Reproductive Management with Ultrasound Scanner-monitoring System for a High-yielding Commercial Dairy Herd Reared under Stanchion Management Style

M. Takagi[1,] *, N. Yamagishi[2], I. H. Lee[1], K. Oboshi[2], M. Tsuno[1] and M. P. B. Wijayagunawardane[3]

[1]Department of Veterinary Clinical Sciences, Obihiro University of Agriculture and Veterinary Medicine
Obihiro, 080-8555 Japan

ABSTRACT : The weekly ultrasound scanner (US) observations of reproductive organs in a commercial dairy herd with the popular stanchion style management were conducted for over 26 months. Based on reproductive records, the following were evaluated: 1) the effect of postpartum period commencement of US monitoring on herd reproductive efficacy, and 2) the effectiveness of a US monitoring-based diagnosis and subsequent treatments of reproductive disorders on postpartum reproductive efficiency. The reproductive parameters of cows, which were subjected to US monitoring between Days 30-40 (Day 0 = day of parturition), Days 41-50, Days 51-60, and above Day 61, were compared. The reproductive parameters of cows diagnosed as having reproductive disorders (RD) with US monitoring before or after the first artificial insemination (AI) were also compared. It was found that the day of commencement of US monitoring in cows diagnosed with and without RD significantly affected the period towards the first AI and the open period. In particular, cystic follicles and anoestrus detected either before or after the first AI significantly affected herd reproductive efficiency. The implementation of US monitoring improved reproductive efficiency by reducing the open period and increasing the number of milking cows in the herd. The results of this field trial indicate that the postpartum reproductive management of dairy cows with the use of the US monitoring system is one strategy to improve reproductive efficiency, especially in a high-yielding dairy herd reared stanchion management style. *(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 7 : 949-956)*

Key Words : Dairy Herd, Reproductive Management, Ultrasound Scanner

INTRODUCTION

Optimal reproductive performance in a dairy herd is imperative for maximizing profitability (Roche et al., 2000; Wiltbank et al., 2002). Several attempts have been made to improve postpartum reproductive efficiency, including monitoring of ovarian activity by observing either the levels of serum steroids/gonadotropins (Rajamahendran and Taylor, 1990; Savio et al., 1990a, b), or milk progesterone (P4) profiles (Lamming and Darwash, 1998; Opsomer et al., 1998), enhancement of oestrus detection (Van Vliet and Van Eerdenburg, 1996; Lyimo et al., 2000), and oestrus/ ovulation synchronisation (Pursley et al., 1995; Keister et al., 1999; Tallam et al., 2001). Despite these efforts, reproductive efficiency has declined during the past two decades in parallel with marked increases in milk production (Beam and Butler, 1999; Roche et al., 2000; Lucy, 2001). It has been suggested that one of the major causes of this reduction is related to the increased incidence of negative energy balance in peri and early postpartum periods (Beam and Butler, 1999; Rukkwamsuk et al., 1999a, b; Butler, 2000; Roche et al., 2000).

The success rate of oestrus detection based on behavioural and physiological changes is rather low (Foote, 1975; Senger, 1994), perhaps due to the low intensity of oestrus behaviour in high yielding cows (Van Vliet and Van Eerdenburg, 1996). Although the use of the oestrus detection aids such as heat mount detectors or pedometers becomes important, the popular stanchion style management of modern high yielding dairy herds, especially in Hokkaido, Japan, often precludes this possibility. Therefore most of the veterinarians and dairy farmers believe that the periodical examination of reproductive organs, usually by rectal palpation, is effective to grasp the oestrous cycle and to improve reproductive efficiency.

In routine clinical practice of commercial dairy farms, ultrasound scanning (US) is one of the useful tools to monitor reproductive organs since the US monitoring technique has been reported to be an accurate and reliable method of observing dynamic changes in ovarian structures (Pierson and Ginther, 1984; Rajamahendran et al., 1994) and determining the patterns of postpartum resumption of ovarian activity (Rajamahendran and Taylor, 1990; Savio et al., 1990a, b). Moreover, the US technique can be

* Corresponding Author: Mitsuhiro Takagi. Department of Farm Animal Production Medicine, Kagoshima University, Kagoshima, 890-0065, Japan. Tel: +81-99-285-8672, Fax: +81-99-285-8672, E-mail: mtakagi@agri.kagoshima-u.ac.jp
[2] Research Center for Animal Hygiene and Food Safety, Obihiro University of Agriculture and Veterinary Medicine, Obihiro, 080-8555 Japan.
[3] Department of Animal Science, University of Peradeniya, Peradeniya, Sri Lanka.

efficiently utilized in the early detection of silent oestrus, anoestrus and cystic ovarian conditions, and thus, useful in reducing the calving interval (Taylor and Rajamahendran, 1991).

