J. Dairy Sci. 87:85–94

Comparison of Timed AI After Synchronized Ovulation to AI at Estrus: Reproductive and Economic Considerations

B.-A. Tenhagen, M. Drillich, R. Surholt, and W. Heuwieser
Clinic for Reproduction, Section of Production Medicine
and Quality Management, Free University of Berlin,
14163 Berlin, Germany

ABSTRACT

A timed artificial insemination (TAI) protocol using OvSynch was compared to artificial insemination (AI) at detected estrus in 2 large dairy herds differing in reproductive management. Cows were synchronized for TAI starting at 62 and 42 d in milk in herds 1 and 2, respectively. The OvSynch regimen included: GnRH (buserelin) at 0.02 mg (i.m.) on d 0; $PGF_{2\alpha}$ (tiaprost) at 0.75 mg (i.m.) on d 7; buserelin at 0.02 mg (i.m.) on d 9; and TAI 16 to 20 h later. After TAI, cows seen in estrus received AI, whereas cows diagnosed not pregnant were resynchronized for TAI. Control cows received AI based on detected estrus after voluntary waiting periods of 72 d in herd 1 and 50 d in herd 2. An economic analysis included costs associated with days open, culling, AI, synchrony products, treatment, and examinations. A sensitivity analysis of those variables determined effects on total costs per pregnancy. Use of OvSynch reduced intervals to first AI and days open in both herds and reduced culling for infertility in herd 2. Conception rates for first AI at detected estrus were significantly higher compared to TAI in both herds and for overall AI at estrus in herd 2. For groups assigned to AI at estrus, mean 21-d submission rates over 200 d for AI were higher in herd 1 than in herd 2 (55.6 vs. 28.6%). Days open and culling were the major cost factors. Although OvSynch improved reproduction in both herds, AI based on detected estrus was economically superior in herd 1, whereas OvSynch was superior in herd 2. This was consistent across ranges of cost factors evaluated. Evaluation of synchrony protocols should include reproductive performance along with appropriate costs associated with treatments. Such costs may offset benefits to reproduction in herds with good estrous detection rates.
(**Key words:** dairy cow, OvSynch, reproductive performance, economics)

Abbreviation key: CL = corpus luteum, **IDE 1**, **IDE 2** = insemination at detected estrus or specifically in herds 1 and 2, respectively, **OvSynch 1**, **OvSynch 2** = synchronization regimen for timed insemination or specifically in herds 1 and 2, respectively, **PD** = pregnancy diagnosis; **TAI** = timed AI, **VWP** = voluntary waiting period.

INTRODUCTION

A protocol for synchronized ovulation and timed AI (**TAI**) in lactating dairy cows known as OvSynch allows AI submission rates close to 100% (Pursley et al., 1995; Risco et al., 1998). Many studies comparing OvSynch to other protocols have been performed and published. Several of those focused on conception and pregnancy rates after the first synchronization (Britt and Gaska, 1998). Some only used OvSynch for first AI and then started observation of cows for estrus (De la Sota et al., 1998; Jobst et al., 2000; Klindworth et al., 2001). However, if OvSynch is used to abandon the need for estrous detection, high submission rates after synchronization are followed by a time lag of approximately 40 d before nonpregnant cows are reinseminated. Pregnancy diagnosis using ultrasound is feasible at about 29 d after AI (Mueller et al., 1999) and 10 d are needed for resynchronization. This causes 0% AI submission rates during this interval (LeBlanc, 2001). Reducing the time lag has been studied in a program called Resynch. However, the efficacy of this program regarding conception rates is doubtful (Moreira et al., 2000; Chebel et al., 2003). Increasing conception rates to OvSynch by presynchronization with prostaglandin $F_{2\alpha}$ has been carried out with varying success (Moreira et al., 2001; Peters and Pursley, 2002). However, the time lag to reinsemination of nonpregnant cows is not reduced with this approach. It has been recognized that OvSynch is more beneficial in herds with poor estrous detection (Mialot et al., 1999).

The economic benefit from OvSynch is based on the reduction of days open and the numbers of cows that are culled for infertility (Risco et al., 1998; LeBlanc, 2001). Further benefits occur because fewer subestrous

Received February 5, 2003
Accepted August 20, 2003
Corresponding author: B.-A. Tenhagen; e-mail: tenhagen@bestandsbetreuung.de.

cows have to be examined. The change of workload when OvSynch is introduced is difficult to assess. Time spent on detection of estrus, cow selection, organization, and documentation cannot be quantified with sufficient accuracy.

The comparative economic evaluation of OvSynch therefore should be based on effects that can be measured. On the benefit side, this is the number of cows pregnant within an acceptable time frame. On the cost side it is the amount of drugs and treatments and AI necessary to achieve this pregnancy rate. So far data on this question are limited. Studies comparing OvSynch to control protocols mostly restricted OvSynch to the first AI and had conflicting results. While 2 studies found significant benefits of OvSynch compared with control protocols (Britt and Gaska, 1998; Risco et al., 1998) a third one found lower costs in a targeted breeding protocol (Nebel and Jobst, 1998). However, none of those studies used OvSynch for repeated inseminations. This was evaluated theoretically by LeBlanc (2001). He also found an economic benefit of OvSynch compared with a protocol based on repeated use of prostaglandin $F_{2\alpha}$. Another theoretical analysis was carried out by Risco et al. (1998) for the climatic conditions of Florida. That trial also found economic benefits from using OvSynch.

The objective of this study was to compare the reproductive efficiency and economic benefit of OvSynch protocols with conventional reproductive management in a field trial in 2 large dairy herds in Germany.

MATERIALS AND METHODS

A field trial was conducted in 2 commercial dairy herds in Brandenburg, Germany. In the first herd, 398 Holstein-Friesian cows were assigned to 2 reproductive management groups by the final digit of their eartag number. The number had been assigned to the animals at birth assuring a random distribution of the cows in the 2 groups. Cows had calved between February and October 1999. Cows with uneven eartag numbers were submitted to an OvSynch protocol (**OvSynch 1**). Cows with even eartag numbers served as the control group to be inseminated at detected estrus (**IDE 1**). The cows were housed in a free-stall barn with slotted floors and cubicles lined with rubber mats. Cows were fed with a mixed ration. High yielding cows received additional concentrates via automatic feeders. Herd average milk production was 8000 kg per cow per year.

