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Pregnancy loss in dairy cows: the contributing factors, the effects on reproductive performance and the economic impact

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This study investigated the effects of the herd, cow parity, the insemination protocol and season on the incidence of pregnancy loss (PL) in dairy herds. Furthermore, we determined the downstream effects of PL on reproductive performance and its economic impact. The overall incidence rate of PL was 6.9% in 1,001 pregnant cows and its incidence peaked ($p < 0.01$) during the second trimester of gestation. GLIMMIX analysis revealed that cow parity was the important risk factor for the PL. The odds ratio showed that the likelihood of PL in cows with parities of 1 or 2 was decreased by 0.6 or 0.5 fold compared to the cows with a parity of 3 or higher. Following PL, the mean rate of endometritis was 23.2% and endometritis was more common ($p < 0.05$) when PL occurred during the third trimester than during the first and second trimesters. The mean culling rate was 46.4% and this did not differ with the period of PL. The overall mean intervals from PL to the first service and conception were 63.4 and 101.8 days, respectively. The mean interval from PL to first service was longer ($p < 0.01$) for cows with PL during the third trimester than for the cows with PL during the first and second trimesters. The economic loss resulting from each PL was estimated at approximately $2,333, and this was largely due to an extended calving interval and increased culling. These results suggest that cow parity affects the incidence of PL, which extends calving interval and causes severe economic loss of dairy herds.

Key words: dairy cow, economic loss, pregnancy loss, reproductive performance, risk factors

Introduction

The fertility of cows plays an important role in the productivity of dairy herds. Pregnancy loss (PL) is one of the major sources of decreased fertility, and this produces adverse economic effects for dairy farms [35,36]. The reported incidence of PL ranges from 0.4 to 10.6% [8] and both infections and non-infectious factors are known to play a role for this. While the infectious causes of PL have been a primary focus of attention, non-infectious PL is actually more common in endemic situations. Various causative factors, including external, maternal and genetic factors, have been reported for PL in dairy cattle. These include heat stress [11], the season [24], milk production [12], cow parity [21], the serum progesterone level after conception [26], the inseminating bull [23], twin pregnancy [23] and the herd [25]. However, other investigations have reported that milk production [31], cow parity [26] and clinical disease [23] were not associated with PL. Further elucidation of the factors that cause PL may enable the development of more effective management regimens for efficient herd reproduction.

PL may result in the retention of fetal membranes and the development of endometritis, which subsequently reduces reproductive performance in dairy cows. Furthermore, a prolonged postpartum interval in cows with PL can lead to increased culling [1]. However, the effects of PL on reproductive performance, culling and economic loss have not been fully determined and there have been no detailed studies of PL in Korean dairy herds. Therefore, the objectives of this study were to determine the effects of herd, cow parity, the insemination protocol and season on the incidence of PL, and to determine the downstream effects of PL on the rate of endometritis and culling, the reproductive performance and the economic viability of dairy herds.

Materials and Methods

Herds and reproductive management

This study was performed on seven Holstein dairy farms (designated A-G) located in Chungbuk province, Korea, over the period from October 2000 to May 2006. All the herds contained 50 or more cows. During this period, the average monthly air temperatures and relative humidity ranged from 4.9-16.7°C and 50.7-60.5% in spring (March to May), 20.8-24.0°C and 67.7-73.8% in summer (June to August), 5.6-18.9°C and 64.6-72.5% in autumn (September to November), and −2.4- −0.4°C and 53.8-61.4% in winter

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(December to February), respectively. During the study period, the mean annual milk yield was 9,782 kg per cow and the culling rate was 27% for all the herds. The cows were maintained in free-stall facilities, fed a total mixed ration and milked twice daily. All the procedures were performed with the approval of the Animal Ethics Committee of Chungbuk National University. Regular reproductive health checkups were carried out every 2 to 4 weeks. The reproductive tract of each cow was examined by rectal palpation and ultrasonography (Sonoace 600 with a 5.0 MHz linear-array transducer; Medison, Korea) within 4 weeks postpartum to check for uterine involution and ovarian activity. The postpartum reproductive diseases were treated until recovery, pregnancy or culling. The voluntary waiting period from calving to the first artificial insemination (AI) in this study was 50 days. Three different insemination protocols were used in this study. Cows with estrus beyond the voluntary waiting period were inseminated according to the a.m.-p.m. rule (AI following natural estrus). Cows failing to receive AI within an 80-day postpartum interval were treated with 25 mg PGF_{2a} (Lutalyse; Pharmacia & Upjohn, Belgium) I.M or they were included in a controlled internal drug release (CIDR)-based timed AI protocol, which entails using a CIDR device containing 1.9 g of progesterone (CIDR; InterAg, New Zealand), GnRH (Fertagyl; Intervet, Netherland) and PGF_{2a} [20]. Those cows displaying estrus after PGF_{2a} I.M received AI according to the a.m.-p.m. rule (AI following synchronization of estrus), whereas those who had the CIDR-based timed AI protocol received a timed AI (AI following synchronization of ovulation).