In this report, we summarised the reproductive records monitored weekly with the use of US observations combined with rectal palpation. The study was done under field conditions in a high-yielding dairy herd managed under the popular stanchion style management. The aims of the present study were 1) to clarify the effect of postpartum periods where the weekly reproductive management commenced with the use of US monitoring on the reproductive efficacy of the herd, and 2) to evaluate the effectiveness of US monitoring-based diagnosis and subsequent treatments of reproductive disorders on postpartum reproductive efficiency. To the best of our knowledge, periodically US monitored reproductive data, based on the observations derived from ovarian and uterine characteristics, have not been studied under field conditions, especially in Japan.

MATERIALS AND METHODS

Dairy herd

In the present study, the high yielding Holstein Friesian dairy herd was located in a commercial dairy farm near Obihiro City, Japan, where ambient temperature ranging from -20°C to 35°C between winter and summer season. All cows were managed in tied up stanchions throughout the year, and received a mixture of grass silage and concentrate twice daily according to their requirements. The mean age of the herd was 3.5 years (ranged from 2 to 10 years), and the mean lactation number was 2.5 with a mean milk production of 10,800 kg per 305 days. The Veterinary Teaching Hospital, Obihiro University of Agriculture and Veterinary Medicine was consulted by the owner of this dairy herd in October 2000. The weekly US monitoring system of reproductive organs in non-pregnant lactating cows was started thereafter. Before commencement of the US monitoring system in October 2000, the herd received typical postpartum reproductive management of stanchion style. In general, artificial insemination (AI) was based on signs of oestrus behaviour at the time of either milking or feeding on an a.m.- p.m.- breeding schedule. The signs observed included hyperrmia and swelling of vulva, discharge of cervical mucus and bellowing. Additionally, per-rectal pregnancy diagnosis was performed by local veterinarians approximately 60 days after the last AI. If the cows did not become pregnant within 60 days postpartum, per rectal examination for reproductive disorders and subsequent treatments were conducted by the local veterinarians.

Implementation of periodical US monitoring of reproductive organs to improve the reproductive efficiency of the herd

Weekly routine US monitoring of reproductive organs was started, beginning one month postpartum using a linear array US scanner equipped with a 5 MHz rectal probe (Aloka, Super Eye SSD-500, Tokyo, Japan). At the first monitoring (fresh check), special attention was paid to the postpartum conditions of both the uterus and ovary. US monitoring was performed to confirm the parameters of both the uterus and ovaries obtained by rectal palpation. Previous studies (Fissore et al., 1985; Kahn and Leidl, 1989) reported that uterine pathological conditions could be detected by using the US technique. The pathological conditions, which included endometritis and pyometra, are characterized by a distended uterine lumen with varying degrees of partially echogenic "snowy" patches with the presence of active CL in the ovary. In the fresh check, cows diagnosed as having a uterine pathological condition were immediately treated with prostaglandin F2α (PGF2α: dinoprost 25 mg, IM) to regress the active CL and to subsequently discharge uterine fluids.

At the fresh check, the ovaries were monitored simultaneously in several planes and all the follicles >5 mm in diameter and CL >10 mm in diameter were identified. Based on the findings of fresh check, the cows were divided into 3 categories: 1) presence of CL; 2) absence of CL; and 3) cystic ovaries (follicles with diameter >30 mm). Previous reports suggested that US observations of follicular cysts reveal large (25-55 mm) non-echogenic very thin walled areas. On the contrary, luteal cysts were reported to appear as non-echogenic areas surrounded by echogenic tissue of varying thickness (Edmondson et al., 1986; Caroll et al., 1990; Farin et al., 1990). Depending on the above criteria, in the present study, all the cows with cystic ovaries were diagnosed as having follicular cysts.

Based on the CL characteristics and cyclic changes of the CL, possible occurrence of the next heat the following week was predicted, and the herdsmen were informed to make close observations of oestrus signs. The cows without CL at the fresh check were continuously monitored for a further 2 weeks (3 consecutive monitoring), and the cows detected to have developed CL during this monitoring period were scheduled for AI based on prior prediction of the day of next heat. The cows with no ovulation and CL development during the three consecutive monitorings were diagnosed to be in anoestrus. These anoestrus cows had some follicular developments and thus, ovulation was induced with GnRH analogue (fertirelin acetate 100 μg; IM) immediately after scanning. The cows with cystic ovaries at the fresh check were also treated with GnRH analogue immediately after monitoring to prevent postpartum anoestrus. The cows diagnosed with prolonged

Table 1. Effect of commencement of US monitoring after parturition on the reproductive efficiency (Mean±SEM) of the herd

Days after parturition	Days to first AI after parturition	No. of monitoring until first AI	Open period*
With RD			
Day 30-40 (n = 21)	77.5±6.1[a]	5.7±0.6	94.8±11.2 (n = 14)[a]
Day 41-50 (n = 6)	92.3±8.6[c]	6.0±0.9	153.3±54.9 (n = 4)
Day 51-60 (n = 5)	113.0±3.8[b]	7.4±0.7	176.8±29.2 (n = 5)[b]
More than 61 (n = 4)	132.0±4.5[bd]	8.2±1.4	132.0±4.5 (n = 4)
Without RD			
Day 30-40 (n = 24)	69.7±4.6	5.0±0.6[e]	99.3±11.4 (n = 15)[e]
Day 41-50 (n = 11)	64.1±5.9	3.1±0.6[f]	187.6±30.4 (n = 5)[f]
Day 51-60 (n = 11)	79.5±7.1	3.6±0.8	154.3±37.3 (n = 9)
More than 61 (n = 5)	74.6±9.5	2.6±0.7	127.6±36.9 (n = 5)

With RD: cows diagnosed as having reproductive disorders before the first AI.
Without RD: cows not diagnosed to be free from reproductive disorders before the first AI.
[b,c,d,e,f] Values within each column are significantly different (p<0.05).
* Open periods were derived from cows which were pregnant during the examination period.