The voluntary waiting period (**VWP**) for all cows in herd 1 was 72 DIM. Pregnancy diagnosis (**PD**) was carried out by using ultrasound between 29 and 35 d after AI or by rectal palpation of the uterus and its contents in the following week. The method of PD was assigned to the cows by the next to last digit of their eartag-number (2, 4, 6, 8, 0 vs. 1, 3, 5, 7, 9). This assured a distribution of PD methods that was independent of the reproductive management protocol.

Cows receiving OvSynch in herd 1 were group OvSynch 1 and synchronized by treatment with 0.02 mg (i.m.) of buserelin (GnRH–analogue, Receptal, Intervet Deutschland GmbH, Unterschleissheim, Germany) on d 0. Luteolysis was induced by 0.75 mg of tiaprost ($PGF_{2\alpha}$-analogue, Iliren C, Intervet Deutschland GmbH, Unterschleissheim, Germany) i.m. on d 7. On d 9, cows received a second dose of buserelin. At 16 to 20 h after the last treatment, TAI was done. Synchronization was started every Tuesday for all cows between 62 and 68 DIM except that in cows that showed clinical signs of disease (lameness, endometritis, mastitis) at the start of or during the synchronization protocol, synchronization and AI were postponed until those cows were cured. Cows returning to estrus were reinseminated based on observed estrus. Cows that were not pregnant at PD were resubmitted to the synchronization protocol.

Cows in herd 1 that were assigned to be inseminated based on estrus were in group IDE 1 and were observed for signs of estrus and bred on observed estrus after the end of the VWP of 72 d. In both IDE and OvSynch groups in herd 1, cows not bred until 92 DIM or not pregnant on PD were palpated per rectum by one of the investigators for diagnosis of abnormalities of the genital tract and determination of stage of estrous cycle. Cows of both groups with signs of endometritis (enlarged uterus, vulval discharge with pus) at this examination received 0.75 mg of tiaprost as a therapeutic treatment. Cows that were treated for endometritis with tiaprost were usually not inseminated on the induced estrus. All cows in OvSynch 1 that did not show signs of endometritis at this examination were resubmitted to the synchronization protocol. Cows in IDE 1 with a palpable corpus luteum (**CL**; Grunert, 1982) after 92 DIM received 0.75 mg of tiaprost to induce estrus. Cows with follicular cysts (fluid filled cavity >25 mm, absence of palpable CL) or signs of anestrus (no CL on repeated examinations in 14-d intervals) received 0.02 mg of buserelin. Examinations were repeated in 14-d intervals until cows were inseminated. Cows not pregnant at 200 DIM were regarded as culled for infertility in both groups.

The second herd was selected to examine the use of OvSynch in a herd differing in reproductive management from herd 1. Herd 2 had low AI submission rates, long days open, and high proportion of cows culled for poor reproductive performance. The trial included 650 dairy cows on a confinement-housed commercial dairy farm in Brandenburg, Germany. Cows on farm 2 were

Holstein × East German Blackpied cows. Herd average milk production was 6700 kg per cow per year at the start of the trial. Cows were housed in groups of 50 animals in a free-stall barn with slotted floors. Cows were grouped by production level and stage of lactation and fed a total mixed ration accordingly.

Cows that had calved between October 1998 and February 1999 were included in the study. All cows were submitted to rectal palpation between 35 and 41 DIM. Cows with signs of endometritis were treated with 0.75 mg of tiaprost and reexamined 14 d later. Cows with persistent signs of endometritis were retreated. Cows without endometritis were assigned to 1 of 2 treatment groups by the final digit of their eartag number. The VWP was set at 50 DIM. Pregnancy diagnosis was carried out between 42 and 48 d after AI by palpation of the uterus and its contents. In the final analysis, cows not pregnant by 200 DIM were regarded as culled for infertility. Cows that were inseminated before the end of the VWP were removed from the final analysis.

Cows in herd 2 assigned to **OvSynch 2** received OvSynch treatments as described for herd 1 except that synchronization started at 42 DIM. In cows that showed clinical signs of disease (lameness, endometritis, mastitis) at the start of or during the synchronization protocol, synchronization, and AI were postponed until cure. Cows returning to estrus after insemination were reinseminated based on observed estrus. Cows that proved to be not pregnant at PD were resubmitted to the synchronization protocol. However, if detected in estrus during resynchronization, they were inseminated on observed estrus.

Cows in herd 2 that were assigned to be inseminated at estrus (**IDE 2**) received AI based on observed estrus after the end of the 50-d VWP. Cows not bred until 80 DIM were examined by rectal palpation; cows with a CL received 0.75 mg of tiaprost to induce estrus; cows with large follicles, cysts, or signs of anestrus were treated with 0.02 mg of buserelin. If not bred within the next 14 d, cows were resubmitted to examination and treatment. Following examination after 80 DIM, cows in IDE 2 regarded as problem cows by the herdsman could also receive OvSynch. However, no systematic synchronization was performed.

Economic Considerations

Price assumptions were used to test the economic benefit of the protocols in the different herds. To analyze the effect of changes in price assumptions, prices were varied over a range that seemed realistic from reports in agricultural magazines and by practitioners. As each cost factor varied, the other price factors were kept constant leading to a total of 63 scenarios (Table 1). The outcome was expressed as total costs per pregnancy. Costs for culling were expressed as the difference between carcass value and the price of a pregnant replacement heifer. No costs for days open were assigned to culled cows. Costs for days open are mainly caused by prolonged late lactations. These did not occur in cows that were culled. Costs for GnRH, PG, and administering treatment included all treatments, not only the ones for synchronization. Costs for rectal palpation included PD and other examinations of cows beyond 92 and 80 DIM, respectively. Costs associated with estrous detection were not included because observations for estrus were carried out in both OvSynch and IDE groups. Because the first TAI was shortly after the VWP, time spent for estrous detection was practically not reduced in the OvSynch groups. Total costs per pregnancy were calculated by the following formula and reported in euros:

$$\text{TCP} = \frac{\text{cGnRH} + \text{cPG} + \text{cTreat} + \text{cAI} + \text{cRP} + \text{cDO} + \text{cCull}}{\text{No. of cows pregnant} + \text{No. of replacements}},$$

where:

TCP = Total costs per pregnancy,
cGnRH = Cost for GnRH (No. of doses × cost per dose),
cPG = Cost for $PGF_{2\alpha}$ (No. of doses × cost per dose),
cTreat = Cost for treatment (No. of treatments × fee for i.m. injection),
cAI = Cost for AI (No. of AI × cost per AI (incl. semen and fees)),
cRP = Cost for rectal palpation (No. of palpations × fee for rectal palpation),
cDO = Cost for days open (No. of days open > 85 d × cost per day open), and
cCull = Cost for culling (No. of cull cows × difference between carcass and replacement value).

