Overall Reproductive Performance of Canadian Dairy Cows: Challenges We Are Facing

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■ Take Home Messages

‣ Although research is needed to improve strategies available to treat and prevent anestrus, pregnancy loss, and postpartum reproductive disease, there are numerous steps that can be implemented today to improve reproductive performance.

‣ On many dairy farms, the single greatest area of opportunity for improvement of reproductive performance is to increase insemination rate.

■ What Is Current Reproductive Performance?

To evaluate reproductive performance and quantify factors that may affect it requires accurate data and valid analytical techniques. Unfortunately, many studies have drawn inferences from data on calving interval or herd average days open, both of which suffer from bias, lag, and momentum (Stewart et al., 1994). Other reports have focused on conception risk (CR) as a measure of fertility, but at best this only reflects part of the process of making open cows pregnant, in that it does not account for cows that were not inseminated, or for when insemination occurred. The best available single measure of overall reproductive performance at the herd level is pregnancy risk (PR), commonly called pregnancy rate (LeBlanc, 2005). The pregnancy, insemination, and conception risks in a large sample of Ontario dairy herds over the last six years are presented in Figure 1. There was no significant decrease in any of the parameters over this period. However, a longer time span and further analyses are needed to determine whether there is a trend for decreased pregnancy rate over time, and to measure the associations of physiologic and management influences on reproductive performance.
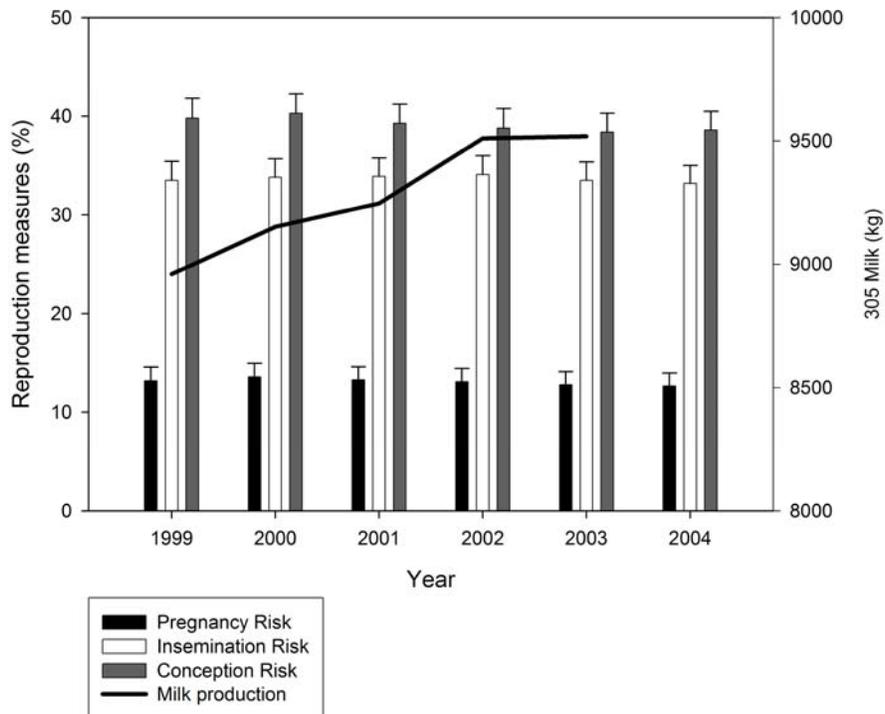
Figure 1. Reproductive performance (95% confidence interval) extracted from Dairy Comp 305 of approximately 2500 dairy herds in Ontario over 6 years. (Data from David Kelton (University of Guelph) and CanWest DHI) and mean 305 day milk yield from Canadian cows with publishable milk records over the same period (http://www.dairyinfo.gc.ca/pdf_files/tab26.pdf, accessed Jan. 14, 2005)

