ABSTRACT

Incidence, predisposing factors, and implications of various reproductive disorders (dystocia, twinning, stillbirth, retained placenta, cystic ovaries, anovulation, infections of the reproductive tract, metritis, and abnormal health status) are reviewed as to their interrelationships and collective impact on reproductive performance, milk yield, and predisposition to other diseases or disorders in the periparturient dairy cow. All reproductive disorders reviewed reduce reproductive performance either directly or indirectly. Concurrent milk yield was reduced marginally in a few studies as a consequence of twinning, retained placenta, cystic ovaries, metritis, or other uterine disorders, and in cows with an abnormal health status. There is strong evidence for associated losses in milk yield following surgical delivery of a stillborn calf. We conclude that most periparturient disorders occur as a complex, rather than as a single abnormality. Cows with one disorder are at increased risk for other disorders, including metabolic ones. In contrast, actual milk yield or potential for high production generally does not predispose cows to increased risk for any of the reproductive disorders. The literature suggests that prophylactic measures to prevent occurrence of the one disorder might decrease the risk and incidence of other related disorders, either directly or indirectly.

INTRODUCTION

Economics of the dairy industry require producers to operate efficiently to remain competitive. Reproductive performance affects the quantity of milk produced per cow per day of herd life, the number of potential replacements needed to maintain a constant herd size, and the longevity of the cow in the herd (4, 15). All of these factors alter efficiency and affect profit. Because reproductive events culminate in an “all or none” endpoint, a cow is either pregnant or not. Therefore, reproductive failure causes great frustration for dairy producers. To be successful and remain competitive, producers must minimize losses resulting from infertility. In practice, this must translate into well-designed programs of herd health and reproductive management that minimize involuntary culling of problem cows by maintaining healthy, profitable cows in the herd. Despite our best efforts in these individually designed programs, some culling will inevitably occur because of reproductive failure and low milk yield.

Causes of infertility or reproductive failure are multiplicative in nature (12, 14, 63, 64, 71, 73). It is a mistake to attempt to diagnose unsatisfactory reproductive performance by focusing on any one particular disorder or symptom because of the interrelationship of the predisposing factors (21). Such factors might include managerial, environmental, metabolic, and nutritional problems in addition to common reproductive disorders, which collectively interact and exert adverse influences on reproduction and milk yield. Although recent reviews delineated the impact of metabolic disorders (22) and udder health (61) in the periparturient dairy cow, the focus of this review will be the interrelationship of various periparturient reproductive disorders and their collective impact on reproductive performance, milk yield, and predisposition to other diseases or disorders in the dairy cow.

Periparturient Health

The term “periparturient” stems from the word “parturition” and the prefix “peri”,...
which literally but vaguely means “around.” The periparturient phase generally includes the dry period and the first 3 to 4 wk after calving. The future reproductive capability of the dairy cow, a major concern for its economic value, is related frequently to postpartum events (55). Undesirable events during the periparturient period might result in culling or even death of the cow. Parturition is one of the most critical stages of the reproductive cycle of the dairy cow. It is a period of significant death rate, as well as potentially severe debilitating injury to both dam and neonate. Future efficiency of reproduction and milk yield can be affected adversely at this time, and for this reason, major efforts have been directed toward minimizing problems during parturition. Mather and Melancon (55) observed that in recent years there has been less emphasis in veterinary curricula in the US on manipulative obstetrics and more concern toward preventive measures that minimize future breeding problems and enhance future reproductive efficiency.

Keeping cows healthy is one of the most important steps in maintaining good fertility and maximal milk yield. Healthy cows produce more milk, rebreed sooner, and have lower culling rates than unhealthy herdmates (63). Poor health, regardless of its cause, usually leads to infertility. A recent study (63) highlighted the reproductive performance of healthy cows from eight dairy herds (Table 1). These cows were diagnosed healthy by the producer or his veterinarian throughout the entire lactation. Healthy cows were first bred at about 70 d postpartum, had conception rates greater than 55%, had fewer than 100 d open, and were culled at rates less than 12%.

The value of preventive herd health programs designed to maintain healthy cows has been well-established from both the economic and health aspects (12, 38, 73). Successful preventive programs require competency, mutual understanding, and respect between owner and veterinarian to yield maximal results. Preventive programs also are recognized by dairy producers as effective ways to help assure stability in their operations. Another study identified the veterinarian involved in a preventive herd health program as the most consistent variable influencing herd reproductive performance (14).