Statistical Analyses

Statistical analyses were performed using SPSS (Version 10.7, SPSS Inc. Munich, Germany). Pregnancy rates by 200 DIM (no. of cows pregnant/no. of cows enrolled) conception rates (no. of cows pregnant/no. of AI in all cows) were compared within herds using chi-square analysis. Days to first service and days open were compared by Mann-Whitney U-Test. To account for animals that did not get pregnant during the study periods, the overall incidence density of pregnancies

Table 1. Price ranges for cost items included in the economic sensitivity analysis with 9 steps per item.

Item	Cost per unit (€)[1]	Range (€)	Increment (€)
GnRH	5.50 per dose	2.50 to 10.50	1.00
Prostaglandin $F_{2\alpha}$	5.00 per dose	1.00 to 9.00	1.00
Treatment	3.00 per injection	1.00 to 5.00	0.50
Artificial Insemination (AI)	20.00 per AI	5.00 to 45.00	5.00
Rectal palpation	3.00 per palpation	1.50 to 5.50	0.50
Day open	2.50 per day >85	0.50 to 4.50	0.50
Cow culled	650.00 per cow	250.00 to 1050.00	100.00

[1]€ = euro monetary unit.

was calculated for each group. "Cow days at risk" were all days between the end of the VWP and either successful AI, the end of the study period, or removal of the cow from the herd. Incidence densities were calculated by dividing the number of conceptions by the number of cow days at risk. For convenience the result was expressed as pregnancies per 1000 cow days at risk. Incidence densities (pregnancies/cow day at risk) were compared as described by Woodward (1999). For all statistical analyses, α was set at 0.05.

RESULTS

Reproductive Performance

Data on reproductive performance of treatment groups in both herds are shown in Table 2 and Figures 1 and 2.

Herd 1. Cows in OvSynch 1 (n = 200) were inseminated an average of 16 d earlier than cows in IDE 1 (n = 198). The AI submission rate during the first 21 d after the end of the VWP was significantly higher in OvSynch 1 than in IDE 1 (82.0 vs. 39.4%). Conception rate to first service was significantly higher in IDE 1 than in OvSynch 1 (45.1 vs. 34.5%). Conception rate to first service did not differ between cows that were diagnosed pregnant by ultrasound (OvSynch 1, 34%; IDE 1, 43.3%) or by rectal palpation (OvSynch 1, 35%; IDE 1, 46.8%). Conception rate to all services did not differ significantly between the groups. Days open for pregnant cows were 10 d lower in OvSynch 1 ($P < 0.05$). However, at the end of the study period the proportion of pregnant cows was similar (Figure 1). The incidence density for pregnancies was slightly higher in OvSynch 1 than in IDE cows. However, the confidence interval

Table 2. Reproductive performance measures in herds 1 and 2 for cows inseminated after OvSynch or inseminated based on detected estrus (IDE).

	Herd 1		Herd 2	
Variable measured	OvSynch 1	IDE 1	OvSynch 2	IDE 2
Cows in protocol	200	198	289	361
Cows inseminated by 200 DIM	197	184	289	313
AI Submissionrate$_{21}$ (%)[1]	82.0[a]	39.4[b]	84.4[a]	21.6[b]
AI Submission rate$_{200}$ (%)[2]	69.6[a]	55.6[b]	65.4[a]	28.6[b]
Days to 1st service[3]	81.2 ± 16.7[a]	97.0 ± 21.2[b]	62.7 ± 14.0[a]	106.7 ± 38.7[b]
1st service conception rate (%)	68/197 (34.5)[a]	83/184 (45.1)[b]	103/289 (35.6)[a]	156/313 (49.8)[b]
No. of inseminations	386	348	585	449
Conception rate (%)[4]	41.7	45.4	39.0[a]	49.7[b]
Cows pregnant at 200 DIM (%)	161 (80.1)	158 (79.8)	228 (78.9)[a]	223 (61.8)[b]
Days open in pregnant cows[3]	111.5 ± 35.1[a]	121.3 ± 36.5[b]	94.4 ± 40.0[a]	117.0 ± 40.6[b]
Cow days at risk[5]	11649	13149	18795	32930
Pregnancies/1000 days at risk	13.8	12.0	12.1[a]	6.8[b]
95% confidence interval (CI)	11.8–16.1	10.2–14.0	10.6–13.8	5.9–7.7
RR[6] of Incidence densities[7] (95% CI)	1.15 (0.92–1.43)		1.79 (1.49–2.16)	

[a,b]Values in rows within herds with different superscripts differ significantly (P <0.05).

[1]Proportion of cows inseminated within 21 d after the end of the voluntary waiting period.

[2]No of inseminations/(cow days at risk/21).

[3]Mean ± SD.

[4]Cows pregnant at 200 DIM/no. of inseminations.

[5]Cumulative number of days for all cows between end of VWP and three possible endpoints: pregnancy, culling, or 200 DIM.

[6]RR = Relative rate.

[7]Incidence density = Cows pregnant/cow days at risk.