CL (CL persist for more than 3 weeks) were treated with PGF2α analogue (dinoprost 25 mg, IM) to induce the estrus cycle after regressing the prolonged CL. The effects of each treatment for these uterine and ovarian disorders were assessed by US monitoring. Recovered cows, which contained CL in the ovary together with absence of fluid in the uterus were scheduled for AI based on the prediction of the possible occurrence of next heat as described above. In certain cows, oestrus synchronization with PGF2α analogue (dinoprost 25 mg, IM) was conducted depending on the time remaining until the occurrence of the predicted next heat, in order to reduce days until the open period.

The cows exhibiting oestrus symptoms such as hyperemia, swelling of vulva, discharge of cervical mucus and bellowing were inseminated. The cows with oestrus symptoms 3 weeks post-breeding were bred again. If signs of oestrus were not observed thereafter, pregnancy diagnosis with US monitoring was conducted around 40 days after the last AI. Weekly US monitoring and appropriate treatments were resumed with non-pregnant cows as described above.

Clinical information of both uterine and ovarian conditions derived from weekly records of US observations in individual cows was utilized to make a reproductive database of the herd.

Evaluation of the effects of postpartum periods of commencing US monitoring on reproductive efficacy

The above reproductive database of cows that had calved between October 2000 and December 2001 was evaluated to determine the effect of the period of US monitoring commencement on reproductive efficacy. The postpartum reproductive management data were divided into 4 groups as follows; Days 30-40 (Day 0 = day of parturition, n = 45), Days 41-50 (n = 17), Days 51-60 (n = 16), and Day 61 and above (n = 9). Additionally, the groups were subdivided into 2 categories depending on whether the

cows were diagnosed as having reproductive disorders (RD) described above (i.e., cystic follicle, anoestrus, uterine fluid and prolonged CL) or not until the first AI. The effects of postpartum periods of commencing the US monitoring on several reproductive parameters such as the number of days to the first AI after parturition, number of US monitorings until the first AI and open period, were compared among these 8 groups.

Evaluation of the effect of reproductive disorders (RD) on reproductive efficiency

A significant reduction of the postpartum periods to the first AI and a tendency of a reduction of the open period were observed when US monitoring was commenced during the period of Day 30-40 after parturition (see Table 1). Therefore, US monitoring in the newly allocated cows (n = 121) was commenced before 40 days postpartum from January 2002. The reproductive records of the above cows were used to evaluate the effect of several RD on herd reproductive efficiency. During data analysis, cows were grouped depending on whether or not an RD was diagnosed before or after the first postpartum AI. The effect of different types of RD diagnosed on the number of days to first AI, number of monitorings until first AI, pregnancy rate after first AI, and the open periods were compared. Additionally, the efficacy of treatments used for different types of RD was evaluated. Moreover, to assess the effect of the US monitoring system on the reproductive efficiency of the herd, monthly changes of both the open period and number of milking cows during the period from April 2000 to December 2002 were screened. This was based on the reproductive records of the herd provided by the Association of Hokkaido Milk Quality Examination.

Statistical analyses

Data on the number of days to first AI, number of monitorings until first AI, and the open period of RD

Table 2. Efficacy of treatments used for different types of reproductive disorders

Reproductive disorder (No. of cows)	No. of total treatments (A)	No. of responses (No. of no response) (B)	Mean response rate (B/A)
Cystic follicle (n=39)	51	39 (12)	76.5%
Anoestrus (n=24)	33	22 (11)	66.7%
Uterine fluid (n=3)	4	3 (1)	75.0%
Prolonged CL (n=5)	5	5 (0)	100.0%

The treatments for cystic follicles and anoestrus were done using GnRH analogue (fertirelin acetate 100 μg; IM), and the treatments for uterine fluid and prolonged CL were done with PGF2α (dinoprost 25 mg, IM).

The treatment effects were evaluated by examination of luteinization of the follicular wall of cystic follicle or new development of CL with the US system in the case of cystic follicles and anoestrus, and absence of uterine fluid or regression of prolonged CL in the case of uterine fluid or prolonged CL.

US monitoring was commenced before day 40 after parturition.

diagnosed and non-diagnosed groups either before or after first AI were analysed using one-way analysis of variance (ANOVA) and a post-hoc test. Both the pregnancy rates after the first AI in RD diagnosed and non-diagnosed groups and the mean respond rate after PGF2α or GnRH treatments were compared using Chi-square tests. Probabilities of less than 0.05 (p<0.05) were considered significant. STATVIEW computer software (Abacus Concepts. Inc., Berkeley, CA) was used for statistical analysis.