**COMMON REPRODUCTIVE DISORDERS**

**Dystocia**

*Incidence.* Dystocia is defined generally to include any calving in which assistance is required. It has been scored quantitatively in various ways. Calving difficulty or dystocia averages about 5.8%, ranging from .9 to 13.7% in eight studies comprising 218 herds (predominantly Holstein) and 40,828 calvings (Table 2).

**Predisposing Factors.** Much has been written about dystocia in cattle, including several reviews concerning its economic significance in terms of calf loss and subsequently impaired reproductive performance (42, 65, 72). The etiology of dystocia is not completely clear, but it is primarily a function of the size of the calf.

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**TABLE 1. Reproductive performance of healthy dairy cows.**

<table>
<thead>
<tr>
<th>Trait</th>
<th>First lactation</th>
<th>Later lactations</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. cows</td>
<td>69</td>
<td>134</td>
</tr>
<tr>
<td>Days to first estrus</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>Days to first service</td>
<td>68</td>
<td>70</td>
</tr>
<tr>
<td>Conception at first service, %</td>
<td>59</td>
<td>71</td>
</tr>
<tr>
<td>Days open</td>
<td>95</td>
<td>84</td>
</tr>
<tr>
<td>Services per conception</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Percentage culled</td>
<td>4.4</td>
<td>11.2</td>
</tr>
<tr>
<td>Percentage culled for reproduction</td>
<td>1.5</td>
<td>4.7</td>
</tr>
</tbody>
</table>

1 Source: adapted from (62).
TABLE 2. Incidence (percentage) of common periparturient reproductive disorders summarized from the literature.

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Unweighted mean</th>
<th>Range</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dystocia</td>
<td>5.8</td>
<td>.9–13.7</td>
<td>14, 16, 19, 23, 30, 34, 64, 72</td>
</tr>
<tr>
<td>Twinning</td>
<td>3.3</td>
<td>1.6–5.8</td>
<td>11, 27, 34, 35, 39, 50</td>
</tr>
<tr>
<td>Stillbirth</td>
<td>4.1</td>
<td>1.4–6.3</td>
<td>30, 34, 35, 50</td>
</tr>
<tr>
<td>Retained placenta</td>
<td>9.4</td>
<td>2.0–17.8</td>
<td>14, 16, 19, 23, 30, 34, 39, 50, 64, 72, 73</td>
</tr>
<tr>
<td>Cystic ovaries</td>
<td>12.3</td>
<td>3.0–29.4</td>
<td>6, 14, 19, 23, 28, 30, 34, 59, 73</td>
</tr>
<tr>
<td>Anovulation</td>
<td>5.5</td>
<td>2.3–22.5</td>
<td>2, 9, 13, 14, 30, 33, 34, 41, 46, 52, 70</td>
</tr>
<tr>
<td>Reproductive tract infections</td>
<td>17.4</td>
<td>8.5–24.2</td>
<td>14, 19, 34</td>
</tr>
<tr>
<td>Metritis</td>
<td>21.3</td>
<td>10.7–36.4</td>
<td>23, 28, 30, 50, 52</td>
</tr>
<tr>
<td>Abnormal health status</td>
<td>36.9</td>
<td>19.9–81.6</td>
<td>2, 13, 34, 52, 59, 63, 67</td>
</tr>
</tbody>
</table>

1 Delayed intervals to first postpartum ovulation longer than 4 wk postpartum.
2 Variously combined specifically diagnosed infections of the reproductive tract.
3 Includes cows with one or more reproductive disorders listed above in addition to various metabolic disorders including milk fever, ketosis, displaced abomasum, etc.

in relation to the pelvic area of the dam. Those factors affecting calf size and pelvic area have been reviewed (55, 65). Other factors that appear to be associated with dystocia or that may predispose its occurrence are related to the calf, dam or sire, nutrition, season, disease, and endocrine aspects.

Calf-related factors associated with dystocia include such characteristics as size (36, 42, 55, 65), sex (36), multiple births (36, 72), malpresentations (36, 55), and stillbirth (36, 55). Increased occurrence of these calf-related factors predispose cows to calving difficulty. Size or birth weight is controlled genetically; heritabilities range from .38 to .51 (43). A recent report summarized evidence for direct genetic effects of the sire (36). Dystocia occurs more frequently with male offspring because bulls are uniformly heavier than heifer calves (42) and because length of gestation is prolonged with male offspring (35).