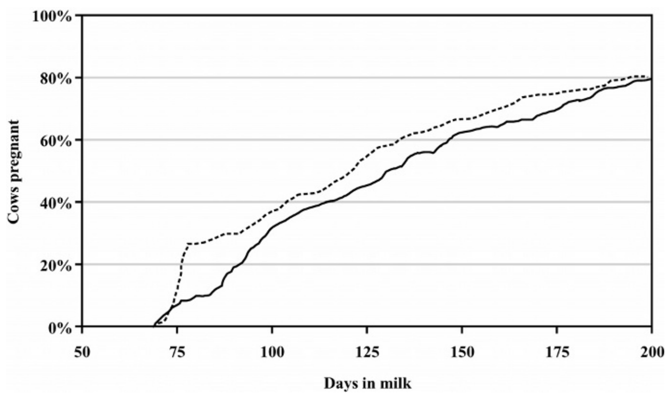

Figure 1. Proportions of cows pregnant in herd 1 for cows inseminated after synchronized ovulation (OvSynch; – –) or inseminated based on detected estrus (—) over 200 d of lactation in herd 1.

of the relative rate of incidence densities included 1, i.e., the difference was not significant (Table 2).

Herd 2. In herd 2, 289 cows were assigned to OvSynch 2 and 361 to IDE 2. Overall reproductive performance was improved for OvSynch 2. Submission rate for AI of OvSynch 2 cows was four times that of IDE 2 cows (84.4 vs. 21.6%, $P < 0.05$). Days to first service and days open were 44 and 23 d lower in OvSynch 2, respectively. Conception rates to first service (49.8 vs. 35.6%) and to all services (49.7 vs. 39.0%) were significantly ($P < 0.05$) higher in IDE 2. Percentages of cows pregnant in the two treatment groups in herd 2 over the course of the trial is given in Figure 2. At the end of the observation period, significantly ($P < 0.05$) more cows were pregnant in OvSynch 2 (78.9%) than in IDE 2 (61.8%). The incidence density for pregnancies was higher in OvSynch 2 than in IDE 2. The relative rate of incidence densities for pregnancies in the two groups was 1.62 (95% CI: 1.28 to 2.04).

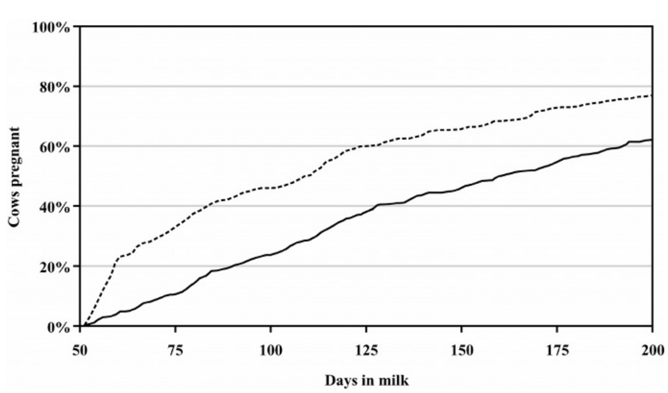

Figure 2. Proportions of pregnant cows in herd 2 for cows inseminated after synchronized ovulation (OvSynch; – –) or inseminated based on detected estrus (—) over 200 d of lactation in herd 2.

At the examination at 35 to 41 DIM, 35.7% of cows were treated for endometritis. The figures did not differ significantly between OvSynch 2 and IDE 2 (34.6 vs. 36.6%). In OvSynch 2 cows, no significant difference was observed between cows with and without signs of endometritis at this examination. In cows with endometritis, conception rate to first service was 39.0% and pregnancy rate at 200 DIM was 81.0%. Average days open were 98.6 ± 39.1 d (mean ± SD). In IDE 2, conception rate to first service was significantly lower in cows with endometritis than in cows without endometritis (41.7 vs. 55.8%, $P < 0.05$). However, neither pregnancy rate by 200 DIM nor days open in pregnant cows differed significantly between cows with and without endometritis.

Cows in IDE 2 that received OvSynch. In IDE 2, 99 of 361 cows (27.2%) received an OvSynch once during the observation period. Of the 99 cows, 67 cows had not been inseminated before. First service in those 67 cows was at 151.3 ± 27.3 DIM (mean ± SD) with conception rate to TAI at 35.8%. Another 32 cows received OvSynch after a negative pregnancy diagnosis. The OvSynch regimen was completed with TAI at 170.6 ± 26.6 DIM in those 32 cows with a conception rate of 40.6%.

Overall, 46 of 99 cows (46.5%) in the IDE 2 group that received OvSynch were pregnant at 200 DIM with an overall conception rate of 29.9% (46/154). Mean days open in these cows were 160.8 ± 28.4 d. The incidence density for pregnancies was 2.6 pregnancies per 1000 cow days at risk.

Economic Analysis

Data for the economic calculations are presented in Tables 3 and 4. In herd 1, the differences in total costs per pregnancy were small between treatments. However, in all scenarios the IDE program was economically superior to the OvSynch protocol.

In herd 2, total costs per pregnancy were higher in IDE 2 than in OvSynch 2. This was mainly due to more cows that were culled and more open days among cows not culled (Table 3). Cost for drugs and treatments and costs for AI were higher in OvSynch 2. In none of the scenarios was the IDE program economically superior. However, the extent of differences between the two programs varied among scenarios examined.

The distribution of costs among the different cost items within a protocol varied substantially between the programs. Overall, differences were larger between OvSynch and IDE protocols than between the OvSynch protocols across herds. Differences between the IDE groups across herds were mainly associated with differences in reproductive performance.

Table 3. Overview of cost items in herds 1 and 2 for cows inseminated after synchronized ovulation (OvSynch) or inseminated based on detected estrus (IDE).

		No. of items per group[2]			
Cost factor	Range of prices (€)[1]	OvSynch 1	IDE 1	OvSynch 2	IDE 2
GnRH	2.50 to 10.50	580	16	876	536
$PGF_{2\alpha}$	1.00 to 9.00	300	165	438	473
Artificial insemination	5.00 to 45.00	386	348	585	449
Injection	1.00 to 5.00	863	181	1314	1009
Rectal palpation	1.50 to 5.50	397	464	428	1124
Days open	0.50 to 4.50	4764	5971	4827	8093
Culling	250.00 to 1050.00	40	38	61	138
Pregnancies		200	198	289	361

[1]€ = euro monetary unit.