Pregnancy diagnosis and detection of PL

We diagnosed pregnancy rectally at 28 to 60 days after AI by performing both ultrasonography and manual palpation. Recognition of the vesicle, embryo or fetus by ultrasonography was the criterion for a positive pregnancy diagnosis [17]. The definition of PL included all the cows with observed abortions and also the cows that were found to be open after a positive pregnancy diagnosis. Thus, PL included both late embryonic loss and fetal loss in this study [7,35].

The reproductive tract of each PL cow was examined by rectal palpation and ultrasonography to check for normal involution of the uterus and ovarian activity. Cows with endometritis following PL were treated with one intrauterine infusion of 1,500 mg oxytetracycline hydrochloride solution (Metrijet 1500; Intervet, UK) or 2% povidone-iodine solution (Korea Pharma, Korea). Subsequent breeding of the cows with PL was undertaken using the same three insemination protocols that were described previously.

Data collection and analysis

Data was collected from 1,001 pregnancies from the seven dairy herds. The following parameters were recorded for each cow: the herd, cow parity, dates of previous calving, AI, the pregnancy diagnosis, PL and present calving, the insemination protocol (AI following the natural estrus, PGF_{2a} I.M. or timed AI), and the incidence of endometritis and/or culling, and the reproductive performance (the intervals from PL to first service and conception) following PL. Parity in these herds was categorized as 1, 2, 3 or higher. The timesters of gestation were as follows: the first trimester was the 46th day to the 90th day, the second trimester was the 91st day to the 180th day and the third trimester was the 181st day to the 260th day of gestation [24]. For estimating the economic losses, the mean delayed calving interval due to PL was evaluated as the interval from the first conception following previous calving to the second conception following the PL.

Statistical analyses were performed using the SAS program [32]. Comparison of the incidence of PL during the first, second and third trimesters of gestation was done using the chi-square test. The generalized linear mixed model (GLIMMIX) procedure of SAS was used to determine the influence of herd, cow parity, the insemination protocol and season on the incidence of PL. The procedure included the random effect of the herd. PL was considered the dependent variable. The herd, cow parity, the insemination protocol and the season were considered as class variables. Table 1

Table 1. Descriptive statistics for the data included in the analysis of risk factors for pregnancy loss (PL) in dairy cows

Item		No. cows pregnant	No. cows with PL	No. cows without PL
Herd	A	79	7	72
	B	173	12	161
	C	98	2	96
	D	177	12	165
	E	244	21	223
	F	128	6	122
	G	101	9	92
Cow parity	1	377	21	356
	2	262	13	249
	3≤	362	35	327
Insemination protocol*	Natural estrus	791	50	741
	$PGF_{2\alpha}$	125	10	115
	Timed AI	85	9	76
Season**	Spring	174	14	160
	Summer	266	20	246
	Autumn	309	23	286
	Winter	252	12	240

*Natural estrus; AI (artificial insemination) following natural estrus, $PGF_{2\alpha}$; AI following synchronization of estrus (using $PGF_{2\alpha}$), Timed AI; AI following synchronization of ovulation (using CIDR-based timed AI protocol).

**Spring: March through May; Summer: June through August; Autumn: September through November; Winter: December through February.

lists the independent variables described above. The comparison of the incidence of endometritis and culling during the three trimesters of gestation following PL were evaluated with using Fisher's exact test. The intervals from PL to first service and conception were analyzed by ANOVA testing. For all the tests, $p < 0.05$ was considered significant.

The expenses associated with PL included the cost of nutrition, the average growth of calves, the labor and medical costs and culling. The economic loss resulting from PL was calculated based on the 2003 standard data for the National Agriculture Products Quality Management Service, Korea [27] and on the report of Kim *et al.* [19].

Results

The overall incidence rate of PL was 6.9% in a population of 1,001 pregnant dairy cows. The incidence was greater ($p < 0.01$) during the second trimester (3.4%) than during the first trimester (1.3%), although the incidence during the second trimester was not significantly different from the rate during the third trimester of gestation (2.3%, Table 2). The average time at which PL occurred was 154.5 ± 63.2 days of gestation. The GLIMMIX procedure demonstrated that the estimated standard error was 0.0398 ± 0.1085, indicating no influence of the herds on the incidence of PL. The procedure identified cow parity as the risk factor for PL (Table 3). Based on the odds ratio, the likelihood of PL in cows with parities of 1 or 2 was decreased by 0.6 or 0.5 fold of that for the cows with a parity of 3 or higher, respectively ($p < 0.05$). However, the herd, the insemination protocol and the season were not found to be risk factors for PL.