Dam-related factors are associated with body weight, body size, pelvic area, and age or parity of the dam. Occurrence of dystocia decreased with age or lactation number, ranging from 14 to 22% in heifers to less than 2% in multiparous cows (29, 72). Cows aged 2 to <4 yr have the highest incidence of calving difficulty, about 1.5× greater than older cows (23). In contrast, cows aged 4 to <7 yr have only 50% of the risk for dystocia as cows of other age groups (23, 72). Increased calving weight of first-calf heifers also reduces the probability for calving difficulty (29). Measures of age, weight, or size of the dam are correlated highly with pelvic area, one of the major factors that affects the incidence of dystocia (65).

Nutritional factors associated with calving difficulty relate to both energy and protein, the effects of which are generally confounded in periparturient diets. Increasing energy fed to multiparous cows during the last 3 wk of the dry period (challenge or lead feeding) above NRC recommendations (60) was associated with .2 to .4× less risk for dystocia (16). However, overly fat cows generally are predisposed to dystocia (48, 58). Studies with beef cattle, however, suggested that long-term energy restriction before parturition reduced birth weights of calves and increased calf mortality without a concurrent reduction in calving difficulty (1, 65). These nutritional effects on dystocia are probably related to the different feeding management of dairy cows in late lactation and the dry period and the marginally longer term maintenance diets of wintering beef cows during late gestation.

Increased risk and incidence of dystocia were observed in fall and winter months for older cows; younger cows had increased risk during all months of the year (24, 36). Prior lactation yields or estimated transmitting
ability for milk yield in heifers were unrelated to the incidence of dystocia (17, 21, 24). One study (17) suggested that cows that experience dystocia at previous parturitions were predisposed to difficult calving at subsequent parturitions. In addition, cows that contract or later succumb to milk fever after parturition are at 4 to 7× more risk for dystocia than cows without milk fever (16, 64). The mechanism for such relationships appears related to uterine hypotonia resulting from hypocalcemia (16, 64).

Implications. The implications of dystocia on other diseases, herd exit, reproductive performance, and milk yield are summarized. Several detrimental consequences of dystocia in primiparous dairy cows include increased risk of retained placenta (2.5 to 4×), metritis (3×), herd exit because of death or culling (3×), and increased intervals from calving to first service compared to normal cows without dystocia (29, 72). Multiparous cows having dystocia also had increased risk for metritis (3.5 to 4.9×) and herd exit (3.7×) but no predisposing effect on retained placenta or days to first service (16, 29). However, in another study (72), cows of all parities have increased risk for milk fever and retained placenta, as a result of increasing calving difficulty. Cows with dystocia also have increased risk (6×) for reproductive tract infections (diagnosed within 3 wk postpartum) and cystic ovaries (2.9×) (17).

Reproductive performance is compromised in cows with dystocia as increased number of services and prolonged intervals to first service and conception are recorded (72). Most studies show little evidence for reduced milk yield in cows with dystocia (21). However, those studies have utilized entire lactation yields (305-d mature equivalent) in the analyses. One study (72) reported a decrease in 30-d, but not in 90-d or 305-d yields of cows with dystocia, and cows with surgical delivery associated with stillbirth at parturition had a 5 to 9% decrease in 305-d milk yield (21).

Twinning

Incidence. Twinning occurs about 3.3% of the time, based on six studies summarizing 56,470 calvings in 2265 herds (Table 2). A thorough review of twinning in cattle and its reported incidence was prepared by Rutledge in 1975.

Predisposing Factors. The reader is directed to two excellent reviews of twinning in cattle (11, 66) that discuss factors affecting twinning rate including breed, season, cow family, age or parity, and inbreeding. Twinning increased quadratically with age or parity, reaching a maximum around 8 yr of age (11, 35, 66). Season or month of conception in some studies altered the frequency of twinning, with peaks in the fall (September to November) and spring (March to April) (11, 66). This seasonal variation may be associated with higher frequency of calvings in the fall and spring as well as external stimuli such as temperature, photoperiod, or quality of forages. Suggested higher fecundity of certain cow families is not uncommon, since daughters of twinning cows twinned at a higher rate than daughters of cows that never twinned (66). Other factors, including exogeneous hormonal treatments such as those used for superovulation or induced twinning studies (3) at the estrus of breeding, are suspected to increase the probability of multiple births.

