Linking Reproduction and Hoof Health

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Take Home Messages

- Prevalence of lameness in dairy farms varies considerably and so does the approach towards a solution
- Understanding the health and reproduction data at the dairy is the first step
- Gait scoring is a useful tool to access the lameness status of the herd
- Lameness will decrease estrous detection and conception rates

Introduction

In the past 50 years, while milk production per cow has steadily increased, lactating cows have experienced a progressive decline in fertility as indicated by lower conception rates. This negative relationship between milk yield and conception rates has been observed in the United States (Lucy, 2001; Santos et al., 2004), as well as in Canada, Great Britain, continental Europe and Israel. The association between low fertility and increased lactation can be regarded as a product of changes necessary to support milk production which directly affects reproductive tissues. Greater milk production has been associated with physiological changes that can reduce fertility such as accentuated negative energy balance (Wathes et al., 2007), lower plasma concentrations of progesterone and estradiol (Wiltbank et al., 2006), and disruption of the growth hormone-insulin-like growth factor 1 axis in the liver. The early postpartum dairy cow undergoes a period of negative energy balance which, when exacerbated, prolongs the period of anovulation and compromises subsequent fertility (Butler, 2000). High-producing cows have reduced estrus expression, which can be further compromised by current management practices in which cows are kept in free-stall barns with concrete flooring and little or no access to dirt lots (Stevenson, 2001), which are all related to a greater prevalence of lame cows in dairy herds.

The prevalence of lameness varies from dairy to dairy and from region to region. The proportion of lame cows will vary according to farm, parity and the definition used to consider a cow lame. Gait scoring, for example, is an important tool to implement some form of lameness data that can be easily recorded and analyzed. Most research has used a clinical diagnosis or a visual observation method to define if the cow is lame or healthy. In general, locomotion scores >2 on a 1 to 5 scale defines moderate to severe lameness. Healthy cows are more physically active and display estrus more frequently, become pregnant more quickly, have lower culling and death rates and increased milk production compared to lame cows. Early diagnosis and intervention may mitigate the effects of lameness and improve reproductive performance in lame dairy cows.

■ Physiological Basis for Sub-Fertility in Dairy Cows

Lactating dairy cows had lower concentrations of ovarian steroid hormones compared with non-lactating dairy cows and growing heifers (Sangsritavong et al., 2002). Because hepatic blood flow was correlated positively with feed and energy intakes, it was hypothesized that the greater feed intake in high-producing dairy cows affected metabolism and circulating concentrations of progesterone and estradiol. In fact, changes in steroid hormone concentrations were shown to be related to acute changes in liver blood flow following feed consumption (Sangsritavong et al., 2002). The decrease in progesterone (P4) concentration observed in the lactating dairy cow was associated with changes in the pattern of follicular wave development (Wiltbank et al., 2006), and possibly with the $PGF_{2\alpha}$ released in the subsequent estrous cycle.

The endocrine milieu in which the pre-ovulatory follicle grows can determine its persistency as well as maturation of the oocyte. Low progesterone concentration increased luteinizing hormone (LH) pulse frequency and consequently the persistency of the follicle, which could be deleterious if the follicle was maintained in such an environment for a long period of time. Inskeep (2004) acknowledged that oocytes from ovarian follicular waves of the same length but growing under less progesterone concentrations after day 6 of the follicular wave resumed meiotic division prematurely. Furthermore, similar findings of premature activation of meiosis in oocytes from first wave dominant follicles at day 10 of the cycle were observed (Inskeep, 2004). Progesterone concentration during follicle development was highly correlated with follicle wave length, which was negatively correlated with embryo quality (Cerri et al., 2009). Another biological window in which progesterone could affect fertility is through the modulation of $PGF_{2\alpha}$ synthesis. High-producing lactating dairy cows exposed to sub-optimal concentrations of progesterone during follicle development may also have delayed effects on $PGF_{2\alpha}$ release similar to what occurs in anovular cows. In another recent study it was determined that small concentrations of P4 during ovulatory follicle development caused a faster growth of the dominant follicle and increased the circulating concentrations of estrogen (E2) and LH. The E2 concentration in the fluid of the dominant follicles was also increased in cows with reduced concentrations of circulating P4 during follicular growth (Cerri et al., 2011a). The smaller concentrations of P4 during the follicular wave prior to ovulation had a marked effect on short luteal phases possibly by inducing a premature release of $PGF_{2\alpha}$, even though the majority of the cows had been classified as cyclic prior to the initiation of treatment (Cerri et al., 2011b). In addition, a greater concentration of PGFM (a measurable metabolite of $PGF_{2\alpha}$) after an oxytocin challenge on d 16 of the estrous cycle was observed in the low P4 group (Cerri et al., 2011b).