RESULTS

Effect of the day of commencement of US monitoring after parturition on reproductive efficacy

Table 1 shows the reproductive records of the cows divided according to the day of commencement of US monitoring after parturition. Days to the first AI in the group of cows diagnosed as having RD were significantly lesser when US monitoring was commenced between Days 30-40 (77.5±6.1 days) than when US monitoring was

commenced either between Days 51-60 (113.0±3.8 days) or above Day 61 (132.0±4.5 days). No significant difference was observed on days to the first AI among different groups without RD. No significant differences were observed in the number of monitorings in the cows diagnosed as having RD; however, the number of monitorings made were higher in cows without RD when US monitoring was commenced between Days 30-40 (5.0±0.6 times), compared with the Days 41-50 group (3.1±0.6 times). In the group with RD, the open period of cows with US monitoring commenced between Days 30-40 (94.8±11.2 days) was significantly shorter than that of the cows with US monitoring commenced between Days 51-60 (176.8±29.2 days). In the group without RD, the open period of cows with US monitoring commenced between Days 30-40 (99.3±11.4 days) was significantly shorter than that of the cows with US monitoring commenced between Days 41-50 (187.6± 30.4 days).

Effect of RD diagnosed before or after the first AI on the reproductive efficiency of the herd

Table 2 shows the effect of treatments used for RD diagnosed either before or after the first AI. The mean response rate of GnRH treatment in cows diagnosed as having cystic follicles and anoestrus were 76.5% and 66.7%, respectively. The mean response rate of PGF2α treatment in cows diagnosed as having uterine fluid and prolonged CL were 75.0% and 100%, respectively.

Table 3 shows the reproductive records of the cows divided according to either the presence or absence of RD before the first AI. Among the 121 cows. 58 (47.9%) cows were diagnosed as having RD and required some treatment before the first AI. The number of monitoring until the first AI in anoestrus (6.1±0.5 times) and prolonged CL (7.6±0.9 times) groups were significantly higher than that in the group of cows without RD (4.0±0.3 times). However, no difference was observed on days to first AI and the pregnancy rate between RD diagnosed and non-diagnosed groups. The open period of cows diagnosed with anoestrus was significantly longer (139.1±18.9 days) than that of the cows without RD (84.0±6.0). However, no significant

Table 3. Effect of reproductive disorders (RD) treated before the first AI on the reproductive efficiency (Mean±SEM) of the herd

Types of RD (No. of cow)	Days to first AI	Number of monitoring until first AI	Pregnancy rate after the first AI	Open period*
Cows with RD (n = 58)				
Cystic follicle (n = 28)	66.7±4.7	4.7±0.5	39.3% (n = 11)	95.8±10.6 (n = 17)
Anoestrus (n = 22)	75.7±4.3	6.1±0.5 [a]	27.2% (n = 6)	139.1±18.9 (n = 16) [a]
Uterine fluid (n = 3)	66.0±20.3	3.0±1.0	0% (n = 0)	120 (n = 1)
Prolonged CL (n = 5)	87.8±11.3	7.6±0.9 [a]	20.0% (n = 1)	89 (n = 1)
Cows without RD (n = 63)	60.6±2.5	4.0±0.3 [b]	34.9% (n = 22)	84.0±6.0 (n = 41) [b]

[b] Values within each column are significantly different (p<0.05).

* Open periods were derived from cows which were pregnant during the examination period.

US monitoring was commenced before day 40 after parturition.

Table 4. Effect of reproductive disorders (RD) treated after the first AI on the reproductive efficacy (Mean±SEM) of the herd

Types of RD (No. of cows)	Day to first AI	Number of monitoring	Number of AI	Open period*
Pregnant cows (n = 76)[1]				
Cystic follicle (n = 4)	60.0±5.5	3.3±1.5	2.3±1.3	137.5±16.5
Anoestrus (n = 1)	78.0	4.0	2.0	168.0
Without RD (n = 71)	65.3±2.8	1.7±0.2	1.0±0.2	95.6±6.3
Non-Pregnant cows (n = 41)[2]				
Cystic follicles (n = 7)	60.0±7.4	7.0±1.7 [a]	3.5±0.8 [a]	242.6±35.5 [a]
Anoestrus (n = 1)	63.0	15.0 [b]	1.0	241.0
Without RD (n = 33)	67.3±3.7	1.2±0.2 [c]	0.8±0.2 [b]	114.4±6.4 [b]

