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Factors Related to the Etiology of Retained Placenta in Dairy Cattle

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ABSTRACT

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Birth records of 369 288 calvings of 160 188 Meuse-Rhine-Yssel cows were analysed to assess the influence of factors associated with retained placenta. Special emphasis was placed on the analysis of a subset containing data on births involving a single live calf and an easy or normal calving process. The overall rate of incidence of retained placenta was 6.6%. The rate increased during the years studied. Abortion, stillbirth and multiple birth caused a marked increase in rate, as did difficult calving, caesarean section and fetotomy. After adjusting for these factors, analysis of the corrected subset showed that the rate of incidence increased with age of the dam. Gestation length prior to retention and birth weight were also associated with higher rates. The combination of short gestation length (<270 days) and low birth weight ($\leqslant 37$ kg) was associated with the highest risk of retained placenta. High birth weights mainly caused higher rates when related to dystocia. The incidence rate in cows delivering a male calf was only slightly higher than in cows delivering a female calf. Cows having retained placenta for a first or second time were three and six times, respectively, as likely to do so again at a subsequent parturition when compared with cows which had not had retained placenta previously.

INTRODUCTION

Retained placenta (RP) is an important reproductive disease. It causes considerable economic loss at farm level, especially when the incidence exceeds the average rate of 5–10% (Lotthammer, 1981; Joosten et al., 1987). The exact cause of the disease is still not known, and this hampers the search for preventive and therapeuric measures. Extensive research has indicated involvement of several causal factors, such as breed (Erb and Martin, 1978; Watts et al., 1979), year (Roberts, 1971), season (Dyrendahl et al., 1977; Du Bois and Williams, 1980), herd (Roberts, 1971), dystocia (Geyer, 1964; Erb et al., 1981; Thompson et al., 1983), gestation length (Muller and Owens, 1974; Grunert,

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1983), age (Muller and Owens, 1974; Dyrendahl et al., 1977; Erb and Martin, 1980), stress (Hindson, 1976; Du Bois and Williams, 1980; Zöldag, 1983), nutrition (Trinder et al., 1973; Morrow et al., 1979; Lotthammer, 1983), and hormone levels (Agthe and Kolm, 1975; Chew et al., 1979; Bosu et al., 1984). Recently, disturbances in the immunological interaction between dam and calf were found by Gunnink (1984a,b,c) and Heuwieser et al. (1985).

There is, however, no consistent opinion among the authors on the exact influence of these factors. Study populations are often small and of variable origin. Most studies focus on only a few specific factors, which makes it difficult to assess the contribution of these factors to the incidence of the disease. In this study, a large data set has been analysed on the influence of various risk factors and their interactions, with special emphasis on the characterization of factors associated with an enhanced frequency of RP in normal calving cows. This first report describes the data set in full and provides results of an initial analysis which intended to provide an in-depth characterization of each factor involved. The factors and their interactions (including bull and herd influence) were further analysed using linear models; these results will be published in a second report.

MATERIALS AND METHODS

Study population

The present study was conducted by making use of the birth registration data of an A.I. centre situated in the south of The Netherlands. The average number of (privately owned) farms in the total area making use of A.I. in the period studied was 1680. The average number of cows per farm used for reproduction was 45. The cattle population was predominantly of the Meuse–Rhine–Yssel (M.R.Y.) breed, a dairy breed also suited for beef production. The average milk production per cow in this region during the years 1975–1983 was 5680 kg, with 3.90% fat and 3.38% protein (Central Milk Recording Service). During winter cows were housed in a tie stall or cubicle housing system; from May through October most cows were at pasture. Rations during housing consisted mainly of corn silage and to a lesser extent of grass and hay silage. Grass was the main feed during summer. In both cases concentrates were additionally supplied. Ninety-three percent of breeding was by A.I. Bulls used were mainly of the M.R.Y. breed and in some cases of the Friesian or Red Holstein breeds. An average of 49% of the farms was affiliated to a breeding society. Veterinary service was provided by local practitioners. The herds were brucellosis free.

Data collection and storage

The data set was created from the birth registration data covering the period from November 1975 through May 1984. Birth registration was by obligatory submission of a birth record by the farmer after each delivery, including abortion and premature delivery. Ninety-nine percent of the records were received. Regular instructions were given to the farmers on how to interpret the variables mentioned on the record. All received records were checked for completion and possible errors. Data were coded and entered on specially written computer programmes (Van Loen and Van Dieten, 1961).

