Periparturient Traits in Seven High Dairy Herds. Incidence Rates, Association with Parity, and Interrelationships Among Traits

ABSTRACT

Interrelationships among nine periparturient traits and their association with parity were investigated in 8521 calvings of dairy cows examined routinely between 5 to 14 d postpartum. Rates of twins, stillbirth, milk fever, prolapsed uterus, retained placenta, primary metritis, displaced abomasum, ketonuria, and aciduria were 5.8, 6.3, 1.4, 3, 17.8, 36.1, 1.7, 30.4, and 29.5%, respectively. The risk for twins, milk fever, prolapsed uterus, displaced abomasum, ketonuria, and aciduria increased with parity, whereas that for stillbirth and metritis was higher in heifers than in cows. Stillbirth, retained placenta, metritis, displaced abomasum, ketonuria, and aciduria were directly associated with birth of twins; prolapsed uterus and retained placenta with stillbirth; prolapsed uterus, retained placenta, and primary metritis with milk fever; displaced abomasum, ketonuria, and aciduria with retained placenta and with metritis; ketonuria and aciduria with displaced abomasum and aciduria with ketonuria.

INTRODUCTION

Parturition is a crucial event in the life of the dairy cow. More diseases and veterinary costs are associated with the periparturient period than any other time (32). Because some diseases appear in the same stage of the lactation and in the same animal, it is desirable that interrelationships among their occurrences be established. Then it may be possible to differentiate among the effects of common causes, direct and indirect causal associations, and incidental relationships (11). Little work has been undertaken to identify these associations; most has applied to monovalent associations involving only two diseases (5, 21) and was based on cows examined because of clinical disease (5, 8). To obtain a large database for epidemiological analysis, most studies are based on diagnosis made by a number of clinicians or research workers.

Factors involved in the etiology of some of the postparturient diseases have been investigated by the author previously (24, 25). The present work describes the incidence of the common diseases or problems associated with parturition, evaluates the effect of parity on the occurrence of these diseases, and intends to establish independent relationships among them.

MATERIALS AND METHODS

Data are from the author’s routine practice on seven Israeli Holstein herds from October 1980 through September 1985. These herds are characterized by high annual milk yield (7000 to 9500 kg/cow) and heavy feeding. Cows are kept in groups according to milk yield. Dry cows are kept in a separate group and are transferred 7 to 14 d prior to calving to a “calving group.” Ration consists of equal parts of the dry cow ration and that of the low producers. Feed is in the form of complete rations, which consist of cotton seed hulls, barley, corn, bran, soybean and cotton meals, and roughages according to availability and price. Roughages are primarily corn or wheat silages and a little hay. Rations basically conform to NRC recommendations (27). Ration composition among and within farms is presented in Table 1.

Clinical Examination

All cows that calved were presented for routine examination 5 to 14 d postpartum on the same day of the week. Of 8521 cows that calved, 8387 cows were examined for post-
periparturient uterine diseases. Of these, 2954 cows were further examined according to the following procedure:

1. Determination of the state of the uterus from the discharge removed from the cervical region by pervaginal manual examination.

2. Examination of urine for acetoacetate and reaction in a sample withdrawn through a metal catheter. A drop of urine was placed on a reagent strip (Ketostix, Ames, England), and the test area was compared to a color chart and read 15 s after wetting for ketonuria. The pH reaction of the urine was determined by universal indicator paper (Macerey-Nagel, West Germany) with a pH range of 6.4 to 8.0 (.2 intervals).

3. Examination of the feces for color, quantity, and consistency.

4. Auscultation for displaced abomasum in all ketonuric cows. Additional clinical examination was carried out if indicated. All cows were under strict veterinary supervision, and routine daily visits were made to each farm. No treatment of the diseases described in the study was carried out by the farmer.

The diseases and traits were defined as follows: 1) Stillbirth. A calf that died as a direct result and within 24 h of parturition or was born dead. Calves born previous to the last month of term were not included in the study.

2) Milk fever. Any cow that showed clinical signs of hypocalcemia ranging from staggering to recumbency. 3) Retained placenta. A cow that retained the placenta for more than 24 h postpartum. 4) Primary metritis. Any cow without a previous history of retained placenta but having a foul smelling, colored discharge removed from the cervix during the routine postparturient examination. 5) Displaced abomasum. Diagnosed in the 1st mo postpartum. All cases were verified by surgery. 6) Ketonuria. Urine with an acetoacetate concentration of .5 mmol/L and more. 7) Aciduria. Urine with a pH of 7.0 or less.