* The open period of non-pregnant cows was defined as the period from the day of parturition to the day when the last pregnancy diagnosis was performed. [a, b, c] Values within each column are significantly different ($p<0.05$).
[1] Cows which became pregnant during the experimental period.
[2] Cows which did not become pregnant during the experimental period.
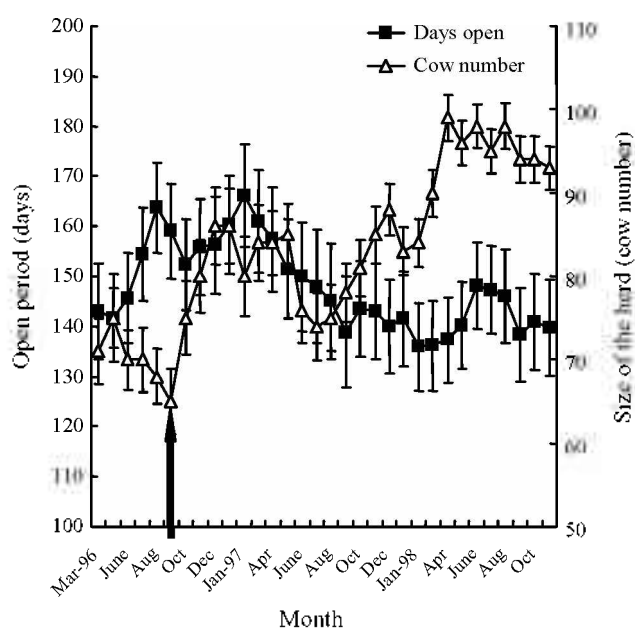US monitoring was commenced before day 40 after parturition.

Figure 1. Changes in monthly open period of the herd and herd size (Mean±SEM). The open period of the herd was considered the period from calving to the day of the last AI derived from all inseminated cows regardless of pregnancy status. ↑: Beginning of US-based reproductive management.

difference in the open period was observed between cows with RD (cystic follicles: 95.8±10.6 days, uterine fluid: 120 days, prolonged CL: 89 days) and cows without RD.

Table 4 shows the reproductive records of the cows divided according to either the presence or absence of RD after the first AI. From the 121 cows studied, 4 cows were culled after the first AI mainly due to sicknesses other than reproductive disorders, thus, the data from 117 cows were used in this comparison. The cows were divided into 2 groups depending on whether the cows became pregnant (n = 76; 65.0%) or not (n = 41; 35.0%) during the monitoring period. A total of 13 cows (11.1%, pregnant: 5 cows, non-pregnant: 8 cows) required treatment for RD after the first AI. Based on the reproductive record, 10 of those cows

(76.9%: 10/13) were also treated before the first AI. Eleven out of the 13 cows with RD (84.6%) were diagnosed as having cystic follicles, while the other 2 cows (15.4%) were diagnosed with anoestrus. In the pregnant cows with or without RD, none of the parameters studied were significant. However, the non-pregnant group of cows with cystic follicles (RD) had a higher number of monitorings (7.0±1.7 times), higher number of AI (3.5±0.8 times) and a longer open period (242.6±35.5 days) than those of non-pregnant cows without RD (1.2±0.2 times, 0.8±0.2 times and 114.4± 6.4 days, respectively).

Figure 1 shows the monthly changes of both the open period and the number of milking cows after parturition during the experimental period. Although no statistical significance was observed among each month of the open period, a trend of decreasing open periods was noted (from 166±10.2 days at maximum level on February 2001 to 136± 8.9 days at minimum level on March 2002). With this trend of decreasing open periods, the number of milking cows of the herd tended to increase after the introduction of the US monitoring reproductive management (99 cows at maximum) compared with the period of reproductive management without US monitoring (75 cows at minimum).

DISCUSSION

Previous reports suggested that the continuous routine use of US monitoring in dairy practice would help to improve the reproductive efficacy of dairy herds (Taylor and Rajamahendran 1991; Rajamahendran et al., 1994). Results of the present study demonstrated that the postpartum period during which the day of commencement of weekly US monitoring significantly affected the reproductive efficiency such as days to the first AI after the parturition and open period of the herd. Additionally, RD diagnosed after the first AI had a more severe influence on the reproductive efficiency of the herd than those in the case of RD which was diagnosed at an early stage in the postpartum period (before the first AI). This observation

suggests that not only the correct diagnosis of RD but also the correct evaluation after treatment for RD are essential for improving a dairy herd's reproductive efficiency. Thus, together with the results of the monthly change of open period, the present results may indicate the usefulness of the US monitoring system to improve the reproductive efficiency of high a yielding commercial dairy herd. However, long-term planning and co-ordination of personal involved is required to achieve this objective as suggested previously (Roche et al., 2000).

It is generally accepted that to obtain the economically optimal calving interval of 1 year, the first postpartum AI should be performed within 85 days after parturition (Savio et al., 1990a, b; Opsomer et al., 1996). The present results clearly demonstrate the possibility of performing the first AI within 85 days after parturition and when cows are free from RD, regardless of the day of commencement of US monitoring. However, with a late commencement of US monitoring, the cows affected with RD displayed a significant delay towards the first AI. In the present herd, cows without RD were required at least 3-5 monitorings before the first oestrus detection and subsequent AI. On the contrary, in cows with RD, both the day to first AI after parturition and the number of US monitoring before the first AI tended to increase with the delay of US monitoring commencement. Additionally, regardless of RD, the open period of cows can be shortened by commencing US monitoring between Days 30-40 after parturition (94.8 and 99.3 days for with RD and without RD, respectively). This observation and a previous finding (Studer and Morrow, 1978) suggest that long open periods can be prevented by early commencement of weekly US monitoring.