Record editing

The final data set was produced by several editing steps. Deletion of records because of obvious input errors resulted in a final data set containing data on 160 188 M.R.Y.cows. The record contained the following variables:
(1) identification: number, breed, herd, date of birth, sire, dam.
(2) reproduction: date of parturition, parity, calving process, retained placenta, single/multiple birth, sex, condition and weight of calf.
(3) insemination: date of first insemination, date of last insemination, number of inseminations, number of sires used, identification of sire.
(4) culling: date of culling, cause of culling, pregnant at culling.

Interpretation of variables
— parity: calving sequence 1, 2 and $\geqslant 3$.
— calving process: easy (no or minor assistance); normal (easy pull); difficult (hard pull: 2 or more persons); caesarean section; fetotomy.
— abortion: gestation length shorter than 260 days. Specifically mentioned by the farmer.
— retained placenta: retention of fetal membranes for more than 24 h post partum.
— weight of calf, estimated by the farmer.
— condition of the calf: alive; stillborn.

Data analysis

For initial analysis all valid data on RP from calvings with gestation lengths between 260 and 300 days were used. In addition abortions were taken into account, but only when mentioned as such by the farmer. The total number of calvings amounted to 369 288. This set was used to analyse effects of year, calving type and calving process.

A special subset (A) was created containing data on single births with live calf and easy or normal calving process. This set was used to analyse year, age

of dam, gestation length, sex and weight of calf and season as risk factors, and contained 312 547 records. For differences between years and seasonal effects, the data for the years 1975 and 1984 were excluded since these data covered only 3 and 6 months, respectively. To assess the chance of recurrence of RP, a second subset was created from subset A. This subset (B) contained data on cows that calved three or more times consecutively starting from the first parity, within the period covered by the data set. Only the first three calvings were taken into account. The subset contained data on 19 374 cows (=58 122 records).

A Pearson's Chi-square test for independence was used for analysis of parity, calving type, calving process, sex of calf and recurrence. To assess differences in rates between years and amongst age groups, a Pearson's Chi-square test for independence was used to compute an overall Chi-square statistic (χ_t^2). This statistic was subdivided into a component due to linear regression of retained placenta on year or age (χ_s^2, with one degree of freedom) and a component due to departure from the linear model (χ_l^2, with $t-1$ degrees of freedom). A significant χ_s^2 statistic implied an increase with year or age; a linear trend was detected by a non-significant χ_l^2 statistic.

Within subset A gestation length and weight of calf were analysed by a Chi-square test for heterogeneity (Snedecor and Cochran, 1980). Differences in gestation length and birth weight between the sexes were analysed by a two-tailed t-test for difference in means. Seasonal patterns were analysed by a test for seasonality of events (Walter and Elwood, 1975). This test allows for variation in the population at risk. The total year length was taken as 365.25 days and the length of February as 28.25 days. The test assumes that the data can be placed at the circumference of a unit circle. A unimodal cyclic pattern is detected when: (1) χ_a^2 is significant, which means that the centre of gravity of the observed data points is significantly removed from the expected centre and (2) χ_f^2 is non-significant, which means that the observed data fits the hypothesized model. As a slight modification of the test method we minimalized the χ_f^2 statistic by computer search for the optimum value of α (amplitude of cyclic variation).

Gestation length and average age at calving per month were analysed by a two-tailed t-test for difference in means.

Because of the large numbers, a level of significance of 0.01 was chosen for all tests.

RESULTS

Population characteristics

Average age at first calving was 858.6 ± 107.3 days, calving interval was 384.2 ± 49.3 days and gestation length was 278.8 ± 5.2 days. The number of

TABLE 1

Rate of incidence (%) of retained placenta from 1976 through 1983. Figures are given for the total set (all births) and for subset A (single births, live calf and easy or normal calving)

Year	Total set	Subset A	No. of calvings	
1976	5.8*	4.0**	40428	35138
1977	6.0	3.9	38947	33103
1978	6.3	4.1	40756	34553
1979	6.3	4.1	42092	35938
1980	6.8	4.1	42764	36209
1981	6.1	3.6	45955	38454
1982	7.1	4.4	48478	39900
1983	7.4	4.8	47088	39088
Total	6.6	4.1	346508	292383

*1976-1983: χ_t^2 (7 d.f.) = 169.4 ($P<0.001$); χ_s^2 (1 d.f.) = 121.2 ($P<0.001$); χ_l^2 (6 d.f.) = 48.2 ($P<0.001$).
**1976-1983: $\chi_t^2 = 84.9$ ($P<0.001$); $\chi_s^2 = 32.7$ ($P<0.001$); $\chi_l^2 = 52.2$ ($P<0.001$).