Implications. Cows that bear twins compared with those giving birth to single calves have increased risk for various diseases or metabolic disorders including stillbirth or calf mortality (3×), retained placenta (12×), metritis (2×), displaced abomasum (2 to 3×), ketonuria (1.4×), and aciduria (1.7×) (27, 39, 50). These studies suggest strongly that twinning is involved in the etiology of periparturient diseases (50). Culling rates also are increased as a result of twinning (27, 39, 49).

Subsequent reproductive performance of cows that twin is impaired as evidenced by increased rates of infertility (39), prolonged calving intervals, and increased number of inseminations (27). Cows bearing twins have shorter gestations than singles, as well as decreased calf size, increased dystocia, and higher mortality of twins, thus reducing the number of potential replacements for breeding (11, 27). Milk yield in cows carrying twins is higher than that in cows carrying single calves (39), but subsequent lactation yields may (11, 27, 56) or may not be reduced (39), depending on the incidence of other reproductive disorders associated with twinning and their effects on concurrent milk yield (21).
Stillbirth

Incidence. Stillbirth generally refers to birth of a dead fetus; however, in the literature, a broader definition, including calves found dead at calving (some of which may have been truly stillborn) probably reflects more accurately the summarized incidence. Occurrence of stillbirth is about 4.1%, ranging from 1.4 to 6.3% at 45,835 calvings in 2264 herds (Table 2).

Predisposing Factors. The highest risk for stillbirth is in heifers and lowest in second parity cows (50). The increased risk for stillbirth probably results from an oversized fetus, overconditioned dam, and increased incidence of twinning (50). Incidence of stillbirths was <2% when gestation was from 270 to 289 d in length for five dairy breeds but increased markedly outside that range (35).

Implications. Cows experiencing stillbirth are at increased risk for a number of other disorders. Risk for a prolapsed uterus (6.8×), retained placenta (4.3×), metritis (2.9×), aciduria (1.3×), and displaced abomasum (2x) all increase for cows with stillbirths compared to cows giving birth to live calves (49, 50). No evidence was found for direct relationships between stillbirth and milk yield or reproductive performance.

Retained Placenta

Incidence. Retention of the placenta from 8 to 12 h to greater than 24 h is the definition of a retained placenta in most studies cited. Occurrence of retained placenta or prolonged retention of the fetal membranes is 9.4%, ranging from 2 to 17.8% in over 55,000 cows of more than 225 herds surveyed (Table 2).

Predisposing Factors. Nutritional factors such as deficiencies of selenium or vitamin E have been implicated in causing retained placentas in areas of low and selenium-sufficient soils (55, 57). In addition, a higher incidence of retained placenta occurs at the first signs of vitamin A or \( \beta \)-carotene deficiencies (55, 60). Results of diets fed during the dry period suggest that feeding higher than recommended amounts (60) of protein in the last 2 to 3 wk of the dry period (lead feeding) might reduce the incidence of retained placenta by 1.4 to 2.5× (16). However, cows that are overly fat (fat cow syndrome) are more likely to have retained fetal membranes (50, 58). Retained placenta increases with advancing age or parity in all studies (16, 24, 29, 72), except in heifers where dystocia increases the risk for retained placenta by fourfold (5, 25).

The effects of days dry and season are conflicting. In one large study (16), shorter dry periods were associated with more placental retention, whereas in another comprehensive study (25), the opposite effect was observed. Calvings during warm seasons (47, 51) or those occurring during periods of heat stress (20) generally were associated with higher incidences of retained placenta, except in one study where a seasonal pattern was not detected (24).

Previous milk yield appears to have no predisposing effect on retained placenta (21). Occurrence of induced parturition (5, 47), twinning (39, 47), milk fever (16, 29, 31), ketosis (47), dystocia in heifers (5, 25), increased calving difficulty in all cows (72), and infections of the reproductive tract diagnosed during a previous lactation [after d 21 postpartum; (17)] are associated with increased risk for placental retention.