Previous studies in modern dairy cows (Butler and Smith, 1989; Beam and Butler, 1999) suggested that the average period to first ovulation is approximately 25-30 days postpartum with a typical range of 17-42 days. Moreover, these studies revealed that the time to first ovulation in dairy cows varies individually, and is related to the timing of the nadir during the period of negative energy balance in an individual cow. On the other hand, Opsomer et al. (2000) recently reported that the first postpartum ovulation in modern high yielding dairy cows tends to occur later than that which occurred a decade ago, perhaps due to a large number of problem cows rather than a general delayed trend to resume ovarian activity. Additionally, it is now accepted that anovulation in dairy cows during the postpartum period occurs due to a failure of dominant follicles to ovulate rather than their absence (Roche et al., 2000). In the present study, it was observed that the number of monitoring performed until the first AI was high with the early commencement of US monitoring. This is probably due to the repeated monitoring performed until the detection of a functional CL in order to schedule the first AI. This

observation may reflect late first postpartum ovulation in high yielding dairy cows described previously (Senger, 1994; Beam and Butler, 1999).

About half of the examined cows (47.8%, 58/121; Table 3) were diagnosed as having RD before the first AI, but a rather small number of cows (11.1%, 13/117; Table 4) after the first AI, suggesting that treatment for RD diagnosed not only after the first AI but also for RD during the early stage of postpartum is crucial to improve reproductive efficiency. The main cause of the poor reproductive efficiency of the herd was the fact that approximately 10% of the cows did not become pregnant. In the present study, 11 out of 13 cows (84.6%) with RD were diagnosed as having cystic follicles and the other 2 cows were diagnosed with anoestrus after the first AI. It is well known that follicular cyst is one of the main causes of infertility in dairy herds (Garverick, 1997). The cystic follicle and anoestrus cows were treated following a commonly used protocol: the administration of synthetic GnRH analogues followed by PGF2α for synchronization of the oestrus for fixed AI (Kesler and Garverick, 1982; Nanda et al., 1988; Garverick, 1997). Previously, the success rate of treatment for cystic follicle with GnRH analogue has been reported as approximately 80% (Garverick, 1997). In the present study, the effectiveness of GnRH treatments used for both cystic follicles and anoestrus were 76.5% (39/51) and 66.7% (22/33), respectively. Thus, to compare the effects of each treatment may still be difficult. However, the treatment protocol used in the present herd is similar to that reported by previous studies (Kesler and Garverick, 1982; Nanda et al., 1988; Garverick, 1997) and seemed to be efficient. On the other hand, previous reports clearly indicate that clinical evaluation of the GnRH treatment for cystic follicles either to detect the ovulation of coexisting dominant follicles or the luteinization of the cystic follicle itself is difficult by rectal palpation alone (Farin et al., 1992; Jeffcoate and Ayliffe, 1995). This may be a possible cause of misdetection of treatment effects and thus, finally lead to an economical loss. In the present study, it was possible to diagnose all 11 cystic follicle cases and 2 anoestrus cases objectively for treatment effects with GnRH analogue following US monitoring. Therefore, US monitoring can be efficiently utilized for clinical evaluation of GnRH treatment for cystic follicles and the US technique is a useful tool in the reproductive management of a modern high yielding dairy herd.

Generally, uterine involution in dairy cows is completed by 40 days after parturition (Okano and Tomizuka, 1987; Kamimura et al., 1993). However, this might be affected by adverse calving conditions such as dystocia or retained placenta (Lewis, 1997), and uterine infection might alter uterine involution and affect follicular development during the postpartum period (Peter and Bosu, 1988a, b). In the

present study, although the calving conditions of the cows with uterine fluid were not known, the pregnancy rate of postpartum first AI in this group was zero. The open period tended to be larger (120 days) than that of cows without RD (34.9% and 84.0 days). Moreover, similar tendencies were also observed in cows with prolonged CL. It was reported that prolonged CL activity in cows is generally associated with either lack of uterine involution, anatomical uterine abnormality or uterine infection, which may reduce the luteolytic uterine-PGF2α secretion or/and transport to the ovary (Lewis, 1997; Opsomer et al., 1998; Wiltbank et al., 2002). Therefore, the cows diagnosed as having prolonged CL in the present study might have had uterine pathological conditions which could not be detected by US monitoring. Thus, both uterine fluid and prolonged CL during the early postpartum period may be risk factors affecting the reproductive efficacy of a herd.