Scope and Methods of Statistical Analysis

All 8521 calvings were used for the evaluation of the association of the various diseases and traits with stillbirth, birth of twins, milk fever, and prolapsed uterus. Of these, 8387 cows were examined for postparturient uterine diseases and to measure the associations of retained placenta, primary metritis, and displaced abomasum with the various traits. We examined 2954 multiparous cows for urine acetoacetate and pH and used them to evaluate association with ketonuria and aciduria.

Data were analyzed by a retrospective study as described by Mantel and Haenszel (19). In this method, a summary Chi-square with 1 df is used to test the association of disease incidence with any particular factor when the effect of any other factor or group of factors ("control factors") is held constant. The animals are classified according to the various control and study factors desired. Variables to control were selected in the light of their possible effect on the association between the disease and the factor under study with the limitation of the sample size. For any set of specified control factors such as farms, parity, and other diseases, there is a $2 \times 2$ contingency table; cows were classified as with or without the disease and with or without the study factor. In each $2 \times 2$ table, which is conditional on the marginal totals, expectation and variance of the number of diseased cows positive for the study factor
are determined. Summation of the observed and expected number of such cases is made over all \(2 \times 2\) subclassified tables, and Chi-square is computed as the square of the cumulated discrepancy, corrected for continuity, divided by the sum of conditional variances. The corrected Chi-square value indicates the significance of the observed association between the disease and factor under study after adjusting for the possible effects connected with the control factors.

The association between the disease and the examined factor is presented in terms of summary relative risk \(R\) of a population with the examined factor to have a disease compared to one without it. The procedure combines the relative risks from the individual subcategories of control factors into a summary relative risk \(R\) and to some degree weights the relative risks of the separate subcategories by importance. Statistical power is increased by reinforcement of relative risks prevailing in the same direction. A crude unconditional value for relative risk \(r\) results when all subclassifications to control factors are ignored by pooling the data into one table.

Association of the various traits with parity was established by our comparing the risk of the disease in one parity group with the risk of all other groups pooled together as used by Erb and Martin (12) and calculated in subcategories of the various control factors according to the Mantel and Haenszel method.

### RESULTS AND DISCUSSION

Incidence rates of the traits and their ranges are in Table 2. The association of the various traits and diseases with parity are in Table 3, and those among traits in Table 4. Relative risks are interpreted as follows: for heifers and twins, the summary relative risk \(R\) is .2, (Table 3), which is significantly different from 1.0 (\(\chi^2 = 156.7\), and with 1 df \(P < .01\)). As the null value (no association) is 1.0, a relative risk of .2 indicates an inverse association. Thus heifers, compared with all other cows and with summary relative risk being calculated in subgroups of the various farms, were .2 times as likely as cows to have twins.

Incidence of many postparturient traits increased with parity as in previous studies (9, 12, 13, 28, 29). Cows with later parities are survivors of earlier ones and the estimates of "risks" might therefore be subjected to culling bias (only survivors of periparturient problems have later observations). This effect was ignored in the case of increasing risk with parity even when the repeatability of the trait is greater than zero and more diseased cows than normal ones are culled. If this effect were taken into account, the effect of parity on the risk of the disease would have been even higher.

### Twins

The twinning rate in the population under study (5.8%) was slightly above the national average for 1984 to 1985 (4.7%) as derived by

<table>
<thead>
<tr>
<th>Trait</th>
<th>Number of calvings</th>
<th>Rate (%)</th>
<th>Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twins</td>
<td>8521</td>
<td>5.8</td>
<td>4.7-7.3</td>
</tr>
<tr>
<td>Stillbirth</td>
<td>8521</td>
<td>6.3</td>
<td>3.9-7.9</td>
</tr>
<tr>
<td>Milk fever</td>
<td>8521</td>
<td>1.4</td>
<td>.7-2.3</td>
</tr>
<tr>
<td>Prolapsed uterus</td>
<td>8521</td>
<td>.3</td>
<td>.1- .7</td>
</tr>
<tr>
<td>Retained placenta</td>
<td>8387</td>
<td>17.8</td>
<td>15.1-23.3</td>
</tr>
<tr>
<td>Primary metritis</td>
<td>8387</td>
<td>36.1</td>
<td>24.8-51.3</td>
</tr>
<tr>
<td>Displaced abomasum</td>
<td>8387</td>
<td>1.7</td>
<td>.9-2.5</td>
</tr>
<tr>
<td>Ketonuria</td>
<td>2954</td>
<td>30.4</td>
<td>29.3-35.3</td>
</tr>
<tr>
<td>Aciduria</td>
<td>2954</td>
<td>29.5</td>
<td>17.0-45.4</td>
</tr>
</tbody>
</table>

Table 2. Incidence rates and range of periparturient traits among farms.
Table 3. The association between traits and parity (summary relative risk "R" of one parity group is calculated against all others pooled together).