■ **Is There Anything Fundamentally Wrong with Modern Cows or Management that is Reducing Reproductive Performance?**

There is evidence that high metabolic rate (associated with high feed intake and production) substantially increases catabolism of estrogen and progesterone (Sangsritavong 2002). This would be expected to work against fertility and has been associated with decreased expression of estrus (Lopez et al., 2004a). This opens up new avenues for research to better understand and influence competitive metabolic demands for production and reproduction. However, the immediate practical implications of this finding are not clear. It

would be illogical to pursue low feed intake or low production in an attempt to enhance fertility.   An antagonistic relationship between negative energy balance (NEB) and reproductive function has been described (Butler and Smith, 1989; Butler 2003). However, all dairy cows are in some degree of NEB in early lactation, and the severity and duration of NEB are not well correlated with milk production (Lucy, 2001).

Butler and Smith (1989) assembled data on conception risk from New York from 1951, 1973 and 1985 that described an apparent inverse association with milk production. Butler (1998) expanded the analysis to include an additional data point from 1996, which appeared to continue the trend.   Data from approximately 140 herds continuously enrolled on DHI (Dairy Records Management Systems) from 1970 to 1999 showed a decrease in CR that occurred concurrent with increased herd average milk production (Lucy, 2001; Stevenson, 2001). There are also reports of apparent decreases in conception risk under very different management systems such as Australia (Macmillan et al., 1996) and England (Royal et al., 2000).   However, these temporal associations do not imply causation. Furthermore, the nature and quality of the data, especially older data, used in some reports warrants scrutiny. Traditionally, artificial insemination units have reported fertility on the basis of 60-day non-return rates, which clearly overestimate CR. Additionally, in the past some producers, if they reported pregnancy data at all, reported only the final (successful) insemination date to DHI organization, which also contributed to biased estimates (Fetrow and Eicker, 2003). More recently, inexpensive semen has been widely available and more producers have learned to inseminate their own cows, lowering the cost of a decision to breed a cow. These developments have combined with an emerging understanding that increased insemination rate can compensate for somewhat lower CR to maintain or enhance pregnancy rate, leading progressive producers to correctly change their paradigm (to a point) to view semen not as a precious scarce resource, but as a low-stakes input into a management system to produce pregnant cows.   Such a shift in perspective underlies the widespread and successful adoption of prostaglandin-based synchronization programs in the early 1990's, and in the last 10 years, Ovsynch programs.

Caution is needed in drawing causal inferences between high production and decreased reproductive performance.   Two studies in New York Holsteins (Eicker et al., 1996; Grohn and Rajala-Schultz, 2000) reported no significant effect of milk production (measured by 60 day yield) on pregnancy rate. Field data from Australian dairy herds also showed no association of milk production with the proportion of cows pregnant by 100 days in milk (DIM) (InCalf Project, reported by Lucy, 2001). It is important to separate fundamental biological effects on reproductive function from the effects of economically based management decisions about culling and continuation of breeding.   For example, low producing cows should be bred fewer times and be subject to greater culling pressure than higher producing cows.   Higher producers are

more likely to be inseminated and less likely to be culled (Eicker et al., 1996; Grohn and Rajala-Schultz, 2000). Therefore, on average, higher producing cows may have a longer interval from calving to pregnancy than lower producers who will rightly be given fewer chances to become pregnant before they are removed from the herd (Eicker et a.,l 2002).

Generally, high producing herds are so because they successfully and consistently implement numerous best management practices. Therefore, at the herd level, higher producing herds may also have above-average pregnancy rates, even if they have somewhat lower conception risk, because in addition to feeding, milking, and housing the cows well, such herds also efficiently inseminate open cows.

