bjetivos

Teniendo en cuenta el interés de la utilización de métodos epidemiológicos para comprender mejor las causas de la infertilidad en ganado vacuno lechero, y una vez constatado el hecho de la ausencia de información sobre estudios realizados en Catalunya o en España con esta finalidad, los objetivos de la presente Memoria de Tesis Doctoral fueron los siguientes:

1. El estudio de factores (disfunciones reproductivas y factores de manejo) que pudieran tener influencia sobre la duración del intervalo entre parto y gestación de vacas lecheras.

2. El estudio de la influencia de factores de manejo y ambientales sobre la pérdida de gestaciones ya diagnosticadas.

3. El estudio de la influencia de disfunciones reproductivas previas a la concepción sobre la pérdida de gestaciones ya diagnosticadas.

Estudio 1

Influence of Calving Season on the Interactions Among Reproductive Disorders of Dairy Cows

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ABSTRACT

The objective of this study was to evaluate the influence of calving season on the interactions among reproductive disorders prior to conception and their effect on subsequent reproductive performance in dairy cows. Data from 3170 lactations of Friesian cows that subsequently conceived were analyzed by means of path analysis techniques. The cows were from nine commercial dairy herds in northeastern Spain. Lactation incidence rates for retained placenta, metritis, ovarian cysts, and repeat breeding (>4 AI per conception) were 6.4, 3.7, 5.4 and 7.9%, respectively, and there were no differences between warm (May to September) and cool (October to April) calving seasons. However, our study showed that calving season influenced the interrelationships among reproductive traits. Lactation number was not related to any of the path model variables for cows calving in cool seasons, and retained placenta did not directly influence ovarian cysts or repeat breeding. In contrast, older cows that calved during warm seasons showed an increased risk of experiencing retained placenta, ovarian cysts, and more days open; retained placenta was a direct risk factor for ovarian cysts and repeat breeding. Our data indicated that cows that calved in a cool environment could more effectively cope with reproductive disorders prior to conception, and this fact was mainly observed in older cows.

Key words: reproductive disorders, path analysis, calving, season

INTRODUCTION

The interval from calving to conception (the number of days open) has a major economic impact on dairy cattle production. Decreased milk production and an increased risk of involuntary culling are the main consequences of delayed conception in dairy cows (2, 30). The effect of herd or farm on reproductive performance of dairy cows has been evaluated in many studies, and both the presence (24) and absence (12, 22) of a relationship have been reported. The reproductive age of the cow, measured as the number of calvings (lactation number), has been related to days open (7), although some studies found no effect of parity on the interval from calving to conception (14, 32). Twinning has resulted in a higher number of AI (28) and increased days open (23, 28); however, twinning has shown no effect on reproductive performance in a previous study (5). Cows that give birth to twins are more likely to experience retained placenta (21, 23, 28) and metritis (21, 28). Several studies have evaluated the direct relationship between reproductive disorders and the interval from calving to conception; the presence of retained placenta (18, 19), metritis (15, 26), and ovarian cysts (1, 4, 13, 24) has usually been related to increased calving intervals.

The use of path analysis techniques has allowed a better understanding of the complex interrelationships among reproductive traits. The whole effect of several previous reproductive

disorders on days open and the interactions among variables have been described previously using path analysis (4, 8, 10, 16, 23). Physical environment has also been related to the interval from calving to conception in dairy cows (17, 33). However, few studies have included environmental variables and reproductive traits in path analysis. In fact, although some reports have observed seasonal influence on the incidence rates of reproductive disorders (2, 16, 18, 19, 22), little is known about the effect of season on the interactions among these disorders.

The objective of the present study was to evaluate the influence of calving season on the interactions among reproductive disorders and, subsequently, the effect of these disorders on reproductive performance in dairy herds using path analysis methods.

MATERIALS AND METHODS

Cows

Between 1987 and 1994, data were obtained during the interval from calving to conception in 3170 lactations of Friesian cows on nine commercial dairy herds in northeastern Spain. Only cows that subsequently conceived were included in the study. For this study population, lactation number was 2.2 $\pm$ 1.5 (X $\pm$ SD) and ranged from 1 to 10 lactations. Number of AI per conception was 2.2 $\pm$ 1.6 and ranged from 1 to 13 AI; the interval from calving to conception (days open) was 118.3 $\pm$ 70.6 d and ranged from 30 to 496 d. Twinning rate was 2.4%.