inseminations per conception was 1.7 ± 1.1 (all values are mean $\pm$ S.D.). On average, 23.3% of the animals was culled each year. Overall percentages of abortion, stillbirth and multiple birth were 1.9%, 4.0% and 3.0%, respectively. Gestation length was shortest (278 ± 5.2 days) in cows calving in summer (June through August) and longest (279 ± 5.2 days) in cows calving in winter (December through February) ($P<0.001$). Average age at calving for each month from January through December was 4.5, 4.8, 5.0, 5.1, 5.1, 5.1, 5.1, 4.8, 4.3, 4.4, 4.4, 4.4 years (S.D. for all months = 2.0–2.3; the overall χ^2 statistic was significant, $P<0.001$).

Effects on retained placenta (RP)

The overall incidence of RP in the total set was 6.6% (Table 1). From 1976 through 1983 the rate of incidence increased from 5.8% up to 7.4% ($P<0.001$). The increase was curvilinear rather than linear, since there was a significant departure from linear regression ($P<0.001$). In subset A, the rate of incidence followed the same trend. Abortion strongly influenced the rate of incidence of RP (61.6% of the aborting animals retained their placenta, Table 2). Also multiple birth and stillbirth were associated with much higher rates (36.8% and 19.4%, respectively) as compared with single births with a live calf ($P<0.001$).

Caesarean section and especially fetotomy caused high rates (Table 3). The rate of incidence after difficult calvings was higher than with normal or easy calvings. There was, however, also a slight difference between the last two ($P<0.001$).

TABLE 2

Relationship between calving type and rate of incidence (%) of retained placenta. Numbers are given for parities 1, 2, ⩾3 and total. The total number of calvings in each class is in parentheses

Calving type	Parity			
	1	2	⩾3	Total
Single live calf	3.1* (58900)	3.3 (85085)	5.3 (185220)	4.4 (329205)
Abortion	50.7 (493)	60.3 (1013)	64.8 (2026)	61.6 (3532)
Stillbirth (single births)	13.3 (4575)	19.3 (3189)	24.4 (5684)	19.4 (13449)
Multiple birth	30.2 (625)	33.8 (4214)	38.2 (7562)	36.8 (10601)

*The differences between all calving types and parities were significant ($P<0.001$).

Figs. 1, 2 and 3 and Tables 4 and 5 show the outcome of analysis of the data for single births with live calf and a normal easy calving (subset A).

Age groups were composed within the parity groups (Fig. 1). In parity 1 as well as in parity 2 there was a linear increase with age ($P<0.005$). In parity 3 and greater, an increase with age was also detectable ($P<0.001$), but the increase appeared to be curvilinear. Both birth weight and gestation length prior to retention influenced RP incidence (Table 4). A gestation length of 275–279 days was associated with minimum incidence rates, more or less irrespective of birth weight. Especially gestation lengths of 270 days or less showed higher rates. Prolonged gestation as such, like high birth weights, did not appear to have a strong influence. Cows with a combination of short gestation period and low birth weight were most at risk; when either one increased the incidence rate dropped.

TABLE 3

Relationship between calving process and rate of incidence (%) of retained placenta. Numbers are given for parities 1, 2, ⩾3 and total. The total number of calvings in each class is in parentheses

Calving process	Parity			
	1	2	⩾3	Total
Easy	2.5* (28757)	4.0 (49350)	6.1 (109878)	5.0 (187985)
Normal	4.0 (28492)	4.8 (37485)	7.7 (84553)	6.3 (150530)
Difficult	10.3 (6377)	11.6 (4695)	17.7 (6273)	13.3 (1734)
Caesarean	10.9 (1543)	13.2 (613)	20.7 (610)	13.6 (3166)
Fetotomy	13.1 (110)	27.5 (69)	44.2 (77)	26.2 (256)

*The differences between all rates for calving process and parity were significant ($P<0.001$).