In summary, it is not clear that pregnancy rate in the Canadian dairy cattle population is falling. It is not appropriate to measure reproductive performance on the basis of conception risk alone, and data on an association of milk production with pregnancy rate are, at most, conflicting. Questions about whether metabolic demands for production and reproduction are reaching a biological or management limit, and whether genetic selection criteria for fertility are optimized are important and warrant valid, large-scale studies. However, there are practical steps that can be taken to improve present reproductive performance in many herds. In the short term, producers and their advisors should focus on practices that are under their control that may improve reproductive performance.

■ Specific Challenges That May Limit Reproductive Performance

Insemination Rate

Lack of a Sense of Urgency about Inseminating Cows in a Timely Manner. Once cows are inseminated, there are numerous factors that may influence conception risk and pregnancy maintenance. Although these are important, they are far less subject to management than is insemination risk (i.e., efficiently inseminating open cows). If conception risk is consistently less than 35%, investigation is warranted into the accuracy of heat detection or of implementation of a synchronization program, semen storage and insemination technique, and possibly uterine disease or nutritional impairments of reproduction. However, in many cases, greater improvement in pregnancy rate can be achieved by increasing insemination rate than by attempting to increase conception risk.

Modeling of factors that contribute to time to pregnancy has shown that a major determinant was first service heat detection (insemination) rate (accounting for

42% of the variability); the length of the voluntary waiting period (VWP) accounted for a further 25% of variability, with conception risk accounting for 24% of variability (Ferguson and Galligan, 1999). VWP is entirely under management control, and synchronization programs can ensure that essentially all cows are inseminated by a fixed interval postpartum.

Need For Greater Appreciation of the Money That Can and Should Be Invested In Achievement of Pregnancies. Cow-specific estimates of the value of making an open cow pregnant (pregnancy value) can be calculated in Dairy Comp 305 (Valley Agricultural Software), to which all customers of CanWest DHI have access. Using this tool typically results in an average pregnancy value for open cows of $300-400 CDN. Simplistically, producers could think of a cow they might consider buying at sale – how much more would the same cow be worth if she were pregnant today?

The economic benefit of an intervention to increase pregnancy rate can be estimated by: [(change in PR) × (average PregVal of OPEN cows) × (average number of pregnancy eligible cows per 21 days)] minus the cost of the intervention. In a typical 100-cow herd, about 20 open cows are past the VWP and not bred, or open. If PR is presently 14% but a change in breeding program that costs $13 per cow is expected to increase PR to 18%, and open cow pregnancy value is estimated at $400, then 18%-14% = 4% expected increase in PR. (4% × $400 × 20 cows) = $320 – ($13 × 20 cows) = net benefit of $60 per cow.

Alternatively, if making a cow pregnant today is worth $300 and the conception risk is 35% (35% chance of earning $300 now is worth $105), then even targeting a 2:1 return on the decision to breed the cow means that one could profitably spend $52 to inseminate the cow (semen + cost of hormones and/or labour).

Reproductive Disease

Postpartum uterine disease may be a limiting factor for resumption of a normal estrous cycle or for the ability to establish and maintain pregnancy that can have an important impact on affected individuals. It is part of the proper role of veterinarians to judiciously treat these individuals and to help to prevent these diseases in the herd. However, a potential pitfall for producers and veterinarians is to devote inordinate attention to the minority of cows with problems at the expense of successful management of the majority of the herd. There are many papers that address the affects of various reproductive and non-reproductive diseases on reproductive performance, including recent reviews (Grohn and Rajala-Schultz, 2000) and a meta-analysis (Fourichon et al., 2000). The correct statistical methodology for measuring pregnancy rate and factors associated with it is survival analysis, which accounts for cows that

fail to become pregnant or are culled (Lee et al., 1989). Studies that use other, inappropriate or incorrect methods such as linear regression on days open should be discounted.