Implications. Retained placenta often predisposes cows to serious infections of the reproductive tract. The risk for various uterine infections is increased 53 to 135× (17), and specifically that for metritis is increased 5 to 6× (16, 29) in cows having retained placenta. In addition, the incidence of ketosis [4 to 16× (16, 17)], displaced abomasum [3.6 to 7×; (17, 49, 50)], and culling or death (29, 63) are increased as a result of retained placenta.

Milk yield (305 d) concurrent with placental retention is unaffected (21, 34, 39); however, when milk yield is expressed as kilograms produced per day of calving interval (18), a .4% decrease in milk yield was detected. Expressing milk yield as a function of calving interval demonstrates that negative effects of retained placenta on milk yield are mediated indirectly by delayed conception or prolonged calving intervals. Therefore, it is not surprising that calving intervals are prolonged (34, 55) and pregnancy rates are decreased (34, 39, 63) in cows after retained fetal membranes. Another study (18) found no direct effect of retained placenta on days open, but an indirect negative effect mediated by various infections of the reproductive tract that were first diagnosed at 22 to 60 d postpartum was noted. Hence, Dohoo and Martin (18) concluded that retained
fetal membranes appeared to have a small direct to nonexistent impact on reproductive performance, but increased infections of the reproductive tract that follow placental retention were detrimental.

Cystic Ovaries

**Incidence.** Based on summaries of over 20,000 cows in 196 herds, incidence of cystic ovaries was 12.3% and ranged from 3 to 29.4% (Table 2). Peak occurrence is between 31 and 60 d postpartum in which 47% of the diagnoses were made (28, 32).

**Predisposing Factors.** Although two different types of ovarian cysts predominate, the thin-walled or follicular cyst and the thick-walled or luteal cyst, only three studies (23, 24, 25) differentiated between the etiology of these two types. Almost all studies have referred to the occurrence of either type of cyst as ovarian follicular cysts. In this review, we refer to both types as cystic ovaries and will not make further differentiation. Cysts are prone to recur in cows having a previous history (16, 17). Furthermore, a number of studies report that cystic ovarian disease has a low to moderate heritability (up to $h^2 = 0.43$) in dairy cattle (32, 40), and its incidence has been reduced in Sweden as a direct result of selecting against its occurrence by bull studs (40). In general, uterine infections, and specifically metritis, increase risk for cystic ovaries (17, 25, 29, 32). One study (17) reported that previous infections of the reproductive tract might predispose cows to the occurrence of cysts in the subsequent lactation.

Occurrence of cysts increases with age in dairy cattle (17, 24). Compared with cows of other age groups, cows aged 2 to <4 yr are less likely (3x) to develop cysts, whereas cows 4 to <7 yr tended to be less likely to have cysts than cows aged 7 to <10 yr (24). Seasonal patterns for cystic ovaries tend to follow the winter months of calving (32, 40); however, one study (24) was unable to detect a seasonal trend. Nutritional factors have been suggested to be involved because cysts occur during periods of high nutrient intake. However, specific nutrients or diet components have not been identified (40), except for the deficiency of $\beta$-carotene and the reported increase in cysts of German cattle (45) but not substantiated by Marcek et al. (54).

Milk yield in prior lactations appears to be related positively to cystic ovaries in some studies. The question is two-edged, because a temporal association between cysts and high milk production is noted frequently (23, 59). The question of whether high milk yield causes cystic ovaries in paramount, because a cause must precede its effect. Moreover, a recent review (21) concluded that neither high milk production in previous noncystic lactations nor high genetic potential for milk yield were risk factors for cystic ovaries. Therefore, the conclusion drawn from five studies was that high milk yield does not cause cystic ovaries in Holstein dairy cows.

Most studies indicate that an endocrine imbalance may be the cause of ovarian cysts, because administration of exogenous estrogens and progestins alone or in combination have caused cysts in cattle (40). Possible causes of spontaneously forming ovarian cysts include: 1) defects in the response of the hypothalamic-pituitary axis to the positive feedback of estradiol (32); 2) back of receptors for LH and FSH in ovarian cystic follicles, which can be restored by exogenous FSH (8); 3) excess FSH overstimulating follicular development (40); 4) inadequate pituitary LH to induce ovulation (40); 5) partial failure of the mechanism controlling pituitary release of LH (40); and 6) deficiency in the synthesis or release of gonadotropin-releasing hormone (68).