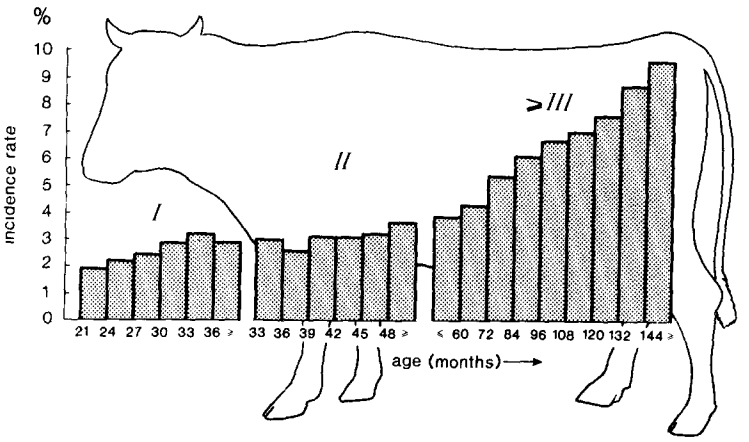

Fig. 1. Rate of incidence of retained placenta (%) related to age (periods of 3 months). Figures are given for parities 1, 2 and ⩾3 (subset A). Parity 1 and 2 (χ^2_s: $P<0.005$; χ^2_l: $P>0.05$). Parity ⩾3 (χ^2_s: $P<0.001$; χ^2_l: $P<0.001$).

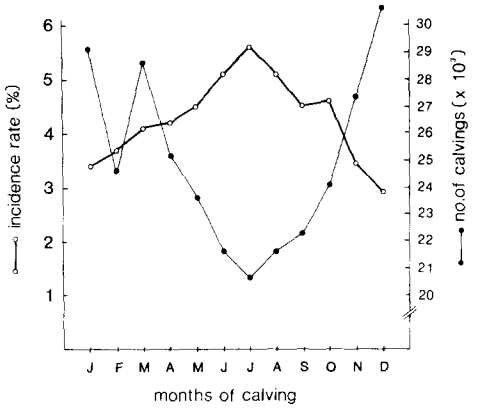

Fig. 2. Monthly rate of incidence (%) of retained placenta and total number of calvings per month (subset A). Based on a period of 8 years; (χ^2_d (2 d.f.) $=287.9$, $P<0.001$; $\alpha=0.21$; χ^2_f (11 d.f.) $=23.4$, $0.025<P<0.01$; $Q^*=194.4$).

There appeared to be a slight, although significant, difference ($P<0.001$) in rate of incidence between male and female calves (Table 5). A seasonal trend in the occurrence of RP was detected (χ^2_d: $P<0.001$). Since comparison of the data with the hypothesized model provided a non-significant χ^2_f ($P>0.01$), the trend was unimodal. Highest rates were seen in July (maximum rate: $Q^*=194.4$), June and August. Lowest rates were recorded during the winter period (November through February).

The chance of recurrence of RP appeared to be substantial. The incidence rates in cows that initially retained their placentas at first, second or third

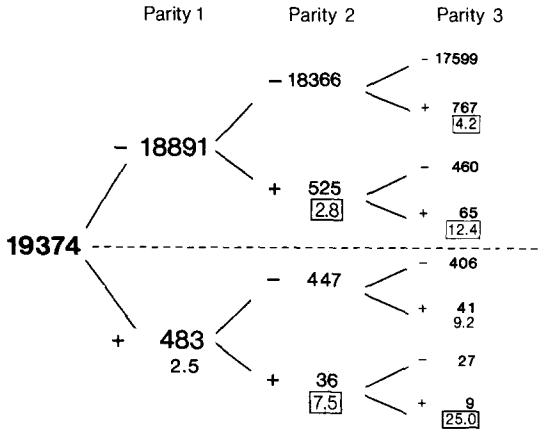

Fig. 3. Recurrence of retained placenta. Consecutive calvings of cows with (+) and without (−) retained placenta (subset B). Upper figures are total numbers, lower figures are percentages. Outlined figures are analysed and differ significantly ($P<0.001$).

calving were 2.5%, 2.8% and 4.1%, respectively. Incidence rates for cows retaining their placenta for the second consecutive time at second or third calving were 7.5% and 12.4%, respectively. Within parity groups, the chance of RP for a second or third consecutive time increased significantly [in parity 2, 2.8% vs. 7.5% (ratio 2.7); in parity 3, 4.2% vs. 12.4% vs. 25.0% (ratio 3.0 and 6.0): $P<0.001$].