■ Health and Management

Lactating dairy cows are subjected to a variety of challenges including metabolic and environmental stressors, particularly during the early postpartum period. Epidemiological studies have shown that between 40 and 60% of cows will suffer from one or more clinical episodes of disease within the first 60 days postpartum (Table 1; Santos et al., 2010). This alarming number of health disorders, that likely masks an even greater number of sub-clinical diseases, is thought to be associated with the energetic requirement for milk production and consequent metabolic stress. The drastic reduction in embryo development and conception rates and the increase in pregnancy losses (Santos et al., 2010) in cows that have experienced one or more health disorder episodes is a poorly understood area central to the causes for reproductive failure in dairy cows.

Understanding the complex interaction of lactation, ovarian steroid milieu, health and stress/inflammatory status during embryo development is a key component to solving the problem of embryonic losses due to a sub-optimal uterine environment. To further understand the intricate mechanisms and cross-communication between the endometrium and conceptus under challenged scenarios and the ability to improve the endocrine and uterine environment of the cow to increase the survival of the embryo more research is needed in this area. There is a scarcity of studies in the literature considering health status, stress and inflammation, and mechanistic studies of the endometrium and conceptus. Within this area, the study of lameness and its different disorders of the feet and legs are necessary to unveil a cause-effect relationship of lameness on embryonic loss in dairy cows. To this date, most of the information on how lameness decreases reproductive performance is more epidemiological; thus based on associations. It is clear that clinical lameness will affect estrous detection rates and consequently pregnancy rates; however, the mechanisms that lead to decreased conception rates in clinical or sub-clinical lame cows are unclear.

▪ Estrus Detection, Physical Activity and Lameness

The detection of estrus in confined dairy cows became a greater challenge as milk production increased. The estrous detection rate in Ontario has been reported to be 48.3% (Kinsel et al., 1998), but more recent information (CanWest DHI Reproduction Benchmarks) shows estrous detection rates below 40% in British Columbia and Canada. This extensive failure to submit cows for artificial insemination has a major impact in the pregnancy rate of Canadian herds, but also indicates a unique window of opportunity to improve fertility. Furthermore, in the past 15 years, the intensive use of timed insemination protocols, most notably Ovsynch, overestimates the true efficiency of estrus detection which suggests that natural estrous behavior expression is likely even lower. The need for more efficient technologies for estrus detection led to the development of activity monitors for estrus detection that rely not on mounting activity, normally used in visual observations and other practices, but rather on the increased overall physical activity or restlessness.

A recent study from Denmark (Lovendahl and Chagunda, 2010) using activity tags showed a 74.6% detection rate and 1.3% daily error rate when using the most efficient algorithm calculated by the authors. The study demonstrates the great potential of this technology to solve the estrous detection problem in commercial dairy herds. There is, however, a scarcity of studies demonstrating possible endocrine and associated management factors that could affect the walking or overall activity of high-producing dairy cows. A large field study (Lopez-Gatius et al., 2005) described that the two main factors affecting activity increase were lactation number and milk production, whereas the degree of activity increase was positively correlated with fertility after artificial insemination. The effect of milk production, for example, seems to affect the overall sensitivity of pedometers or activity monitors to detect true events of estrous behaviors (Holman et al., 2011). Surprisingly, there are not many studies with sufficient numbers of animals showing the effects of lameness on physical activity of dairy cows. Mazrier et al. (2006) and Holman et al. (2011) described decreases in overall physical activity when clinical lameness was detected and decreased accuracy in estrus detection when cows were classified with lame scores > 2.

Table 1. **Health problems in the first 60 days in milk and its effect on pregnancy per AI in lactating dairy cows. *(Table kindly provided by Dr. Jose Santos, University of Florida)***

Health Problems in the First 60 DIM and Pregnancy in Dairy Cows

Category	Pregnant, %	Adjusted OR (95% CI)	*P*
Healthy	51.4	1.00	
1 case of disease	43.3	0.79 (0.69 – 0.91)	0.001
> 1 case of disease	34.7	0.57 (0.48 – 0.69)	< 0.001
Type of health problem			
Calving problem	40.3	0.75 (0.63 – 0.88)	< 0.001
Metritis	37.8	0.66 (0.56 – 0.78)	< 0.001
Clinical endometritis	38.7	0.62 (0.52 – 0.74)	< 0.001
Fever postpartum	39.8	0.60 (0.48 – 0.65)	< 0.001
Mastitis	39.4	0.84 (0.64 – 1.10)	0.20
Clinical ketosis	28.8	0.50 (0.36 – 0.68)	< 0.001
Lameness	33.3	0.57 (0.41 – 0.78)	< 0.001
Pneumonia	32.4	0.63 (0.32 – 1.27)	0.20
Digestive problem	36.7	0.78 (0.46 – 1.34)	0.38