**Implications.** Most consequences of ovarian cysts impact reproductive performance, resulting in increased (1.5x) proportions of cows culled from the herd (6, 29). However, a controversy may exist concerning the effect of ovarian cysts on concurrent milk yield. Most studies indicate that milk production is higher in cows with ovarian cysts (18, 25, 29), when milk yield is expressed as 305-d yield. However, when milk yield is expressed as kg/d of calving interval, a 2.5% loss of milk yield is detected in cows diagnosed as cystic (18). As Erb (21) pointed out in a recent review, these measures of milk production (305-d yield vs. kg/d) lead...
to opposite conclusions because the standardized 305-d yield, even if adjusted for days open, does not fully account for the length of the dry period or the shape of the lactation curve. The increased milk yield observed in lactations associated with ovarian cysts more likely occurs because of increased days to first service (29), prolonged calving intervals (18, 25, 59), and reduced conception rates at first service (29), all of which delay the subsequent negative effect of pregnancy on milk production during late lactation (60).

Anovulation

Incidence. We have defined anovulation to include those cases in which dairy cows have prolonged or delayed intervals to first postpartum ovulation. Because most dairy cows first ovulate between 2 and 4 wk postpartum (2, 5, 30, 33, 34, 41, 59, 69, 70), any delay beyond 4 wk was defined as delayed ovulation or anovulation. The incidence of anovulation is 5.5%, ranging from 2.3 to 22.5% in 15,918 cows studied in 130 herds (Table 2).

Predisposing Factors. Incidence of anovulation decreases with increasing age, i.e., 89% of the 2-yr-old dairy cows examined for anestrus had delayed ovulation compared with 47% of the anestrous mature cows (33). Other attempts to account for the variation in days to first ovulation, which included such factors as season, age, milk yield, or various periparturient disorders, showed few significant effects and accounted for only 18 to 21% of the variation (34, 52). Most studies agree that milk yield does not predispose cows to anovulation (9, 34), but a previous history of anovulation may be a predisposing factor (14).

Various studies have implicated other diseases as a mediating factor for increased anovulation. Increased incidence of anovulation is usually associated with poor general health of the cow (52, 62, 63), fatty liver and subclinical ketosis (37), postpartum purulent discharge, delayed uterine involution, and metritis (53, 62). Recent evidence suggested that average energy balance during the first 3 wk postpartum was inversely related to days to first ovulation and to milk production, whereas milk yield was not related closely with days to ovulation (10). Generally, cows that are prone to various metabolic diseases because of poor body condition are at risk for anovulation (52).

Implications. Reproductive performance is affected adversely by anovulation. Prolonged intervals to first estrus (13, 31, 70), to first service (9, 13, 31, 70), and to conception (31, 70) occur as a result of anovulation, as well as an increased number of services (70). Conception rates at first service also tend to be lower in cows with previous anovulation (70). Delayed postpartum ovulation was reduced markedly by administering gonadotropin-releasing hormone between 10 and 14 d postpartum (3, 7, 30, 41, 58). However, we (46) have observed that 5% of the cows receiving two injections of prostaglandin F20 (11 d apart) have low concentrations of progesterone in serum as late as 51 to 57 d postpartum, suggesting that anovulation had persisted for nearly 60 d after calving.

Reproductive Tract Infections

Incidence. Studies in which various infections of the reproductive tract were diagnosed, including various types of abnormal or purulent discharges from the genitalia, probably resulted from, but were not limited to, metritis, pyometra, endometritis, vaginitis, or cervicitis. The incidence of this broad category of reproductive tract infections was 17.4%, ranging from 8.5 to 24.2% in 13,271 cows from 137 herds (Table 2). The time course of these diagnoses include cases of acute metritis diagnosed in the first 21 d postpartum; cases of metritis and pyometra first observed between 22 and 60 d; and first evidence of vaginitis, cervicitis, and metritis after 60 d postpartum (19). The majority of the diagnoses coincided with postpartum veterinary examination of cows (20 to 40 d) and controlled research examinations at various experimental periods during the periparturient period.