<table>
<thead>
<tr>
<th>Trait¹</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
<th>Fifth and more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number examined</td>
<td>3137</td>
<td>2267</td>
<td>1389</td>
<td>922</td>
<td>806</td>
</tr>
<tr>
<td>Twins (1)</td>
<td>.2**</td>
<td>1.5**</td>
<td>1.6**</td>
<td>1.6**</td>
<td>2.0**</td>
</tr>
<tr>
<td>Stillbirth (2)</td>
<td>1.9**</td>
<td>.6**</td>
<td>1.0</td>
<td>.8</td>
<td>.7*</td>
</tr>
<tr>
<td>Milk fever (1)</td>
<td>0</td>
<td>.02**</td>
<td>.9</td>
<td>4.2**</td>
<td>11.2**</td>
</tr>
<tr>
<td>Prolapsed uterus (3)</td>
<td>.5†</td>
<td>1.3</td>
<td>.9</td>
<td>1.9 (8)</td>
<td></td>
</tr>
<tr>
<td>Number examined</td>
<td>3096</td>
<td>2244</td>
<td>1360</td>
<td>898</td>
<td>789</td>
</tr>
<tr>
<td>Retained placenta (4)</td>
<td>.5**</td>
<td>.8**</td>
<td>.9</td>
<td>2.0**</td>
<td>3.3**</td>
</tr>
<tr>
<td>Primary metritis (4)</td>
<td>1.5**</td>
<td>.8**</td>
<td>.8**</td>
<td>.9*</td>
<td>1.0</td>
</tr>
<tr>
<td>Displaced abomasum (5)</td>
<td>.5**</td>
<td>1.2</td>
<td>1.0</td>
<td>1.6†</td>
<td>2.1**</td>
</tr>
<tr>
<td>Number examined</td>
<td>0</td>
<td>1261</td>
<td>726</td>
<td>491</td>
<td>476</td>
</tr>
<tr>
<td>Ketonuria (6)</td>
<td>.4**</td>
<td>1.2†</td>
<td>1.6**</td>
<td>2.0**</td>
<td></td>
</tr>
<tr>
<td>Aciduria (7)</td>
<td>.8*</td>
<td>.8*</td>
<td>1.5**</td>
<td>1.3*</td>
<td></td>
</tr>
</tbody>
</table>

¹ Variables selected as control factors: 1) Farms. 2) Farms, twins, and milk fever. 3) Crude relative risk (all control factors pooled together). 4) Farms, twins, stillbirth, milk fever. 5) Farms, twins, stillbirth, milk fever, and postparturient uterine diseases. 6) Farms, twins, and postparturient uterine diseases. 7) Farms, twins, postparturient uterine diseases, and ketonuria. 8) Fourth or later parity.

*P<.05.
**P<.01.
†P<.10.

The increased risk for displaced abomasum in twins (R = 1.8), which is independent of the effects of farms, parity, stillbirth, milk fever, and postparturient uterine diseases, could be the outcome of the larger space evacuated by the postparturient contracting uterus. This was suggested previously as the mechanical explanation for displaced abomasum (3). An alternative explanation is the sudden change in diet from the dry ration to that of high yielding cows, without "lead" feeding normally practiced on the seven farms prompted by the earlier and unexpected calving. This sudden change in diet leads to a drop in rumen pH, a key stage in the evolvement of abomasal atony (3).

The relative low risk for ketonuria in cows with twins (R = 1.4) can be explained by the fact that ketonuria in the 1st wk postpartum in these herds is mainly a manifestation of a lower...
TABLE 4. The associations among traits (summary relative risks "R").