Although the significant effect of the US monitoring system itself on the reproductive efficiency of the herd was obscure due to the lack of a negative control, the present study clearly indicates that the implementation of the US monitoring system improved the reproductive efficiency by reducing the open period and increasing the number of milking cows in the herd. The reproductive efficacy in dairy herds has decreased in recent years world wide (Beam and Butler, 1999; Roche et al., 2000; Lucy, 2001), possibly due to the negative energy balance accompanied by increased milk production (Butler, 2000; Roche et al., 2000), toxic concentrations of urea and nitrogen (Ferguson et al., 1993), heat and other forms of stress (Badinga et al., 1985; Lucey et al., 1986) as well as physio-pathological disorders like ketosis, mastitis, and retained placenta (Opsomer et al., 2000; Lucy, 2001). To overcome these problems to some extent, pharmacological manipulation of the oestrus cycle has been attempted (Pursley et al., 1997). However, the use of hormones for reproductive management should be made with great care, considering both animal welfare and public health, and therefore hormonal treatment should be done only with an accurate diagnosis (Refsdal, 2000). Therefore, routine US monitoring is a possible strategy not only to improve reproductive efficacy but also to reduce the use of hormones through the accurate diagnosis of reproductive disorders.

The result of this study indicated that RD significantly affects the reproductive efficiency of dairy herd. However, objective diagnosis of RD with routine US monitoring system followed by appropriate treatments might used as a strategy to improve the reproductive efficiency of a high-yielding dairy herd reared stanchion management style.

ACKNOWLEDGEMENTS

REFERENCES

Badinga, L., R. J. Collier, W. W. Thatcher and C. J. Wilcox. 1985. Effects of climatic and management factors on conception rate of dairy cattle in subtropical environment. J. Dairy Sci. 68:78-85.

Beam, S. W. and W. R. Butler. 1999. Effects of energy balance on follicular development and first ovulation in postpartum dairy cows. J. Reprod. Fertil. Supple. 54:411-424.

Butler, W. R. and R. D. Smith. 1989. Interrelationships between energy balance and postpartum reproductive function in dairy cattle. J. Dairy Sci. 72:767-783.

Butler, W. R. 1998. Review: effect of protein nutrition on ovarian and uterine physiology in dairy cattle. J. Dairy Sci. 81:2533-2539.

Butler, W. R. 2000. Nutritional interactions with reproductive performance in dairy cattle. Anim. Reprod. Sci. 60-61:449-457.

Caroll, D. J., R. A. Pierson, E. R. Hauser, R. R. Grummer and D. K. Combs. 1990. Variability of ovarian structures and plasma progesterone profiles in dairy cows with ovarian cysts. Theriogenology 34:349-370.

Edmondson, A. J., R. A. Fissore, R. L. Pashen and R. H. Bondurant. 1986. The use of ultrasonography for the study of the bovine reproductive tract. I. Normal and pathological ovarian structures. Anim. Reprod. Sci. 12:157-165.

Farin, P. W., R. S. Youngquist, J. R. Parfet and H. A. Gaverick. 1990. Diagnosis of luteal and follicular ovarian cysts in dairy cows by sector scan ultrasonography. Theriogenology 34:633-642.

Farin, P. W., R. S. Youngquist, J. R. Parfet and H. A. Garverick. 1992. Diagnosis of luteal and follicular ovarian cysts by palpation per rectum and linear-array ultrasonography in dairy cows. J. Am. Vet. Med. Assoc. 200:1085-1089.

Ferguson, J. D., D. T. Galligan, T. Blanchard and M. Reeves. 1993. Serum urea nitrogen and conception rate: the usefulness of test information. J. Dairy Sci. 76:3742-3746.

Fissore, R. A., A. J. Edmonson, R. L. Pashen and R. H. Bondurant. 1985. The use of ultrasonography for the study of the bovine reproductive tract: II. Non pregnant, pregnant and pathological conditions of the uterus. Anim. Reprod. Sci. 12:167-177.

Foote, R. H. 1975. Estrous detection and estrous detection aids. J. Dairy Sci. 58:248-255.

Garverick, H. A. 1997. Ovarian follicular cysts in dairy cows. J. Dairy Sci. 80:995-1004.

Jeffcoate, I. A. and T. R. Ayliffe. 1995. An ultrasonographic study of bovine cystic ovarian disease and its treatment. Vet. Rec. 136:406-410.

Kahn, W. and W. Leidl. 1989. Ultrasonic characteristics of pathological conditions of the bovine uterus and ovaries. Curr. Top. Vet. Med. Anim. Sci. 51:53-65.

Kamimura, S., T. Ohgi, M. Takahashi and T. Tsukamoto. 1993. Turnover of dominant follicles prior to first ovulation and subsequent fertility in postpartum dairy cows. Reprod. Dom.

Anim. 28:85-90.

Keister, Z. O., S. K. DeNise, D. V. Armstrong, R. L. Ax and M. D. Brown. 1999. Pregnancy outcomes in two commercial dairy herds following hormonal scheduling programs. Theriogenology 51:1587-1596.

Kesler, D. J. and H. A. Garverick. 1982. Ovarian cysts in dairy cattle: a review. J. Anim. Sci. 55:1147-1159.

Lamming, G. E. and A. O. Darwash. 1998. The use of milk progesterone profiles to characterize components of subfertility in milked dairy cows. Anim. Reprod. Sci. 52:175-190.

Lewis, G. S. 1997. Uterine health and disorders. J. Dairy Sci. 80:984-994.