Predisposing Factors. Increasing age and parity resulted in a greater incidence of reproductive tract infections as well as the prior occurrence of retained placenta and dystocia (19). At least one study (17) suggested that displaced abomasum and previous uterine infections may predispose cows to new reproductive tract infections after subsequent calvings. The condition of the uterus at parturition or soon after is critical to the invasion of potential pathogens. Although data may be
lacking to validate the paramount importance of cleanliness at calving on subsequent reproductive tract health, studies identifying retained placenta, dystocia, types of discharge from the genitalia, and involution characteristics of the cervix and uterus as predisposing factors for various infections might well be due to the lack of hygiene in calving areas and assisting personnel (17, 18, 19, 23, 24, 39, 55, 62). In another large study, 80% of all cows with ketonuria concurrently suffered from postpartum uterine diseases (48).

Implications. One study identified a 2 to 5% loss in milk yield (kg/d) when reproductive tract infections were diagnosed after 3 wk postpartum (18). Most detrimental effects are related to fertility. Increased calving intervals, longer intervals to first estrus and first service, and decreased conception at first service are associated with reproductive tract infections and abnormal discharges (18, 62). The size of the cervix and uterus following abnormal parturitions and during subsequent involution is much increased compared to normal cows, and those abnormal cows are at risk to various infections (34, 39, 44, 59, 73). Reproductive tract infections that predispose cows to poorer fertility also hamper involution of the reproductive tract (17, 34, 39, 62).

Metritis

Incidence. In studies where specific diagnoses of reproductive tract infections were limited to metritis, incidence averaged 21.3%, but ranged from 10.7 to 36.4% in over 15,167 cows from more than 60 herds (Table 2). A study examining incidence rates of various diseases suggested that 75% of the metritis cases were diagnosed during the first 30 d after parturition (16, 28).

Predisposing Factors. Occurrence of metritis increased with increasing age or parity, with the lowest incidence in cows aged 2 to <4 yr and the highest incidence in cows aged >7 yr (24, 50). However, when younger cows were divided into yearly groups, the risk for metritis was highest in heifers and lowest in second parity cows but increased thereafter (30). Cows with lactations initiated in the late summer to early fall had increased risk for metritis with cases peaking in the fall to winter months (24, 47).

Several health problems associated with metritis that increased its risk include milk fever (1 to 2x), retained placenta (5 to 6x), displaced abomasum (3 to 4x), ketonuria (2x), and aciduria (2x) (16, 21, 29, 49, 50). Over-conditioning at calving, twinning (2x), stillbirth (3x), prolonged gestations, induced parturitions, and dystocia (3 to 5x) are associated generally with increased metritis (16, 29, 47, 50, 58). A particularly strong relationship between displaced abomasum and periparturient uterine diseases is well-documented (17, 49, 50). At least four studies cited in a recent review concluded that high milk yield or the potential for high milk yield failed to increase the risk of metritis (21). Marked herd effects in most studies stressed the fact that an epidemiological pattern may not be generalized across herds (52) because of many factors affecting reproductive performance within herds. A herd veterinarian is the most consistent variable identified in analyses (14).

Implications. One study concluded that metritis decreased (2 to 5%) current milk yield (kg/d), whereas two other studies (26, 29) only suggested possible losses of milk. Higher risks for displaced abomasum, ketonuria, and aciduria were present in cows with retained placenta and metritis. The former disease conditions appeared to be related to overfeeding before parturition (47, 48). For cows with retained placenta, metritis was an intervening variable of significance between retained placenta and cystic follicles, suggesting an interrelationship and possible link in the epidemiology of metritis and follicular cysts (25, 26, 27).

The consequences of metritis on reproductive performance are dramatic, as expected. Metritis increased days to first service, days to conception, and reduced conceptions at first service by one-half compared with those of cows without metritis (25, 26, 27). Indirect effects of metritis on increased total services and culling are mediated through the occurrence of cystic ovaries and poorer fertility (29). In addition, cows with metritis have increased risk for anovulation or true anestrus (53).

Abnormal Health Status

Incidence. A number of studies have summarized the effects of variously combined health and disease factors that interact with milk yield, reproductive performance, and
overall herd productivity. In those summaries, abnormal health status included factors that were associated with abnormal parturitions and other abnormal periparturient characteristics. Those factors included dystocia, stillbirth, twinning, retained placenta, cystic ovaries, abnormal vaginal discharges, any type of uterine or reproductive tract infection, anovulation or anestrus, and measures of cervical and uterine involution, as well as displaced abomasum. In eight studies, the average incidence of abnormal health status was 36.9%, ranging from 20 to 82% in 17 herds comprising 2933 dairy cattle (Table 2). In total, those studies suggest that over one-third of all cows suffer from some type of health problem during the periparturient period.