Management

In all farms, cows were fed a total mixed ration according to NRC (27) requirements, and were housed in open stalls, without access to pastures, throughout the year. Cows were mantained according to a reproductive management program that included gynecological examinations that were performed daily (from 12 to 24 h after calving to ensure that the placenta had been expelled and prior to AI to confirm estrus) or weekly (for uterine involution and ovarian structures at 30 to 36 d postpartum, for anestrus in cows without detected estrus after 70 d postpartum, for pregnancy diagnosis, and for the evaluation of cows with previously diagnosed disorders). Only cows that were free of clinical abnormalities were inseminated. Pregnancy diagnosis was performed by palpation per rectum.

Environmental Conditions

Mean monthly thermal conditions in the geographical area where the farms were located for the

period between 1987 and 1994 are given in Table 1. All farms were less than 20 km from the meteorological station. Mean rainfall in this area was low (375 mm per year).

According to the observed environmental temperatures during this period, we divided the year into a warm period (May to September) and a cool period (October to April). Table 1 shows that relative humidity was lower in the warmest months.

Data Collection

Reproductive disorders were registered following calving (retained placenta) and at the subsequent period prior to conception (metritis, ovarian cysts, and repeat breeding). Retained placenta was registered if cows retained fetal membranes longer than 12 h after calving. Metritis was diagnosed when flacks of pus were observed in the vaginal fluid and abnormalities of the uterus were not palpable per rectum. Ovarian cysts were registered if a structure with a diameter of 25 mm or larger in one or both ovaries persisted for at least 7 d and was accompanied by the absence of a palpable corpus luteum. A cow with more than four AI prior to pregnancy was considered a repeat breeder. Disorders were recorded as 1 = present or 0 = absent. Because of their low incidence, data on pyometra were not included in the study. Lactation number and interval from calving to conception were recorded as continuous variables, twinning was registered as a dichotomous variable, and herd was recorded categorically (nine classes). Season of calving (May to September or October to April) was also registered.

TABLE 1. Monthly means for mean, minimum, and maximum daily temperature, mean number of days in a month that the minimum temperature was lower than 0°C, mean number of days in a month that the maximum temperature was higher than 25°C, and monthly mean relative humidity.

Month	Mean temperature (°C)	Maximum temperature (°C)	Minimum temperature (°C)	Days minimum temperature was <0°C (no.)	Days maximum temperature was >25°C (no.)	Mean relative humidity (%)
Jan.	4.4	8.0	0.5	13.0	0.0	85.7
Feb.	7.6	13.8	1.3	10.4	0.0	69.2
Mar.	11.4	18.6	4.3	4.1	0.8	61.8
Apr.	13.1	20.2	6.0	0.2	3.6	58.5
May	17.6	25.1	10.2	0.0	19.6	57.6

June	21.5	28.7	13.7	0.0	24.1	53.6
July	24.9	33.0	16.8	0.0	30.5	50.5
Aug.	25.5	33.2	17.8	0.0	30.4	54.6
Sep.	20.8	27.6	13.9	0.0	24.9	64.0
Oct.	14.8	20.6	9.2	0.4	3.0	74.9
Nov.	9.6	14.2	5.0	4.9	0.0	83.1
Dec.	5.9	9.7	2.1	10.8	0.0	83.8

Descriptive Statistics

Lactational incidence rates were obtained for each reproductive disorder and were defined as the proportion of lactations during which at least one occurrence of a reproductive disorder was noted (9). Rates were determined for all cows for the two groups classified according to calving season. The rate of reproductive disorders according to the calving season was assessed by means of the chi-square test.

Path Analysis

Two path models were developed to explore the effect of calving season on the interrelationships among reproductive traits, i.e., one model for cows calving in the warm season (May to September) and another model for cows calving in the cool season (October to April). All models included lactation number, twinning, retained placenta, metritis, ovarian cysts, days open, and repeat breeding as path variables. The path diagram is shown in Figure 1. Variables were arranged from left to right in accordance with chronology. Metritis was assumed to occur prior to the detection of ovarian cysts because, according to our data, metritis had been observed previously in 9 of the 12 cows that experienced both disorders. Similarly, previous studies on time of diagnosis of reproductive disorders (3) have suggested that metritis precedes ovarian cysts. Each variable can only be a possible effect for the variables that chronologically precede it (putative risk factors). Thus, hypothesized relationships among variables were indicated by drawing arrows from left to right (Figure 1); no feedback loops were considered.