5,719 postpartum dairy cows evaluated daily for health disorders in seven dairy farms in the US

Santos et al. (2010) Reprod. Dom. Rum. VII:387-404

▪ Prevalence of Lameness and other Reproductive Responses

The prevalence of lameness varies tremendously from dairy to dairy and from region to region (Figure 1). In a study accessing lameness data in Northeastern US (Bicalho et al., 2007) the proportion of lame cows varied according to farm, parity and the definition used to consider a cow lame. Most research has used a clinical diagnosis or a visual observation method to define if the cow is lame or healthy. In general, locomotion scores >2 on a 1 to 5 scale defines moderate to severe lameness.

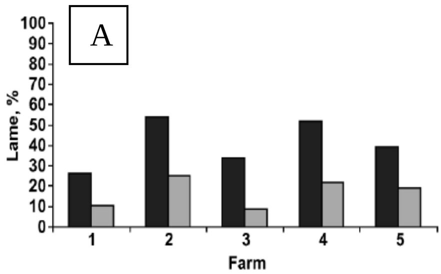

Figure 1. Proportion of cows detected with visual locomotion score (VLS) ≥3 (black bars) and cows detected with VLS ≥4 (gray bars) by farm, in the first 70 DIM.

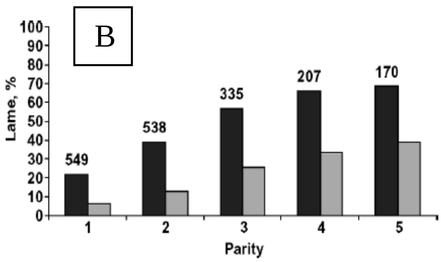

Figure 2. Proportion of cows detected with visual locomotion score (VLS) ≥3 (black bars) and cows detected with VLS ≥4 (gray bars) by parity, in the first 70 DIM. The numbers above the bars represent the total number of cows per parity. Cows with parity ≥5 were grouped into category 5. A strong increase in the occurrence of lameness was detected as parity increased ($P < 0.001$).

Figure 1. Extracted from Bicalho et al., 2007. J. Dairy Sci. 90:4586-91. Portion A describing the proportion of cows lame, and portion B describing the proportion of cows lame according to parity. Locomotion score >2 (black bars) and >3 (gray bar).

Hernandez et al. (2005) classified a total of 837 dairy cows into 1 of 4 groups on the basis of types of disease or lesions observed, including foot rot, papillomatous digital dermatitis, claw lesions, or multiple lesions. Cows not affected with lameness were classified as healthy. Two hundred and fifty four (30%) cows were affected with lameness during lactation. Most lame cows (59%) had claw lesions. Lame cows with claw lesions were 0.52 times as likely to conceive as healthy cows. Median time to conception was 40 days longer in lame cows with claw lesions compared with healthy cows. Number of services per conception for lame cows with claw lesions was significantly higher than that for healthy cows. In another study by the same group (Hernandez et al., 2001), 499 Holstein cows, were classified as non-lame, moderately lame, or lame by use of a 6-point locomotion scoring system during the pre-breeding period. Time to conception (days) was compared among cows. Cows classified as lame were examined on a tilt table for diagnosis and treatment of lameness: 154 (31%), 214 (43%), and 131 (26%) cows were classified as non-lame, moderately lame, and lame, respectively. Most cows classified as lame had laminitis (54%) or disorders of the claw (33%). Median time to conception was 36 to 50 days longer in lame cows than in non-lame cows. Among lame cows, the median time to conception was 66 days longer in cows with high cumulative locomotion scores than in cows with low scores. Non-lame cows became pregnant more quickly than lame cows. Lame cows with low cumulative locomotion scores during the prebreeding postpartum period became pregnant sooner than lame cows with high scores. Early diagnosis and intervention may mitigate the effects of lameness and improve reproductive performance in lame dairy cows.

Other studies have also demonstrated that locomotion scores >2 decreased cumulative conception rates up to 140 days in milk (53.9 vs 67.0%), lower conception rates at first AI (around 10 to 20% units; Bruno et al., 2009) greater culling and death rates (Bicalho et al., 2007) and decreased milk production (314 to 424 kg/com per 305 d lactation; Bicalho et al., 2008).

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