[2]The numbers in each treatment group column represent the number of times each cost factor was used or occurred in that treatment group. OvSynch 1 and IDE 1 are for herd 1; Ovsynch 2 and IDE 2 are for herd 2.

Costs associated with culling and replacement accounted for half of the costs in the OvSynch groups and IDE 1 (47.6 to 51.8%), while it accounted for 68% in IDE 2 (Table 5). Days open between 85 DIM and pregnancy accounted for a higher proportion of costs in herd 1 than in herd 2. Within herd 1, the share attributed to days open was lower in OvSynch 1 than in IDE 1 (21.9 vs. 30.0%). In herd 2, the proportion of costs for additional days open did not differ between groups but total cost of days open was higher in IDE 2 than in OvSynch 2. As expected, costs for GnRH and $PGF_{2\alpha}$ were higher for OvSynch groups and costs associated with additional days open were lower. In the OvSynch groups, costs for hormones and treatments accounted for 13.6 and 14.6% of the total costs, respectively, whereas costs for examination of cows were of minor importance (2.3 and 1.7%). In IDE 1, costs for hormones and treatment were minimal (3.0%), whereas in IDE 2, hormones and drugs accounted for 6.5% of all costs. Costs for AI accounted for 15% of all costs in the both herds for OvSynch groups and for IDE in herd 1, but cost for AI was only 7.2% of total costs in IDE 2.

Because the proportion of cows pregnant at 200 DIM did not differ between the 2 protocols in herd 1 (Figure 1), variation in price assumptions for culling a cow had a minor impact on the difference between the 2 programs. Variation in losses associated with additional days open had a stronger impact on the difference. However, it did not change the relationship between programs (Figure 3).

In herd 2 changes in the assumption for costs associated with culling and replacing a cow had a major impact on the difference between OvSynch and IDE. However, there was no breakeven point for the protocols in the range of cost scenarios analyzed. Although days open differed significantly between the two groups in herd 2, changes in price assumptions for each day open had a smaller influence on the economic comparison of the programs, because its proportion of the total costs was similar in the 2 groups.

DISCUSSION

The OvSynch regimen proved to be superior considering just the reproductive performance in both herds. The benefit resulted from higher AI submission rates, which is in accordance with the concept of OvSynch (Pursley et al., 1995). Conception rates on first TAI were lower compared to conception to first service in the IDE groups. This has also been observed previously.

Table 4. Summary data on the comparison of costs per pregnancy for cows inseminated after synchronized ovulation (OvSynch 1, Ovsynch 2) or inseminated based on detected estrus (IDE 1, IDE 2) in herds 1 and 2, respectively. Data from 63 cost scenarios.

Variable	OvSynch 1	IDE 1	OvSynch 2	IDE 2
Average cost per pregnancy	272.43	251.11	263.75	363.16
(1€, mean ± standard deviation)	±25.12	±25.54	±24.83	±39.50
Range (€) Minimum	190.50	172.91	177.34	208.90
Maximum	350.50	326.44	346.20	514.75
Difference OvSynch – IDE	21.43		–99.41	
(€, mean and range)	8.15 to 34.92		–31.59 to –168.55	

[1]€ = euro monetary unit.

Table 5. Relative importance of cost factors per pregnancy (based on average costs for each factor) in the 4 groups in herds 1 and 2 for cows inseminated after synchronized ovulation (OvSynch) or inseminated based on detected estrus (IDE).

	Herd 1		Herd 2	
	OvSynch 1	IDE 1	OvSynch 2	IDE 2
Days open > 85 d	21.9%	30.0%	15.9%	15.6%
Culling	47.6%	49.6%	51.8%	68.1%
Artificial insemination	14.7%	14.5%	15.9%	7.2%
Hormones and treatment	13.6%	3.0%	14.6%	6.5%
Examinations	2.3%	2.9%	1.7%	2.7%

However, in several studies the difference was not significant (Stevenson et al., 1996, 1999; Pursley et al., 1997; Jobst et al., 2000; Klindworth et al., 2001). The major difference between the 2 herds was that the proportion of cows pregnant in the IDE program in herd 1 was equal to the proportion pregnant for the OvSynch protocol at the end of the observation period. The proportion of pregnant animals in the course of lactation was substantially higher in the OvSynch protocol early after the voluntary waiting period in both herds. This is in agreement with a report by De la Sota et al. (1998). Whereas in herd 2, a difference of about 20 percentage units was constant throughout the observation period, the difference diminished in herd 1 (Figures 1 and 2). Most of the benefit was lost, when estrus was induced using $PGF_{2\alpha}$ after 92 DIM in IDE 1. The major difference between the two IDE groups was the AI submission rate, which was about twice as high in herd 1 than in herd 2. Although direct comparison between the 2 IDE groups is not scientifically valid, it points out the major benefit of OvSynch, i.e., the increase in AI submission rates. Submission rates for AI below 100% in the 2 OvSynch protocols were caused by several conditions of the cows such as lameness, clinical mastitis, or clinical signs of endometritis at the start of or during the synchronization protocol. On both farms it was the herdsman's policy to postpone AI in such cases. This policy was adopted for both treatment groups in both herds. Therefore cows with postponed synchronization and AI were not removed from the analysis.

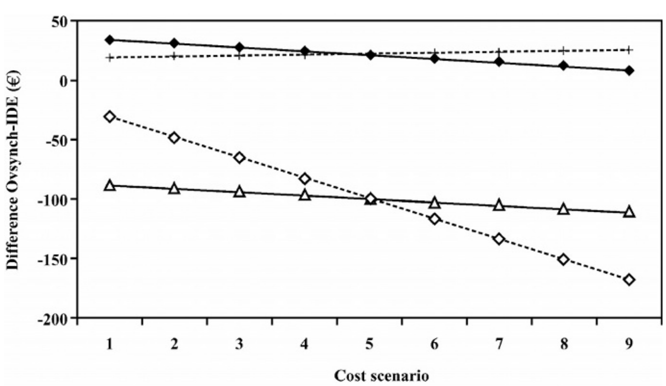

Figure 3. Sensitivity analysis for differences in total costs per pregnancy in herds 1 and 2 between groups inseminated after synchronized ovulation (OvSynch) or groups inseminated based on detected estrus (IDE). Price assumptions in euro monetary units (€) are for costs associated with culling (herd 1 – – + – –, herd 2 –◇–) and days open (herd 1 —◆—, herd 2 –△–). Cost scenario 1 = minimum assumption for culling (250 €) or days open (0.50 €). Cost scenario 9 = maximum assumption for culling (1050 €) and one day open (4.50 €).

