preparation

Kaim, M., Herz, Z., Rosenberg, M. and Folman, Y.

Management of reproduction in dairy heifers based on the synchronization of estrous cycles. Theriogenology.

Rosenberg, M., Kaim, M. and Folman, Y.

Comparison of methods for synchronization of estrous cycles: I. Effect on plasma progesterone levels and manifestation of estrus. J. Dairy Sci.

Folman, Y., Rosenberg, M., Herz, Z. and Kaim, M.

Comparison of methods for synchronization of estrous cycles: II. Factors affecting reproductive performance. J. Dairy Sci.