Lucey, M. C., G. S. Rowlands and A. M. Russell. 1986. The association between lameness and fertility in dairy cows. Vet. Rec. 118:628-631.

Lucy, M. C. 2001. Reproductive loss in high-producing dairy cattle: where will it end ? J. Dairy Sci. 84:1277-1293.

Lyimo, Z. C., M. Nielen, W. Ouweltjes, T. A. M. Kruip and F. J. C. M. van Eerdenburg. 2000. Relationship among estradiol, cortisol and intensity of estrous behavior in dairy cattle. Theriogenology 53:1783-1795.

Nanda, A. S., W. R. Ward, P. C. W. Williams and H. Dobson. 1988. Retrospective analysis of the efficacy of different hormone treatments of cystic ovarian disease in cattle. Vet. Rec. 122:155-158.

Okano, A. and T. Tomizuka. 1987. Ultrasonic observation of postpartum uterine involution in the cow. Theriogenology 27:369-376.

Opsomer, G., M. Coryn, H. Deluyker and A. de Kruif. 1998. An analysis of ovarian dysfunction in high yielding dairy cows after calving based on progesterone profiles. Reprod. Dom. Anim. 33:193-204.

Opsomer, G., Y. T. Grohn, J. Hertl, M. Coryn, H. Deluyker and A. de Kruif. 2000. Risk factors for post partum ovarian dysfunction in high producing dairy cows in Belgium. Theriogenology 53:841-857.

Opsomer, G., P. Mijten, M. Coryn and A. de Kruif. 1996. Post partum anestrus in dairy cows: a review. Vet. Quart. 18:68-75.

Peter, A. T. and W. T. K. Bosu. 1988. Influence of intrauterine infections and follicular development on the response to GnRH administration in postpartum dairy cows. Theriogenology 29:1163-1175.

Peter, A. T. and W. T. K. Bosu. 1988. Relationship of uterine infection and folliculogenesis in dairy cows during early puerperium. Theriogenology 30:1045-1051.

Pierson, R. A. and O. J. Ginther. 1984. Ultrasonography of the bovine ovary. Theriogenology 21:495-504.

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.

Pursley, J. R., M. O. Mee and M. C. Wiltbank. 1995. Synchronization of ovulation in dairy cows using PGF2α and GnRH. Theriogenology 44:915-923.

Rajamahendran, R., D. J. Ambrose and B. Burton. 1994. Clinical and research applications of real-time ultrasonography in bovine reproduction: a review. Can. Vet. J. 35:563-572.

Rajamahendran, R. and C. Taylor. 1990. Characterization of ovarian activity in postpartum dairy cows using ultrasound imaging and progesterone profiles. Anim. Reprod. Sci. 22:171-180.

Refsdal, A. O. 2000. To treat or not treat: a proper use of hormones and antibiotics. Anim. Reprod. Sci. 60-61:109-119.

Roche, J. F., D. Mackey and M. D. Diskin. 2000. Reproductive management of postpartum cows. Anim. Reprod. Sci. 60-61:703-712.

Rukkwamsuk, T., T. A. M. Kruip and T. Wensing. 1999a. Relationship between overfeeding and overconditioning in the dry period and the problems of high producing dairy cows during the postparturient period. Vet. Quart. 21:71-77.

Rukkwamsuk, T., T. Wensing and T. A. M. Kruip. 1999b. Relationship between triacylglycerol concentration in the liver and first ovulation in postpartum dairy cows. Theriogenology 51:1133-1142.

Savio, J. D., M. P. Boland, N. Hynes and J. F. Roche. 1990a. Resumption of follicular activity in the early post-partum period of dairy cows. J. Reprod. Fertil. 88:569-579.

Savio, J. D., M. P. Boland and J. F. Roche. 1990b. Development of dominant follicles and length of ovarian cycles in post-partum dairy cows. J. Reprod. Fertil. 88:581-591.

Senger, P. L. 1994. The estrous detection problem: new concepts, technologies, and possibilities. J. Dairy Sci. 77:2745-2753.

Studer, E. and D. A. Morrow. 1978. Postpartum evaluation of bovine reproductive potential: comparison of findings from genital tract examination per rectum, uterine culture, and endometrial biopsy. J. Am. Vet. Med. Assoc. 172:489-494.

Tallam, S. K., T. L. Kerbler, K. E. Leslie, K. Bateman, W. H. Johnson and J. S. Walton. 2001. Reproductive performance of postpartum dairy cows under a highly intervenient breeding program involving timed insemination and combination of GnRH, prostaglandin F2α and human chorionic gonadotropin. Theriogenology 56:91-104.

Taylor, C. and R. Rajamahendran. 1991. The use of real-time ultrasonography in postpartum reproductive management of dairy cattle. J. Dairy Sci. 74:193(Abstr.).

Van Vliet, J. H. and F. J. C. M. Van Eerdenburg. 1996. Sexual activities and estrus detection in lactating Holstein cows. Appl. Anim. Behav. Sci. 50:57-69.

Wiltbank, M. C., A. Gumen and R. Sartori. 2002. Physiological classification of anovulatory conditions in cattle. Theriogenology 57:21-52.