Submission rates for AI were similar in the two OvSynch groups and considerably higher than in both IDE groups. The difference was much greater during the first 21 d after the end of the VWP than later. Interventions that were started in the IDE groups at 92 and 80 DIM for herds 1 and 2, respectively, increased the AI submission rates considerably. This effect was stronger in IDE 1 than in IDE 2. Average AI submission rates of 55% in IDE 1 over the whole observation period are higher than those used for IDE protocols in calculations by Risco et al. (1998) and LeBlanc (2001). This probably reduced the benefit of OvSynch in the current study compared with those studies. Submission rates for AI in IDE 1 cows were similar to the AI submission rates for first service in the study by Britt and Gaska (1998). However, in the latter study, conception rates were poorer in the IDE group than in OvSynch group, which was not the case in either herd in the current study as conception rates tended to be higher in the IDE groups in our study. This could partially explain differences in the economic evaluation between herd 1 and the report of Britt and Gaska (1998).

The AI submission rate for the total trial period in OvSynch 1 was also higher than the estimates of LeBlanc (2001; 69.6 vs. 62%). This was probably associated with the additional use of estrous detection for nonpregnant cows in this group that has been assumed to be beneficial (LeBlanc, 2001; Tenhagen et al., 2001a). Submission rates for AI for the total period studied in each herd were slightly higher in OvSynch 1 than in OvSynch 2. This can be explained by an earlier pregnancy diagnosis in herd 1 and higher detection of estrus efficiency on this farm.

There has been some concern about pregnancy losses after early pregnancy diagnosis (Cartmill et al., 2001, Chebel et al., 2003). However, in an earlier study in herd 1, we found only 1% cows not pregnant at rectal palpation on d 40 that had been diagnosed pregnant with ultrasound between d 29 and 35 (Mueller et al., 1999). In herd 1, first-service conception rates in cows, which were examined for pregnancy by ultrasound, did not differ from those examined by rectal palpation about 10 d later. Therefore it may be assumed, that pregnancy loss during this interval was minor in herd 1. Whether the results in herd 2 would have been changed by an earlier PD is not clear. An earlier pregnancy diagnosis increases the risk of false positives, because pregnancies that are detected early are subject to more days at risk for losses. On the other hand, later diagnosis of pregnancy increases the time to reinsemination of nonpregnant cows.

Conception rates between herds for IDE groups were comparable. They were higher than recently reported for the United States (Washburn et al., 2002). Conception rates in the OvSynch groups were comparable to those reported in recent studies (Jobst et al., 2000; Cartmill et al., 2001; Peters and Pursley, 2002). In both herds, conception rates tended to be lower in the OvSynch groups. In herd 2, this difference was significant. This also conflicts with the assumptions and reports of other studies on the economics of OvSynch (Britt and Gaska, 1998; Nebel and Jobst, 1998; Risco et al., 1998; LeBlanc, 2001). The reasons for the differences in conception rates are not known. They were observed in both herds and the conception rates in the OvSynch groups did not differ between the two herds. In another recent study carried out in herd 1, 87% of the cows synchronized with OvSynch ovulated within 40 h after the second GnRH treatment (Wittke et al., 2003), which is similar to other studies (Vasconcelos et al., 1999). Therefore, lack of synchronization is not a likely cause for differences in conception rates in herd 1. For the cows in herd 2, there is no information on synchronization rate. However, the difference in conception rate between OvSynch and IDE groups is similar in the two herds, therefore we do not assume that lack of synchronization was a major problem in herd 2 either.

In herd 1, the increase in reproductive efficiency was not sufficient to offset the costs for synchronization. This finding is related to the cost structure assumed for the analysis. The objective was to evaluate the differences between the 2 protocols compared in the respective herds and not to describe the absolute values in the groups. The model used in our study simplifies cost structures as it does not try to deduce costs associated with days open or culling from data from the specific farm. It can be assumed that within the same farm, the price level for most cost items was identical for both groups and therefore could be neglected. To account for differences in cost structures between farms, years, and country-specific cost items were varied over a wide range in a sensitivity analysis and the change of the relative costs in both herds was observed. Most assumptions were similar to studies previously published (Tenhagen et al., 1998; Drillich et al., 2002). However, due to a sharp drop in carcass value following the BSE crisis, costs per culling increased and the price assumptions were adjusted accordingly.

The assumptions are also in line with other studies on the economics of OvSynch (Britt and Gaska, 1998; Nebel and Jobst, 1998; Risco et al., 1998; LeBlanc, 2001). Consequently, the contribution of the different cost factors to the overall costs is also similar. Costs for culling and additional days open are the major cost items, followed by semen and drugs (Risco et al., 1998; LeBlanc, 2001). In agreement with Risco et al. (1998) and LeBlanc (2001), the major benefit of OvSynch resulted from the reduction in culling and days open, while hormone costs were higher in the OvSynch groups. However, in herd 1, proportions of cows that were not pregnant by 200 DIM were similar in the two groups. Therefore, the difference was smaller.

Costs associated with estrous detection were not included in the cost analysis. One claimed benefit of OvSynch is to reduce the workload because detection of estrus is not necessary in the protocol. However, this is only valid if all cows are synchronized and no detection of estrus is carried out. This was not realized in our study, because cows were observed for estrus after the first timed AI in the OvSynch groups. As the first insemination was shortly after the end of the voluntary waiting period, time spent on estrus detection was practically not reduced in the OvSynch groups compared with the IDE groups and was therefore not included in the economic analysis.

In herd 1, costs per pregnancy were lower for IDE 1 compared with OvSynch 1 over all scenarios, although reproductive performance was better. However, the difference between the 2 groups was small (€8.15 to 34.92 per pregnancy). This supports the report of Nebel and Jobst (1998) who recognized that drug costs might well offset benefits associated with synchronization protocols.