Multiple regression analyses were performed to obtain the path coefficients, and each variable was regressed on all preceeding variables that had arrows leading to it. Ordinary least squares multiple regression was carried out for days open according to the SAS REG program (31), and multiple logistic regression, using the SAS LOGISTIC program (31), was used for the remainder of the dependent variables, which were dichotomous. Herd was always included as a fixed effect in the analyses for all reproductive disorders and for days open. Regression coefficients (b's) and standard partial regression coefficients in least squares regression, and odds ratios and standard partial regression coefficients in logistic regression were obtained as path coefficients. Once the path coefficients were determined, restricted models were derived from the complete model by removing nonsignificant arrows ($P > 0.10$).

RESULTS

Descriptive Statistics

Table 2 shows the lactational incidence rates of twinning and each reproductive disorder for each calving season and for the whole population. The mean lactational incidence rate for twinning was 2.4%, for repeat

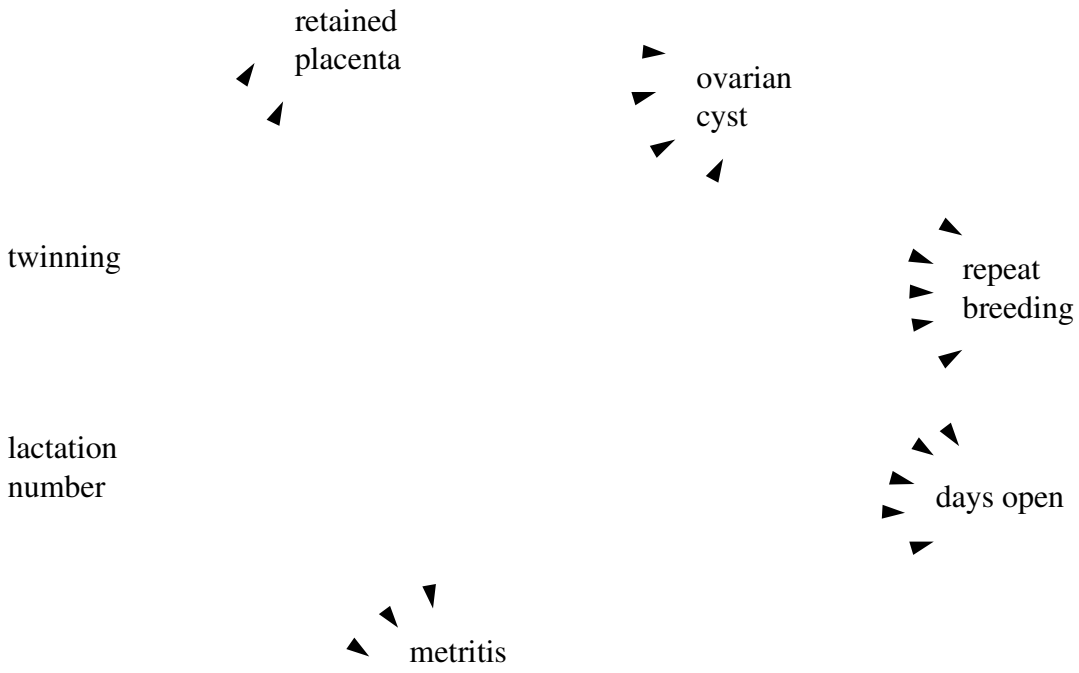

Figure 1. Path analysis model structure, where variables are arranged from left to right in accordance with chronology. Hypothesized relationships among variables are indicated by arrows directed from left to right.

breeding was 7.9%, for retained placenta was 6.4%, for metritis was 3.7%, and for ovarian cysts was 5.4%. Mean lactation number was 2.3±1.5 (X±SD) and 2.2±1.4 for cows calving in warm and cool seasons, respectively. There were no significant differences between the incidence of twinning and the reproductive disorders in cool versus warm season. Conversely, marked differences were detected among herds.

Path Analysis

Cows calving in the warm season.