Following PL, the mean incidence rate of endometritis was 23.2% and this rate was higher ($p < 0.05$) for the cows with PL during the third trimester (45.5%) than for the cows with PL during the first (7.7%) and second trimesters (14.7%, Table 4). The mean culling rate following PL was 46.4% and the time of PL did not affect the culling rate (Table 4). The overall mean intervals from PL to the first service and conception were 63.4 ± 5.2 and 101.8 ± 10.8 days, respectively. The interval from PL to first service was longer ($p < 0.01$) for the cows with PL during the third trimester than for the cows with PL during the first and second trimesters, while the interval from PL to conception did not differ according to time of PL (Table 4). Thus, the overall mean extended calving interval in cows with PL was 256 days.

The economic loss resulting from each case of PL in these herds was estimated at approximately $2,333 due to the effects on the cost of nutrition, the average growth of calves, the labor and medical costs, and culling (Table 5).

Discussion

In this study, we determined the risk factors for PL and the

Table 2. Occurrence of pregnancy loss (PL) in seven Korean dairy herds

No. of cows confirmed pregnant	No. of cows with PL (%)	Period of PL*		
		First trimester (%)	Second trimester (%)	Third trimester (%)
1,001	69 (6.9)	13/1,001 (1.3)^{a}	34/988 (3.4)^{b}	22/954 (2.3)^{ab}

$^{a,b}p < 0.01$.
*Trimesters of pregnancy were the first for the 46th to 90th days, second for the 91st to 180th days and the third for the 181st to 260th days of gestation, respectively.

Table 3. Odds ratios and 95% confidence intervals of the independent variables associated with pregnancy loss in the random effect logistic model

Independent variables		Odds ratio	95% confidence interval	*p*-values
Cow parity	1 vs. 3≤	0.6	[0.314,0.966]	$p < 0.05$
	2 vs. 3≤	0.5	[0.253,0.941]	$p < 0.05$

Table 4. Effects of the period of pregnancy loss (PL) on the incidence of endometritis, culling and the intervals from PL to first service and conception in dairy cows

Period of abortion	Incidence of endometritis (%)	Culling (%)	Interval from PL to first service (days)*	Interval from PL to conception (days)*
First trimester (n = 13)	1 (7.7)^{ab}	9 (69.2)	44.9 ± 7.2^{c}	68.8 ± 25.4
Second trimester (n = 34)	5 (14.7)^{a}	14 (41.2)	54.6 ± 5.0^{c}	90.2 ± 14.0
Third trimester (n = 22)	10 (45.5)^{b}	9 (40.9)	87.5 ± 11.6^{d}	130.1 ± 19.0
Total (n = 69)	16 (23.2)	32 (46.4)	63.4 ± 5.2	101.8 ± 10.8

*Values are means ± SE.
$^{a,b}p < 0.05$.
$^{c,d}p < 0.01$.

Table 5. Economic loss due to pregnancy loss in dairy cows

List	Content	Loss cost
Cost of nutrition	Cost of nutrition per cow/day: $4.71 × 256 days ≒ $1,206	$1,206
Average growth of calves	Bottle calves -clostrum calves $150/57days × 256 days ≒ $673	$673
Production labor	Labor per lactating cow/day $1.21 × 256 days ≒ $310	$310
Medical cost (veterinary service)	Uterine infusion: $25/cow	$25
Culling	Difference between the value of the cull cows and replacement heifers: $625 $625 × 19% ≒ $119/cow	$119
Gross economic loss	Cost of nutrition + the average growth of calves + the production, labor + medical cost + culling ≒ gross economic loss	$2,333 /cow

downstream effects of PL on reproductive performance, as well as assessing the economic impact of PL in seven dairy herds. Cow parity was positively correlated with the frequency of PL. Furthermore, the risks of endometritis and of a longer interval from PL to first service were greater when PL occurred during the third trimester of gestation. The overall mean economic loss resulting from PL was estimated at approximately $2,333.

The overall incidence of PL (6.9%) in this study is in agreement with several previous papers [11,21,25,33,34], which reported PL rates of 6.4~8.6%. It is notable, however, that the reported rate and incidence of PL does vary widely between studies, and 6.9% is higher than some previously reported rates (0.4 and 3.6%; [13,28]) and it is lower than the rates (10.2 and 10.6%) reported in other studies [23,24]. These discrepancies may reflect differences in the geography, the study population, the case definitions and the procedures among the studies. The incidence of PL peaked during the second trimester in this study, and this is consistent with the results of Thurmond *et al.* [35]. Yet Forar *et al.* [9] found that the risk of PL was highest in the first trimester of gestation and then it progressively decreased as gestation progressed. On the other hand, Markusfeld-Nir [24] demonstrated that the greatest risk of PL was observed in the first trimester, whereas the second trimester had the lowest incidence of PL. The reasons for these differences are unclear, but they may reflect variations in the detection time between studies and/or a discrepancy in the detection time versus the actual time of PL.