Implications. Any type of health problem during this critical period in lactation increased the risk of culling or death by 2 to 5x (29, 63). Cows in their first lactation were at greater risk to be culled than multiparous cows (63). Path analysis models suggested that involuntary culling of primiparous cows was forced by udder disease and poor fertility before voluntary culling of low milk-producing heifers could be exercised by dairy producers (29). However, multiparous cows were culled for low milk yield and old age, in addition to involuntary loss because of poor breeding performance and disease (29).

Few studies have examined current milk yield of cows diagnosed in abnormal health groups, but as expected, cows with variously combined reproductive disorders probably produce less milk because they are in poorer general health. One study (67) reported that cows with abnormal health status produced about 3% less milk in 305 d than normal cows, as well as less milk fat, during the first 50 d of those lactations associated with health problems.

Reproductive performance of abnormal cows is greatly compromised since intervals to first estrus (34, 62) and first service (2, 34, 62) are delayed, conception rates are reduced (2, 62), number of services are increased (2, 7, 67) and calving intervals are reduced (2, 62), number of services are increased (2, 7, 67) and calving intervals are prolonged (2, 34, 62, 67). Results similar to those we observed recently in one large herd, when reproductive performance was compared in cows with and without health problems (Table 3), are reported for most herds. With similar rates of prebreeding culling, every reproductive trait was affected adversely, resulting in 21% of the abnormal cows never conceiving compared with only 6% of the normal cows.

CONCLUSIONS

The effects of various periparturient disorders on reproductive performance and milk yield of the current lactation are summarized in Table 4. All of the reproductive disorders

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**TABLE 3. Health status and reproductive performance in a large dairy herd.**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \bar{X} )</td>
<td>SE</td>
</tr>
<tr>
<td>No. cows</td>
<td>592</td>
<td></td>
</tr>
<tr>
<td>Calving to first estrus, d</td>
<td>66</td>
<td>1.3</td>
</tr>
<tr>
<td>Calving to first service, d</td>
<td>70</td>
<td>1.3</td>
</tr>
<tr>
<td>Calving to conception, d</td>
<td>98</td>
<td>2.3</td>
</tr>
<tr>
<td>Services per conception</td>
<td>1.9</td>
<td>.1</td>
</tr>
<tr>
<td>Conception at first service</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Pregnancy rate, %</td>
<td>91</td>
<td></td>
</tr>
</tbody>
</table>

1 Source: Stevenson and Call, unpublished data.

2 Cows were classified abnormal if one or more of the following were diagnosed: retained placenta, cystic ovaries, prolonged anestrus, twinning, or uterine infection based on palpation or the presence of a purulent discharge at anytime including breeding.

*P<.05.
examined in this review reduced reproductive performance either directly or indirectly. Milk yield was impaired in few cases as a consequence of a disorder. With the exception of surgical delivery of dead calves, there was little strong evidence for associated losses of milk yield for any other reproductive disorder. However, there are marginal suggestions of lost yield as a consequence of twinning, retained placenta, cystic ovaries, metritis, or other uterine disorders, and in cows with an abnormal health status. These suggestions are limited to very few studies (21, 26, 29, 67).

We conclude that most periparturient reproductive disorders occur as part of a complex, rather than appearing as a single abnormality. Cows with one disorder are at increased risk for other disorders, including many metabolic ones (22). It appears from all data combined that actual yield or potential for high milk production does not predispose cows to increased risk for any of the reproductive disorders reviewed. In some cases, however, milk yield concurrent with some reproductive disorders may be reduced slightly. Most data imply that prophylactic measures to prevent the occurrence of one disorder may decrease the risk and incidence of other related disorders, either directly or indirectly. Further analyses of large data sets involving thousands of cows are needed to define further the inter-relationships of these reproductive disorders, as well as various other metabolic diseases. Through such work, the epidemiology and etiology of these disorders should be better defined, thus allowing better designed preventive herd health measures to be adopted on the farm to improve the general health status and overall productivity of dairy cattle.

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