The restricted model in Figure 2 shows the odds ratios from logistic regression, or regression coefficients from least squares regression, for cows caving in the warm season. Ovarian cysts and metritis caused an increase in days open (52 and 28 d, respectively). Cows were 2.4, 2.7, and 3.2 times more likely to be repeat breeders if they experienced retained placenta, metritis, or ovarian cysts, respectively. Metritis and retained placenta were risk factors for ovarian cysts (odds ratios = 2.5 and 2.1, respectively), and retained placenta increased the likelihood of metritis 2.2 times. Twinning was associated directly with retained placenta (odds ratio = 5.0) and with metritis (odds ratio = 5.1). Older cows were at a higher risk of experiencing retained placenta and ovarian cysts (odds ratio = 1.2 for both when lactation number was increased by one). Figure 2 also shows a direct effect of lactation number on days open (a 2.5-d increase per lactation). Some herds showed no incidence of metritis (two of nine herds) or retained placenta (two of nine herds) for cows calving between May and September. Regression analyses showed an effect of herd on days open and repeat breeding ($P < 0.05$).

Cows calving in the cool season.

As is shown in Figure 3, no arrows leading from lactation number remained in the restricted model. Metritis and ovarian cysts caused increased days open (52 and 53 d, respectively) and increased the risk of repeat breeding (odds ratio = 3.5 and 2.4, respectively). Only metritis increased the likelihood of ovarian cysts (odds ratio = 2.5), and retained placenta was the only direct cause of metritis (odds ratio = 2.4). Cows that had twins were 5.1 times more likely to experience retained placenta. The effect of herd on retained placenta, metritis, repeat breeding, and days open was significant ($P < 0.05$). The comparison of these interactions in warm versus cool calving seasons is summarized in Table 3.

TABLE 2. Lactational incidence rates and range of incidence rates for twinning, retained placenta, metritis, cysts and repeat breeding, calculated for all cows, and for the two groups of cows defined by calving season.

Reproductive trait	All cows (n = 3170)	Cows calving in the warm season (n = 1348)	Cows calving in the cool season (n = 1822)	Range
			(%)	
Twinning	2.4	2.6	2.3[a]	0.8 to 3.1
Retained	6.4	6.9	6.0[a]	3.9 to
Metritis	3.7	3.6	3.7[a]	2.2 to
Ovarian cyst	5.4	5.6	5.2[a]	4.0 to
Repeat breeding	7.9	7.8	8.0[a]	2.3 to

[a] No differences in lactational incidence rates between seasons (Chi-Square Test; $P > 0.05$)

DISCUSSION

Incidence rates of reproductive disorders in previous studies ranged from 3.8% (29) to 19.4% (20) for retained placenta, from 2.5% (13) to 36% (21) for metritis, and from 3.3% (24) to 38.2% (1) for ovarian cysts. According to our data, 6.4% of lactations were affected by retained placenta, 3.7% were affected by metritis, and 5.4% of lactations showed signs of ovarian cysts. Reproductive disorders could have been higher if culled cows had been included in the experiment.

Our study showed that calving season influenced interrelationships among reproductive traits. Lactation number was not significantly related to any of the path model variables for cows calving in the cool season, and retained placenta did not directly affect repeat breeding or ovarian cysts. In contrast, for older cows that calved during the warm season, there was an increased risk for retained placenta, ovarian cysts, and increased days open; retained placenta was a direct risk factor for ovarian cysts and repeat breeding.

