Predicting and Identifying Illness Through Changes in Dairy Cow Behavior

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Introduction
There is mounting empirical evidence that measures of behavior can be used to predict and identify health and welfare concerns in dairy cattle (von Keyserlingk et al., 2009). Interest in the association between dairy cow behavior and illness is growing, particularly with an increasing availability of commercially available equipment that is readily available for the automated monitoring of dairy cow behavior. These technologies provide ready access to vast quantities of accurate and repeatable measures of behavior. Thus, with such technologies, there are new opportunities for the automation detection (through identification and prediction) of health concerns in dairy cattle, potentially allowing for better prevention and treatment protocols to be implemented. Recent publications have reported on changes in behavior associated with various health issues, including metabolic and infectious disease, lameness, and mastitis; these health issues not only pose immediate welfare concerns to dairy cattle, but can also affect efficiency and productivity. This paper will review a few examples of how various cow behaviors have been associated with various illnesses, and how these associations may be used to make assessments and improvements in dairy feeding, housing, and management.

Acidosis and Ruminating Behavior
In dairy cattle, the rumen environment is designed to function optimally within a pH range of 6.2 to 7.2. When ruminants consume excessive amounts of rapidly fermentable (non-fiber) carbohydrates, combined with low intake of physically-effective neutral detergent fiber (NDF), cows are not able to maximize their ruminating time and salivary buffer flow to the rumen, and thus ruminal pH drops below normal physiological levels. Sub-optimal ruminal pH (e.g., pH 5.2 to 5.8) is often referred to as sub-acute ruminal acidosis (SARA) (Owens et al., 1998). Rumen pH < 5.8 is harmful to ruminal cellulolytic bacteria (Russell and Wilson, 1996) and, thus, SARA is detrimental to fiber digestibility. As result, dairy cattle with SARA are less productive because of poor feed efficiency, reduced feed digestibility and protein synthesis, reduced milk fat, inconsistent dry matter intake (DMI), as well as face increased incidence of diseases, including diarrhoea, ruminal ulcers, parakeratosis, liver abscess, and laminitis (Krause and Oetzel, 2006; Plaizier et al., 2008). One of the major concerns with SARA is the lack of specific clinical symptoms. Symptoms that are identifiable, such as a depression of DMI (Plaizier et al., 2008), are difficult to detect in animals that are group-fed. Many dairy nutritionists traditionally consider a dairy herd to have healthy rumen function when at least 40% of the cows are ruminating at any given time (Eastridge, 2000). We recently provided experimental evidence supporting this guideline; in a group of healthy cows, on average, 40% were ruminating at times of the day when ruminating behavior was expected (Figure 1a; DeVries et al., 2009). Alternatively, 10% fewer cows were ruminating during these peak ruminating times when an acidosis event was occurring (Figure 1b). However, we were not able to detect suboptimal rumen function (i.e. a herd-level acidosis event) using this criterion if only a single observation of a herd was undertaken. Rather, to detect a herd-level acidosis event greater than 48 individual observations would be required to accurately estimate the percentage of cows ruminating within a herd. Such a task may appear onerous, however, new technologies that allow for the objective and repeatable automatic capture of behavior are becoming available. An example of this is an electronic rumination monitoring system, which was recently validated by Schirman et al. (2009); such a system would allow for easy detection of changes in both the individual cow, as well as herd rumen health, and thus allow for the detection of a bout of acidosis.

Metabolic and Infectious Disease and Feeding Behavior
During the transition period dairy cows are vulnerable to metabolic and infectious diseases. Researchers have shown that cows diagnosed with acute metritis after calving spent less time feeding during the prepartum period (d –12 to –2 prior to calving; Urton et al., 2005). In a follow-up study, Huzzey et al. (2007) monitored individual feeding time and dry matter intake (DMI) using a larger sample size of cows and also monitored individual-cow DMI. Cows diagnosed with severe metritis 7-9 d postpartum consumed less feed and spent less time at the feed bunk during the 2 wk period before calving, nearly 3 wk before the observation of clinical signs of infection. Moreover, during the week before calving cows were 1.7 times...
more likely to be diagnosed with severe metritis for every 10 min decrease in feeding time. For every 1 kg decrease in DMI during this period, cows were also nearly 3 times more likely to be diagnosed with severe metritis. Recent work showed similar findings with cows that developed subclinical ketosis (SCK; Goldhawk et al., 2009). Cows diagnosed with SCK during the week after calving showed differences in feeding behavior and DMI as early as 1 wk before calving. Not only was DMI reduced pre partum, but SCK animals also initiated fewer displacements at the feed bunk during the week before calving. This is similar to the findings of Huzzey et al. (2007) where cows diagnosed with metritis engaged in fewer aggressive interactions at the feedbunk during peak feeding periods, resulting in lower DMI, particularly during peak feeding times. These results indicate that those cows at risk metritis and SCK may be identified through their feeding behavior patterns already 1-2 weeks prior to calving. Further, some of these at risk animals that we were able to identify by their daily and diurnal feeding activity patterns can also be identified by their failure to compete at the feed bunk during periods of peak feeding activity.