In herd 2, costs per pregnancy were lower in OvSynch 2 over all cost scenarios calculated. The difference between the 2 protocols was highly influenced by the estimated costs associated with a culled cow. The maximum difference was €168.55 per pregnancy, the minimum €31.60. The difference in herd 2 between the OvSynch group and the IDE group was in the range of other studies that found benefits of OvSynch (Risco et al., 1998; LeBlanc, 2001). Although conception rates were higher in the IDE group, the low AI submission rate of 28.6% reduced the pregnancy rate far below the pregnancy rate of the OvSynch group.

The results of the 2 trials indicate that the use of OvSynch is highly effective for controlling days to first service by achieving high AI submission rates. However, if the protocol is compared to a control protocol with comparatively high AI submission rates as in herd 1, the benefits are lost in the period between timed AI and resynchronization after pregnancy diagnosis. Decreasing the time-lag between 2 OvSynch cycles by starting resynchronization before PD has been attempted but was not successful (Moreira et al., 2000). The use of ultrasound for early PD will reduce the interval from AI to PD to 29 d (Mueller et al., 1999). This might have been beneficial in the 2 OvSynch groups. However, early PD is also beneficial in conventional reproductive management (Thompson et al., 1995). Therefore it is not likely that it would have changed the differences in reproductive performance substantially. Furthermore, in herd 2, OvSynch was highly beneficial although PD was at 42 to 48 d after AI.

Close observation of synchronized cows at 18 to 24 d after AI combined with AI on observed estrus has also been proposed (LeBlanc, 2001; Tenhagen et al., 2001a). However, this protocol requires effective estrus detection routines and unsatisfactory estrus detection efficiency will be the reason for introducing synchronization protocols in most cases. On the other hand, estrus detection that can focus on certain cows or groups may be more effective than general estrus detection. This effect is used with $PGF_{2\alpha}$-based protocols that do not use timed AI. This approach could not be realized in our trial as the IDE group had to be observed for estrus anyway. It is not realistic to implement two different levels of intensity of estrus detection in one group of cows under field conditions. However, AI submission rates of considerably more than 62% during the trial period may be associated with the detection of nonpregnant cows in estrus before PD.

In herd 2, some of the IDE cows also received OvSynch. However, use of OvSynch was not systematic in this group. Removing those animals from the analysis would have caused more bias as they were regarded as problem cows by the herdsman. This is underlined by the reproductive performance of those cows, which was worse in all aspects than that of the rest of the cows in IDE 2. This was probably not due to use of OvSynch in these cows because their conception rates after TAI were similar to those of the cows in OvSynch 2. However, OvSynch was initiated later postpartum and therefore there was less time left for them to become pregnant. It is likely that the reproductive performance of IDE 2 would have been even worse without the use of OvSynch in these cows.

Reproductive performance of cows with signs of endometritis at 35 to 41 DIM was similar to the rest of the group in OvSynch 2. In two recent studies, we also found similar conception rates in cows that had been treated for endometritis in the postpartum period and cows without endometritis in the postpartum period (Tenhagen et al., 2001b, 2003). In IDE 2 conception rate to first service was lower than in cows without endometritis. However, the proportion of pregnant cows at 200 DIM and days open in pregnant cows did not differ. Therefore no separate economic analysis was carried out for cows with endometritis.

Some authors used OvSynch only for first insemination and then used traditional reproductive management (De la Sota et al., 1998; Jobst et al., 2000; Klindworth et al., 2001). This approach does not aim at abolishing estrus detection but combines maximum first-service AI submission rates with estrus detection for further services to limit use of hormones in reproductive management. In herd 1, the IDE protocol managed to catch up with the OvSynch protocol in the course of lactation. This is an indication that this approach may be reasonable on farms that can realize acceptable estrus detection rates. Reducing the time-span to resynchronization in the OvSynch group could be another alternative, but the efficacy of early resynchronization protocols is controversial (Moreira et al., 2000, Chebel et al., 2003).

The results of this study indicate that the benefit from OvSynch is more pronounced in farms with low estrus detection efficiency. This is in accordance with previous reports (Mialot et al., 1999; LeBlanc, 2001). On farms with acceptable estrus detection efficiency, OvSynch may be of limited value even if it increases reproductive efficiency to some extent. Although reproductive performance remains the key criterion to evaluate reproductive management protocols, costs for drugs and treatment should not be neglected. In synchronization protocols, those costs might account for a substantial proportion of total costs and offset minor benefits in reproductive performance.

Further research is required to increase conception rates after OvSynch and to compare benefits from OvSynch to other methods of increasing AI submission rates.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of Intervet Deutschland GmbH and the cooperation of the farms.

REFERENCES

Britt, J. S., and J. Gaska. 1998. Comparsion of two estrus synchronization programs in a large, confinement housed dairy herd. JAVMA 212:210–212.

Cartmill, J. A., S. Z. El-Zarkouny, B. A. Hensley, G. C. Lamb, and J. S. Stevenson. 2001. Stage of cycle, incidence, and timing of ovulation, and pregnancy rates in dairy cattle after three timed breeding protocols. J. Dairy Sci. 84:1051–1059.

Chebel, R. C., J. E. P. Santos, R. L. A. Cerri, K. N. Galvão, S. O. Juchem, and W. W. Thatcher. 2003. Effect of resynchronization with GnRH on day 21 after artificial insemination on pregnancy rate and pregnancy loss in lactating dairy cows. Theriogenology 60:1389–1399.

De la Sota, R.L., J. M. Burke, C. A. Risco, F. Moreira, M. A. DeLorenzo, and W. W. Thatcher. 1998. Evaluation of timed insemination during summer heat stress in lactating dairy cattle. Theriogenology 49:761–770.

Drillich, M., B.-A. Tenhagen, E. Birkelbach, and W. Heuwieser. 2002. Einfluss von Ovarialzysten bei Milchkühen auf die Effektivität zweier Fruchtbarkeitsprogramme. Tieraerztl. Prax. 30 (G):138–143.

Grunert, E. 1982. Rektale Untersuchung. Pages 81–97 in Fertilitätsstoerungen beim weiblichen Rind, 2. Edition. E. Grunert, and M. Berchtold ed. Paul Parey Verlag, Berlin and Hamburg, Germany.