Cow parity was positively linked to PL in this study. The incidence of PL was greatest in the cows with a parity of 3 or higher, which is similar to the results of Thurmond *et al.* [35], who reported that PL increased after 4 calvings. Similarly, Humblot [16] showed that frequency of embryonic mortality increased with parity (1st to 3rd parity), although others have reported no effect of parity on PL [21,26]. The influence of parity on PL is unclear. One possibility is that high milk production at the third parity compared to previous parities, which mobilizes more body fat and results in severe loss of body condition (BCS) [22], might be linked to the increased PL. Silke *et al.* [33] showed that BCS loss between days 28 and 56 of gestation was a risk factor for PL. Likewise, a drop in BCS from the previous parturition to 30 days postpartum has been shown to increase PL, with a 1 unit decrease in score increasing the pregnancy loss by a factor 2.4 [23]. In agreement with previous reports [9,11], there were no significant differences in the incidence of PL among the seven dairy herds in this study. However, some previous investigations have found a herd effect [16,25]. Moreover, as indicated by Labernia *et al.* [21], the management characteristics and man-cow interactions that tend to vary from farm to farm may influence the rate of PL. Various protocols for the synchronization of estrus and/or ovulation have been used to optimize the service rate in dairy herds. We found no significant effect of the previous synchronization of estrus and ovulation on the incidence of PL, and this was consistent with the results of López-Gatius *et al.* [23], who demonstrated no significant effect of previous estrus synchronization on PL. Several other studies found that the PL rates were not different between the cows inseminated following timed AI and the cows inseminated upon detecting estrous; these results also concur with our present findings [4,6,14,30]. However, in a report by Cartmill *et al.* [5], a tendency for an increased PL was observed with timed AI. PL was not associated with the season in our investigation, and this is inconsistent with previous studies. For example, it has been reported that the risk for PL was increased during the warm period (May to September) versus the cool period (October to April) due to heat stress [11]. Similarly, in another report, PL was increased during June to October, and it peaked in July and September [3]. On the other hand, Markusfeld-Nir [24] demonstrated that the incidence of PL was greater during autumn and early winter than during the summer months, and this is in agreement with the report of Grimard *et al.* [12]. These differences in the effect of season on PL might be due to different climates (temperature-humidity), geography or other environmental factors among studies.

There are very few published reports about the effects of PL on the subsequent incidence of reproductive disturbances and/or reproductive performance. However, PL was associated with an extension of 80 days from first service to conception and an extension of 77 days in the calving interval [10]. The mean incidence of endometritis following PL was 23.2%

and this was more common in those cows that suffered PL during the third trimester than in the cows with PL during the first and second trimesters. This may reflect the more delayed uterine involution and increased incidence of retained placenta associated with PL in the third trimester, as compared to the earlier trimesters of gestation [15,29]. Endometritis following PL may lead to increased culling and it may extend the period of open days. Interestingly, the culling rates were not different among cows that experienced PL during the first, second and third trimesters of gestation. However, the overall mean culling rate of 46.4% for the cows with PL was higher than the general rate of 27% for all the herds. The mean interval from PL to the first service was 63.4 days and this interval was longer for the cows with PL during the third trimester than for the cows with PL during the first and second trimesters. Again, this might be associated with delayed uterine involution and/or the increased incidence of endometritis, as indicated by Kim and Kang [18], and Borsberry and Dobson [2]. In fact, earlier re-pregnancy may be important for PL cows if further economic loss is to be minimized. Our results showed that the overall mean interval from PL to conception was 102 days, thereby culminating in a calving interval that was 256 days longer than that of the cows without PL.

A delayed calving interval and increased culling are the main sources of economic loss in dairy herds. Here, the economic loss resulting from each PL was estimated at approximately $2,333 due to the effects on the cost of nutrition, the average growth of calves, the labor and medical costs, and culling. In view of this economic impact, it would be desirable to reduce the interval from PL to conception. On the other hand, earlier culling might be recommended to prevent a further economic loss when PL occurs in the later period of gestation.

In conclusion, we have demonstrated here that cow parity is positively correlated with PL, and that the risks of endometritis and a longer interval from PL to first service are greater when PL occurred during the third trimester of gestation. Yet irrespective of when PL occurs, it produces a serious economic impact on dairy herds. Therefore, reducing nutritional stress by improving the management of cow parity and minimizing the interval from PL to conception will be necessary strategies for reducing the adverse economic effects of PL in dairy herds.

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