<table>
<thead>
<tr>
<th>Trait</th>
<th>Twins</th>
<th>Stillbirth</th>
<th>Milk fever</th>
<th>Retained placenta</th>
<th>Primary metritis</th>
<th>Displaced abomasum</th>
<th>Ketonuria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still birth</td>
<td>3.4** (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk fever</td>
<td>1.3 (2)</td>
<td>.4 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolapsed uterus</td>
<td>2.3 (3)</td>
<td>6.8** (3)</td>
<td>11.5** (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retained placenta</td>
<td>12.0** (4)</td>
<td>4.3** (4)</td>
<td>2.3* (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary metritis</td>
<td>2.3** (4)</td>
<td>2.9** (4)</td>
<td>1.8* (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displaced abomasum</td>
<td>1.8* (6)</td>
<td>1.2 (7)</td>
<td>.6 (8)</td>
<td>6.8** (9)</td>
<td>4.7** (9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ketonuria</td>
<td>1.4* (10)</td>
<td>1.1 (10)</td>
<td>1.0 (10)</td>
<td>3.4** (11)</td>
<td>2.5** (11)</td>
<td>50.4** (10)</td>
<td></td>
</tr>
<tr>
<td>Aciduria</td>
<td>1.7** (10)</td>
<td>1.3† (10)</td>
<td>1.3 (10)</td>
<td>1.9** (12)</td>
<td>2.0** (12)</td>
<td>5.8** (10)</td>
<td>2.4** (13)</td>
</tr>
</tbody>
</table>

1 Variables selected as control factors in parentheses: 1 Farms, parity, and milk fever. 2 Farms and parity. 3 Parity. 4 Farms, parity, stillbirth and milk fever. 5 Farms, parity, twins and stillbirth. 6 Farms, parity, stillbirth, milk fever, and postparturient uterine diseases. 7 Farms, parity, twins, milk fever, and postparturient uterine diseases. 8 Farms, parity, twins, stillbirth, and postparturient uterine diseases. 9 Farms, parity, twins, stillbirth, and milk fever. 10 Farms, parity, and postparturient uterine diseases. 11 Farms, parity, and twins. 12 Farms, parity, twins, and ketonuria. 13 Farms, parity, twins, and postparturient uterine diseases.

*P<.05.

**P<.01.

†P<.10.
than normal functioning liver due to overfeeding before calving (25, 26). Because cows with twins are relatively underfed they would be expected to have less of a problem.

Stillbirth

The rate of stillbirth (6.3%, Table 2) is similar to that for other herds in the country (30). The risk for stillbirth was highest in heifers and lowest in second parity cows. No significant risks were associated with the other parity groups. The increased risk for stillbirth in heifers is in agreement with that previously reported for dystocia (35). Together with the increased risk for metritis in this parity group, stillbirth is a probable manifestation of damage to the uterine wall during parturition because of an oversized fetus or an overfat mother (24). The problem is presumably more acute in the smaller heifers.

Cows with stillbirth are at higher risk for prolapsed uterus, retained placenta, and metritis. The increased risk of prolapsed uterus in cows with stillbirth (R = 6.8, Table 4) could result from mechanical stress associated with dystocia, which might lead to weakening of the uterine musculature and later to prolapse. The increased risk for retained placenta might be explained by the same course of events, whereas that for metritis is the result of the damage inflicted on the uterus during calving and subsequent bacterial infection. No association was established between milk fever and stillbirth. The significant increased crude relative risk for ketonuria and aciduria in cows with stillbirth (r = 1.6) could not be substantiated when the factors of farms, parity, and postparturient uterine diseases were controlled. It is evident, therefore, that this apparent association is the outcome, at least in part, of the postparturient uterine diseases, which are strongly associated with ketonuria and stillbirth.

Milk Fever

Rate of milk fever is lower than that reported (4, 5, 8, 37). This lower rate (1.4%) is probably due to the low calcium diet fed during the dry period and the common practice of injection of Alfalcaldol (Veralfa, Teva, Israel) to all adult cows before calving. In agreement with previous studies (5, 9, 16, 33), risk of milk fever increased with parity. All separate risks except that for the tripara were statistically significant. The higher risk for prolapsed uterus in cows with milk fever when parity is controlled implied that a major factor in its etiology is loss of uterine muscle tone, possibly associated with a drop in the blood calcium.