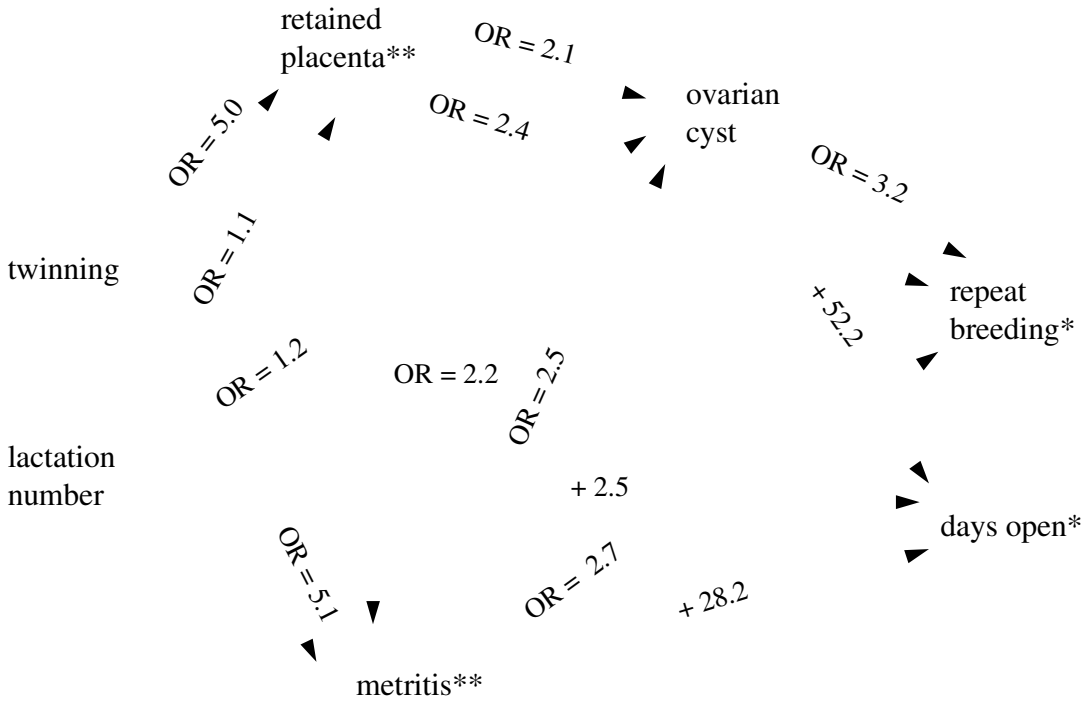

Figure 2. Path analysis model of reproductive variables for cows calving in the warm season (n = 1348). All coefficients included were significant at $P < 0.10$. Coefficients within paths are odds ratios from logistic regression or least squares regression coefficients. *Farm effect on the variable ($P < 0.05$). **Some herds showed no incidence of the disorder.

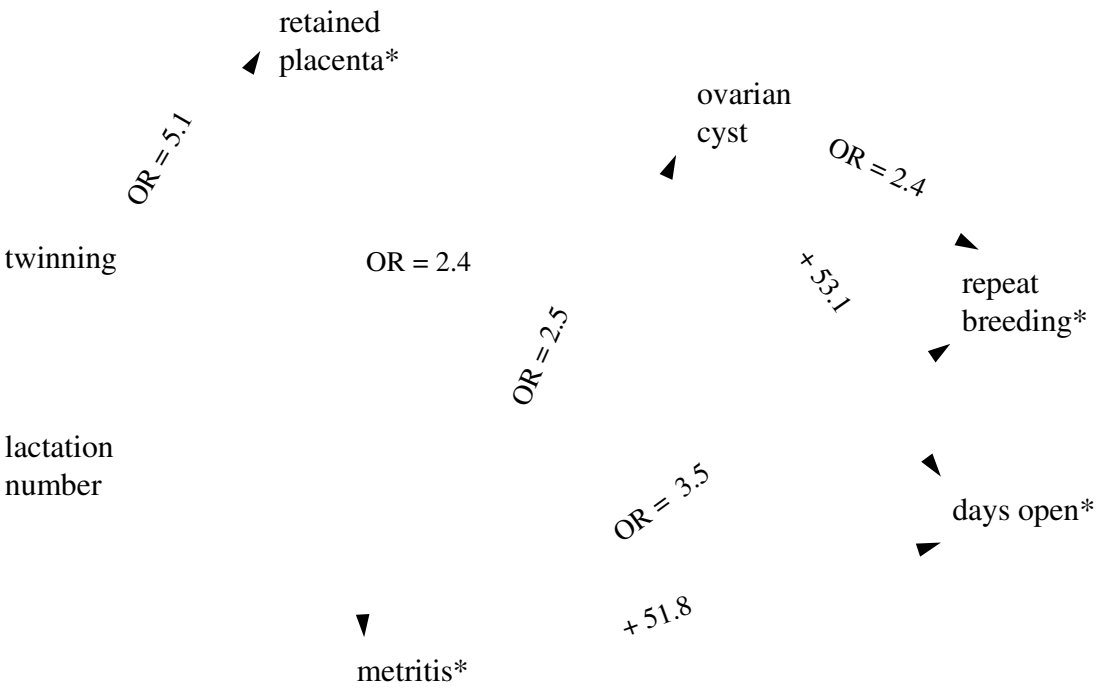

Figure 3. Path analysis model of reproductive variables for cows calving in the cool season (n = 1822). All coefficients included were significant at $P < 0.10$. Coefficients within paths are odds ratios from logistic regression or least squares regression coefficients. *Farm effect on the variable ($P < 0.05$).