There are several studies that quantify the effects of uterine disease on pregnancy rate. Retained placenta (RP) was estimated to reduce pregnancy rate by 14 to 34% (hazard ratio (HR) for pregnancy of 0.86 and 0.66, Eicker et al., 1996 and Lee et al., 1989, respectively). In some studies it is difficult to separate the effect of uncomplicated RP from its effect as a risk factor for subsequent metritis or endometritis. Although RP is clearly undesirable, it appears that some cows suffer few consequences of RP itself unless they progress to metritis or endometritis. Metritis has been inconsistently defined in the literature, but Lee et al., (1989) found that cows with severe metritis had a 30% reduction in pregnancy rate (HR = 0.70). Recently, diagnostic criteria have been validated to define and measure the impact of clinical endometritis on reproductive performance. In a large field study, 17% of cows had clinical endometritis at 4-5 weeks postpartum and had a 27% reduction in pregnancy rate (HR = 0.73; LeBlanc et al., 2002). Recent research has also indicated that subclinical endometritis is a prevalent problem, affecting 35 to 51% of cows at 40 to 60 DIM, with substantial decreases in pregnancy rate in affected cows (Gilbert et al., 2004; Kasimanickam et al., 2004). Although not yet a practical diagnostic procedure for routine use, subclinical endometritis merits further investigation.

Retained placenta, metritis and endometritis are largely diseases of peripartum immune function (Kimura et al., 2002; Hammon et al., 2004). Further research is needed to extend understanding of immune function in the transition period into specific preventive measures. In general, best management and nutritional practices (e.g. transition diet to meet or exceed National Research Council (2001) requirements for > 3 weeks prepartum with average DMI > 12 kg/cow/day, > 60 cm manger space/cow, calving at body condition score of 3.5 out of 5, lack of crowding (at least 100 sq. ft of bedded pack space or < 100% stocking density in freestalls), heat abatement measures above 27 C, free access to clean water) will plausibly favour peripartum immune function and therefore help to prevent RP, metritis, and endometritis. In particular, the prepartum diet should include 0.3 ppm selenium and 1000-2000 IU/cow/d of vitamin E.

The effect of ovarian follicular cysts on reproductive performance is not clear. Although there are reports of a 20 to 25% reduction in pregnancy rate in affected cows (Lee et al., 1989, HR = 0.70; Eicker et al., 1996, HR = 0.75) it is not clear if this is truly a biological effect or an artifact of management. Traditionally, cows diagnosed as cystic would not be inseminated until the cyst was treated and "cured", often a delay of one month. It is now clear that cows with cysts may have reduced CR in the short term, but that cysts spontaneously resolve, cows can become pregnant even when cystic, and the Ovsynch

protocol produces acceptable short-term PR in cystic cows (Bartolome et al., 2000).

New associations between peripartum health and later reproductive performance are emerging. Subclinical ketosis affects approximately 20% of cows in the first two weeks postpartum (Duffield, 2000). In one study, subclinical ketosis did not affect time to first insemination postpartum but significantly decreased first service CR (Walsh et al., 2004). This finding reinforces the association between health in the transition period and subsequent reproductive performance.

Investments of time and money to identify and treat cows with postpartum reproductive disease can be considered "management sort gates". If such interventions are to be implemented, they must either prevent death, further disease or milk loss, or result in cows getting pregnant sooner than they would have otherwise. More data from large-scale field trials are needed to inform management decisions about treatment protocols for postpartum uterine disease. The value of the effort for individual diagnosis and treatment of postpartum uterine disease is herd-specific and depends on the sensitivity and specificity of the diagnostic criteria, the prevalence of disease, and the cost and efficacy of treatment.

Anestrus

Approximately 20% of dairy cows are not undergoing a normal estrous cycle by approximately 60 DIM (Table 1). This is a higher proportion than was traditionally assumed, and this problem has implications for reproductive performance relative to economic goals. Non-cyclic cows have decreased CR in the Ovsynch protocol (Gumen et al., 2003; Moreira et al., 2001) and with heat detection (Gumen et al., 2003). Prolonged postpartum anestrus is multifactorial, and further research is needed to describe its determinants at the cow and herd levels to affect prevention. In one study, anovulation was associated with body condition but not milk production (Lopez et al., 2004b). Progesterone implants show promise to treat anestrus (Pursley et al., 2001; El-Zarkouny et al., 2004; Rhodes et al., 2003), but there is a practical problem to identify the affected individuals when heat detection rate is low.