Jobst, S. M., R. L. Nebel, M. L. McGilliard, and K. D. Pelzer. 2000. Evaluation of reproductive performance in lactating dairy cows with prostaglandin $F_{2\alpha}$, gonadotropin-releasing hormone, and timed artificial insemination. J. Dairy Sci. 83:2366–2372.

Klindworth, H.-P., M. Hoedemaker, D. Burfeindt, and T. Heilenbrinker. 2001. Ovulationssynchronisation (OVSYNCH) in hochleistenden Milchviehherden: I. Fruchtbarkeitsparameter, Body Condition Score und Plasmaprogesteronkonzentration. Dtsch. tierärztl. Wschr. 108:11–19.

LeBlanc, S. 2001. The OvSynch breeding program for dairy cows—A review and economic perspective. Bov. Pract. 35:13–22.

Mialot, J. P., G. Laumonnier, C. Ponsart, H. Fauxpoint, E. Barassin, A. A. Ponter, and F. Deletang. 1999. Postpartum subestrus in dairy cows: comparison of treatment with prostaglandin $F_{2\alpha}$ or GnRH + prostaglandin $F_{2\alpha}$ + GnRH. Theriogenology 52:901–911.

Moreira, F., C. Orlandi, C. A. Risco, R. Mattos, F. Lopes, and W. W. Thatcher. 2001. Effects of presynchronization and bovine somatotropin on pregnancy rates to a timed artificial insemination protocol in lactating dairy cows. J. Dairy Sci. 84:1646–1659.

Moreira, F., C. A. Risco, M. F. A. Pires, J. D. Ambrose, M. Drost, M. DeLorenzo, and W. W. Thatcher. 2000. Effect of body condition on reproductive efficiency of lactating dairy cows receiving a timed insemination. Theriogenology 53:1305–1319.

Mueller, K., M. Drillich, B.-A. Tenhagen, and W. Heuwieser. 1999. Genauigkeit und Wirtschaftlichkeit einer Trächtigkeitsuntersuchung mittels Ultraschall zwischen dem 20. und 34. Tag nach der künstlichen Besamung beim Rind. Teil 1: Genauigkeit. Prakt. Tierarzt. 80:1097–1104.

Nebel, R. L., and S. M. Jobst. 1998. Evaluation of systematic breeding programs for lactating dairy cows: A review. J. Dairy Sci. 81:1169–1174.

Peters, M. W., and J. R. Pursley. 2002. Fertility of lactating dairy cows treated with OvSynch after pre-synchronization injections of $PGF_{2\alpha}$ and GnRH. J. Dairy Sci. 85:2403–2406.

Pursley, J. R., M. O. Mee, and M. C. Wiltbank. 1995. Synchronization of ovulation in dairy cows using $PGF_{2\alpha}$ and GnRH. Theriogenology 44:915–923.

Pursley, J. R., M. R. Kosorok, and M. C. Wiltbank. 1997. Reproductive management of lactating dairy cows using synchronization of ovulation. J. Dairy Sci. 80:301–306.

Risco, C. A., F. Moreira, M. DeLorenzo, and W. W. Thatcher. 1998. Timed artificial insemination in dairy cattle—Part II. Comp. Cont. Educ. Pract. Vet. Food Anim. 20:1284–1289.

Stevenson, J. S., Y. Kobayashi, M. Shipka, and K. C. Rauchholz. 1996. Altering conception of dairy cattle by Gonadotropin-releasing hormone preceding luteolysis induced by prostaglandin $F_{2\alpha}$. J. Dairy Sci. 79:402–410.

Stevenson, J. S., Y. Kobayashi, and K. E. Thompson. 1999. Reproductive performance of dairy cows in various programmed breeding systems including OvSynch and combinations of gonadotropin-releasing hormone and prostaglandin $F_{2\alpha}$. J. Dairy Sci. 82:506–515.

Tenhagen, B.-A., M. Tischer, W. Heuwieser, and H. Blum. 1998. Use of sensitivity analysis to economically evaluate reproductive management programs in dairy herds. Pages 663–668 in Proc. 20th World Buiatrics Congress, Sydney.

Tenhagen, B.-A., M. Drillich, and W. Heuwieser. 2001a. Management aspects and economics of OvSynch-Protocols in dairy herds. Pages 74–77 in Proc. III. Middle-Europ. Congr. Buiatr.—Health Problems in Ruminants. Milovy, CZ, Czech Assoc. Buiatrics, Brno.

Tenhagen, B.-A., M. Drillich, and W. Heuwieser. 2001b. Analysis of cow factors influencing conception rates after two timed breeding protocols. Theriogenology 56:831–838.

Tenhagen, B.-A., C. Vogel, M. Drillich, G. Thiele, and W. Heuwieser. Influence of stage of lactation and milk production on conception rates after timed artificial insemination following Ovsynch. Theriogenology 60:1527–1537.

Thompson, J. A., W. E. Marsh, W. G. Etherington, H. W. Momont, and M. L. Kinsel. 1995. Evaluation of the benefits of the timing of pregnancy testing by transrectal palpation in dairy cattle. JAVMA 207:1462–1465.

Vasconcelos, J. L. M., R. W. Silcox, G. J. M. Rosa, J. R. Pursley, and M. C. Wiltbank. 1999. Synchronization rate, size of the ovulatory follicle, and pregnancy rate after synchronization of ovulation beginning on different days of the estrous cycle in lactating dairy cows. Theriogenology 52:1067–1078.

Washburn, S. P., W. J. Silvia, C. H. Brown, B. T. McDaniel, and A. J. McAllister. 2002. Trends in reproductive performance in southeastern Holstein and Jersey DHI herds. J. Dairy Sci. 85:244–251.

Wittke, M., M. Drillich, B.-A. Tenhagen, and W. Heuwieser. 2003. Effects of an Ovsynch protocol in a dairy herd on conception rate and comparison with a prostaglandin $F_{2\alpha}$ program. Wien. Tieraerztl. Mschr. 90 (Suppl) 1:29.

Woodward, M. 1999. Epidemiology. Study Design and Data Analysis. Chapman and Hall/CRC, London, UK.