Discrepancies in effects of lactation number on reproductive disorders have been reported in the literature. Age has been described as a risk factor (8, 16, 21, 25), a preventive factor (23), and without effect (6, 10, 11) on ovarian cysts. Other studies (25) have found a higher risk of ovarian cysts in medium-aged cows (4 to 6 years of age). The effect of calving order on metritis is not well established. Markusfeld (21) reported an increased risk of metritis for primiparous cows than for multiparous cows, being the lowest risk of metritis for second lactation cows. However, other studies found no relationship between age of cow and metritis (6, 10, 16). There is also disagreement about the effect of age on days open and calving interval (8, 11, 23, 32). Finally, few studies have described the effect of lactation number on repeat breeding. Lactation number appears to increase the number of AI per conception (2, 10, 23). Our study might suggest a new point of view in relationship to these discrepancies. Unstressful meteorological conditions during the cold season (the absence of severely cold temperatures) could account for the absence of adverse effects of age on reproductive performance postpartum, which could also be the reason why our findings contrasted with those of numerous other studies (3, 6, 8, 10, 16, 19, 23) in which age was considered a risk factor for retained placenta . A cool environment appears to favour expulsion of the fetal membranes in older dairy cows. Further studies are needed to determine the effects of a cool environment on the puerperal period of the cow.

Retained placenta was positively correlated with subsequent reproductive disorders. Thus, direct effects of retained placenta on subsequent metritis (3, 6, 8, 10, 16, 18, 23), ovarian cysts (3, 16), repeat breeding (23), and days open (8, 18, 23) have been reported. In the present study, the adverse effects of retained placenta on reproductive performance were increased for cows calving in a hot environment.

In conclusion, our data indicated that cows that calved in a cool environment could more effectively cope with reproductive disorders prior to conception, and this fact was mainly observed in older cows.

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TABLE 3. Comparison of the direct relationships among reproductive variables for cows calving in the warm season (n = 1348) and cows calving in the cool season (n = 1822) by means of coefficients obtained by path analysis[1].

Variable	Risk factor	Warm calving season			Cool calving season		
		RC[2]	SC[3]	*P*	RC[2]	SC[3]	*P*
Days Open	Lactation	2.5±1.3	0.06	0.04	0	0	0.85
	Twinning	0	0	0.53	0	0	0.33
	Retained placenta	0	0	0.31	0	0	0.99
	Metritis	28.2±9.2	0.08	0.002	51.8±8.8	0.13	0.0001
	Ovarian cyst	52.2±7.4	0.18	0.0001	53.1±7.4	0.16	0.0001
Repeat breeding	Lactation	0	0	0.42	0	0	0.70
	Twinning	0	0	0.73	0	0	0.70
	Retained placenta	2.44 (1.3 to 4.6)	0.12	0.006	0	0	0.23
	Metritis	2.75 (1.2 to 6.5)	0.10	0.022	3.48 (1.8 to 6.6)	0.13	0.0001
	Ovarian cyst	3.21 (1.7 to 6.2)	0.15	0.0005	2.43 (1.3 to 4.4)	0.11	0.003
Ovarian cyst	Lactation	1.15 (1.0 to 1.3)	0.12	0.008	0	0	0.19
	Twinning	0	0	0.34	0	0	0.71
Table 3 (Continued)							
Ovarian cyst	Retained placenta	2.08 (1.0 to 4.2)	0.10	0.041	0	0	0.21
	Metritis	2.53 (1.1 to 6.0)	0.09	0.036	2.95 (1.4 to 6.2)	0.11	0.004
Metritis	Lactation	0	0	0.51	0	0	0.98
	Twinning	5.10 (1.9 to 13.3)	0.14	0.0009	0	0	0.89
	Retained placenta	2.23 (1.0 to 5.1)	0.11	0.056	2.36 (1.1 to 5.2)	0.11	0.032

Retained placenta	Lactation	1.15 (1.0 to 1.3)	0.12	0.028	0	0	0.14
	Twinning	5.02 (1.9 to 13.3)	0.14	0.0001	5.06 (2.4 to 10.8)	0.13	0.0001

[1]Coefficients different from zero were significant at $P < 0.10$.

[2]Regression coefficient: least squares regression coefficient±SE are given in the study of risk factors for days open. Odds ratio and odds ratio 95% confidence interval are given for the other regressions (with dependent dichotomous variables).

[3]Standard partial regression coefficient.