Table 1. Summary of the prevalence of anestrus or anovulation in dairy cows at the start of the breeding period in recently published reports.

Reference	Location	n	DIM	Prevalence (%)	95% CI
Opsomer et al., 2000	Belgium	334	50	21.5	17 – 26
Moreira et al., 2001	Florida	543	63	23	20 – 27
Cartmill et al., 2001	Kansas	705	67	16.2	14 – 19
Pursley et al., 2001	Midwest	634	89	24	21 – 27
Gumen et al., 2003	Wisconsin	316	60	20	16 – 24
Galvao et al., 2004	California	685	?	17	14 – 20
Lopez et al., 2004b	Wisconsin	267	70	28.5	23 – 34
El-Zarkouny et al., 2004-1	Kansas	262	67	56	50 – 62
El-Zarkouny et al., 2004-2	Kansas	630	69	20	17 – 23
Moreira et al., 2004	Mexico	466	60	15	12 –18

Pregnancy Loss

There is substantial loss of embryos from fertilization until the earliest normal diagnosis of pregnancy (Santos et al., 2004). Additionally, over 20% of pregnancies are lost between 28 and 60 days of gestation (Vasconcelos et al., 1997). Although these losses are largely described in studies of synchronized breeding programs, they do not appear to be associated with such programs (Santos et al., 2004). The multiple reasons for the apparently high rate of pregnancy loss in dairy cows are not well understood. Pregnancies are difficult to achieve, so reduction in embryo loss and abortion would be highly desirable. There is evidence that hormonal and nutritional interventions may have benefits (Santos et al., 2004). However, presently there are few practical means to prevent pregnancy loss and this problem warrants further research.

Dystocia/Stillbirth

Approximately 10% of full-term pregnancies in Holstein cows result in a dead calf (Meyer et al., 2001). Although this may still allow for initiation of a lactation for the dam, this is a considerable reproductive inefficiency. There is a strong association of dystocia with stillbirth, some of which could be mitigated through increased vigilance and training of farm workers in basic obstetrics. Beyond the calf, calving-related injuries may be important detriments to the welfare, production, and subsequent reproductive performance of dairy cows (Lombard et al., 2003)

Heat Stress

Many producers do not appreciate that heat stress begins at a temperature humidity index of 72, or approximately 27 C (West, 2003). Heat stress affects

both estrus expression and early embryo survival (DeRensis and Scaramuzzi, 2003; Jordan, 2003). Heat stress is likely an under-recognized problem in Canadian dairy herds. The effects of heat stress on reproduction, even in a temperate climate, add to the reasons for which investments in fans and soakers may be profitable.

Bovine Virus Diarrhea

BVD has been reported to be associated with decreased conception (Grooms, 2004), and may be an important cause of abortion and clinical disease. These latter risks justify a strategic vaccination program. However, the ability of vaccination to prevent fetal infection is less than perfect (Kelling, 2004) and the ability of vaccination to prevent possible effects of BVD on conception risk is unclear.

■ Conclusion

Reproduction is important to dairy herds and achievement of economically optimal performance is a substantial, multifactorial challenge in many herds. While more research is needed to improve prevention of uterine disease, prolonged anestrus and pregnancy loss, there are management opportunities available now to improve performance. Evaluation of reproductive performance should begin with a thoughtful, valid analysis of records, and include a broad investigation of factors that many limit pregnancy rate. The major preventable reproductive problem in many herds is insemination deficiency. Therefore, the first step to improved reproductive performance should be a systematic program to increase insemination rate.

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