Mastitis and Standing Behavior
In addition to feeding related behaviors, standing and lying behavior patterns of lactating cows may be related to health concerns. One such behavior is the amount of time cows spend standing following milking. The common belief is that the longer the animal stands after milking, the lower the risk for bacterial penetration of the teat orifice when the cow eventually lies down, and thus lower risk of mastitis. Availability of fresh feed following the return from milking has been used to encourage cows to remain standing (while feeding) rather than to lie down. It is well established that the presence of fresh feed in the bunk encourages longer post-milking standing times (DeVries and von Keyserlingk, 2005). In a recent study we found that the provision of feed around milking time resulted in the longest post-milking standing times (DeVries et al., 2010). Further, this was the first study to document how post-milking standing time relates to the risk of subclinical udder infection; cows that lay down, on average, for the first time 40 to 60 min after milking tended to have lower odds of a new subclinical udder infection caused by environmental bacteria compared to cows that lay down within 40 min after milking (Figure 2). However, we also found that cows with post-milking standing times much greater than 60 min had increased odds of acquiring a new environmental subclinical infection. We speculated that the increased susceptibility to infection in cows that stood for more than an hour may be the result of increased teat bacterial penetrability caused by pressure created by accumulation of milk within the teat and gland sinuses. Overall, these results suggest that management practices that discourage cows from lying down immediately after milking, such as providing fresh feed frequently through the day (near the time of milking) may help decrease the risk of subclinical mastitis. However, we also caution producers to be on the “lookout” of cows that stand for extended periods of time following milking, as they too may be a greater risk of udder infection.

Lameness and Standing Behavior
Another health concern that has been related to the standing and lying behavior of dairy cattle is lameness. Proudfoot et al. (2010) recently demonstrated that cows that developed sole lesions and ulcers in mid-lactation stood for longer periods of time during the 2 weeks prior and 24 hour after calving compared to those cows that retained good hoof health during that time period. Interestingly, these researchers were able to determine where those cows that developed sole lesions and ulcers were spending more time standing during those time periods. Cows that developed sole lesions and ulcers spent more time “perching” half way in the stall compared to healthy cows before calving, while spending the same amount of time standing in all other parts of the pen. Such a behavioral indicator can, thus, not only allow producers to identify those cows that may be at risk or experiencing lameness, but also identify housing design and management strategies that minimize such behavioral patterns (for example, moving the free-stall neck rail forward from the curb and higher from the stall base; Tucker et al., 2005), and thus reduce the overall risk of lameness in the herd.

Conclusions
This review has outlined how common diseases like subclinical ketosis, metritis, sub-acute ruminal acidosis, mastitis, and lameness can be better identified and predicted in dairy cattle through observations of cow behavior. It is anticipated that through monitoring of such behavior, particularly with aid of automation, those cows at risk or experiencing illness can be identified. This, in turn, will allow producers to identify and implement prevention and treatment protocols at earlier time points.

Acknowledgements
This research was funded in part by the Natural Sciences and Engineering Research Council of Canada (NSERC), Dairy Farmers of Canada, Agriculture and Agri-Food Canada, the Canadian Bovine Mastitis Research Network, Westgen Endowment Fund, Investment Agriculture Foundation of British Columbia, the Ontario Ministry of Agriculture, Food, and Rural Affairs, the University of Guelph, and the University of British Columbia Animal Welfare Program (http://www.landfood.ubc.ca/animalwelfare/).
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FOOTNOTES
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Figure 1.
Percentage of cows ruminating during (a) a baseline period and during (b) the 24 h following an acidosis challenge (d-1 post challenge) for cows at high and low risk for ruminal acidosis (adapted from DeVries et al., 2009)

Figure 2.
Adjusted estimates of the odds of acquiring a new environmental subclinical udder infection across average post-milking standing time (solid line) with 90% (dashed lines), and 95% (dotted lines) confidence limits (adapted from DeVries et al., 2010).