TABLE 4

Rate of incidence (%) of retained placenta related to birth weight and gestation length prior to retention (subset A: single live calf, easy or normal calving)

Gestation length (days)	Birth weight (kg)							Total no. of calvings
	≤27	28-32	33-37	38-42	43-47	≥48	Total	
260-264	20.2*	18.7	14.3	7.5	8.7	6.8	12.4	2667
265-269	11.0	9.8	8.0	7.1	6.4	6.6	7.9	8565
270-274	4.8	4.4	4.2	4.3	5.4	4.8	4.4	44967
275-279	3.7	3.1	3.1	3.3	3.9	4.4	3.4	118167
280-284	3.2	3.8	3.5	3.6	4.6	5.2	3.9	97211
285-289	6.7	3.1	4.3	4.2	5.2	5.7	4.7	34353
290-294	3.6	4.4	4.2	5.3	6.2	8.2	5.9	5577
295-299	—	8.9	1.9	4.0	4.8	5.5	4.2	1031
Total	6.1	4.6	3.9	3.8	4.6	5.3	4.1	312547
Total no. of calvings	2699	17414	58806	160441	56192	16995	312547	

*Differences between expected values and observed values were significant ($P<0.001$).

TABLE 5

Rate of incidence (%) of retained placenta, birth weight and gestation length in female and male calvings (single live calf, easy or normal calving (subset A) 47.5% female and 52.5% male calves)

	Sex of calf	
	Female	Male
% retained placenta	4.0*	4.2*
Birth weight (kg)	38.9 ± 4.3	40.7 ± 4.8
Gestation length (days)	278.7 ± 5.1	279.1 ± 5.3

*Values for female and male calvings differ significantly ($P < 0.001$; % retained placenta, $P < 0.01$).

DISCUSSION

As reported by Roberts (1971), Dyrendahl et al. (1977), Arthur (1979), Thompson et al. (1983) and Larson et al. (1985), abortion, stillbirth, multiple birth and dystocia exert a marked influence on the incidence of RP. Still, we found a 4% incidence of RP in normal calvings. The aforementioned factors are closely linked to a problematic calving process with all its other complications, the presence of which will very likely obscure the exact influence of other factors. Therefore a data set containing data on calvings with a single live calf and easy or normal calving process was created. In the initial analysis described here, each factor was examined separately to provide a more extended characterization. This was done in addition to the utilization of an expanded linear model to be described in a later report.

The risk of RP increased with age of the dam as was also reported by Dyrendahl et al. (1977) and Erb and Martin (1980). Dohoo et al. (1984) could not detect a consistent age pattern, but they did recognize a trend toward lower rates in heifers. Since the age effect was detected within the parity groups, the effect of recurrence can be ignored.

Birth weight and gestation length were somewhat entwined in their influence on the incidence of RP. Cows most at risk had the combination of low birth weight and short gestation length (< 270 days). The effect of the combination became weaker when one of the factors increased, more or less compensating for the other. The effect of short gestation, however, was predominant. Other authors (Muller and Owens, 1974; Larson et al., 1985) mentioned a tendency toward heavier calves causing higher RP rates, but dystocia rate was not mentioned.

Sex of the calf had only a slight influence on the RP rate. Male calves were associated with 0.2% higher rates. It is debatable whether this statistically significant difference is indicative of a real difference or the number of cases analysed. Muller and Owens (1974) reported no influence of sex, just as Larson et al. (1985) for parity 2. In parity 1 the latter authors found higher rates

for males, but since they did not correct for dystocia (which is related to birth weight (Thompson et al., 1983) – male calves being heavier) this might have been caused by the increased chance of calving problems in heifers.

Seasonal changes in RP rate followed a unimodal trend. The highest rates were found during the summer months when the cows were at pasture, and the lowest rates were found in mid-winter when the cows were housed. A similar pattern was found by Dyrendahl et al. (1977) and Du Bois and Williams (1980). By contrast Muller and Owens (1974) found high rates during the winter period. Erb and Martin (1980) and Dohoo et al. (1984) detected no seasonal pattern. Comparison of these data is difficult. Climate and feed conditions differ for the regions studied, and other factors may also have been of influence. In the present data there was a tendency toward older cows calving in spring and early summer. Since older cows are more prone to RP the variability in age pattern might to some extent account for the higher RP rates in certain months. However, a comparison of age pattern and RP rate did not show a perfect fit. This implies the influence of other factors as well. In this respect, Du Bois and Williams (1980) mentioned a shorter gestation length (2.8 days shorter) in summer than in the cold season (a tendency confirmed by our results).

Cows having retained placenta were more likely to do so again at a subsequent parturition (the chances were approximately three times higher than average, and even six times as high after two consecutive retentions). This is consistent with the findings of Brands (1966) and Larson et al. (1985). Muller and Owens (1974) report little tendency for recurrence, but this might have been due to the small numbers analysed.

Apart from describing the variation of incidence rate of RP related to different risk factors, it is interesting to know how many of the RP cases can actually be explained by the aforementioned factors. We will deal with this in another report.

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