Contradictory results regarding the association of postparturient uterine diseases with milk fever have been published. In contrast to metritis, retained placenta was associated with milk fever in one study (4) but not in another (9), whereas in the present study both diseases were associated with milk fever. In contrast to some other studies (4, 7, 15, 17, 31), there was no association between displaced abomasum and milk fever, and no evidence that hypocalcemia is involved in the etiology of displaced abomasum (6). In the present study, milk fever had a crude relative risk with ketonuria and aciduria (r = 2.1 for both associations). Although these findings are in agreement with other studies (4, 5) this crude association is the direct result of the common increase in the rate of milk fever, ketonuria, and aciduria with parity and their independent association with retained placenta. When these factors are controlled, no such association exists (Table 4). It is the author's conclusion, therefore, that the common tendency to include milk fever in the “parturition” and “fat cow” syndromes is not justified and is merely an erroneous conclusion based on bivariate statistical analysis.

Prolapsed Uterus

The rate of prolapsed uterus was 0.3% with heifers being at lower risk. This tendency agrees with that reported previously (2). As most cases of prolapsed uterus occur within 24 h of parturition, the apparent association of this condition with retained placenta (2) could not be established because retained placenta in this study was defined as extending beyond this period, and all placentas were peeled off the uteri before they were replaced.

Retained Placenta and Metritis

Rates of retained placenta (17.8%) and metritis (36.1%) are higher than those described (5, 8, 11) but lower than those in a herd with the “fat cow syndrome” (22). These higher rates are partly the result of the high twinning
The risk for retained placenta increased with parity. All separate risks except that for tripara were significant (Table 3). This increasing risk is in agreement with most previous studies (5, 12, 24, 35) but in contrast to one (9) where differences in risk between heifers and multipara only were found. In another study (23) it is claimed that the rise of retained placenta may seem apparent, but it actually is because of an increase in the number of twins. Present results show that risk of retained placenta increased with parity even when the effect of twins is controlled. The risk is statistically significant to all parity groups except for the tripara.

Risk of metritis is highest in heifers and lowest in second parity cows. The increased crude relative risk in the oldest cows \((r = 1.2)\) is not statistically significant when the effect of twins is controlled. The high risk of metritis in heifers is the direct outcome of overfattening and the higher rate of stillbirth in this parity group (24).

Higher risks for displaced abomasum, ketonuria, and aciduria were present for cows with retained placenta and metritis. These diseases are associated with overfeeding before calving (24, 25). The association of displaced abomasum with postparturient uterine diseases is well established (7, 31) even when parity is controlled. These findings are in contrast to another study (34) where no association could be established between ketonuria and displaced abomasum, the increased risk for ketonuria in cows with displaced abomasum established in the present study is in agreement with others (5, 31, 36). The high association established between the two traits \((R = 50.4, \text{Table 4})\) strongly implies that the pathway, displaced abomasum \(\rightarrow\) ketonuria, is not the only one possible. The reverse route and the outcome of a common factor, such as overfeeding before calving, could be involved as well (5).

**Ketonuria and Aciduria**

The rate of ketonuria was 30.4% and that of aciduria 29.5%. The range in aciduria values was more scattered (Table 2), which may reflect variation in amount and quality of the roughage fed prior to and after calving. Risk for ketonuria and aciduria increased with parity; each individual parity group was statistically significant. The increased risk for ketonuria with increasing parity has been described (9, 10, 14). Together with the increased risk for aciduria, ketonuria values might represent increasing difficulties in liver function associated with age. Aciduria was associated with ketonuria \((R = 2.4)\) when parity and postparturient uterine diseases were controlled. This association is not only a reflection of ketonuria (26) but could reflect the starvation associated with ketosis and inadequate liver function (1).

**Conclusions**

The rate and risk of most traits and diseases associated with parturition are greatly influenced by parity. Special care must be taken when prospective experiments or retrospective studies are made to take parity into account to avoid bias in the results due to parity. The interrelationships established among the traits in terms of risk might on occasion prove erroneous when the summary risk is calculated. It is essential, therefore, that the possible affecting factors are controlled when multifactorial traits are studied.

Although some traits chronologically associated with parturition can be grouped under

### Displaced Abomasum

The rate of displaced abomasum (1.7%) is similar to that in other herds with similar feeding regimens (5, 8) but is somewhat higher than that previously reported (3). Although no linearity was established in the association between displaced abomasum and increasing age in one study (9), others (31, 34) agree that displaced abomasum is associated with age. In the present study a steady rise in incidence rate with parity is apparent, but only the separate risks for heifers and for fifth and later parity are statistically significant.
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