A New Method of Analyzing Daily Milk Production and Electrical Conductivity to Predict Disease Onset

Jeffrey K. Reneau[1], Joanna M. Lukas[1], and Richard L. Wallace[2]
[1]University of Minnesota, St. Paul, MN
[2]University of Illinois, Champaign, IL

Introduction

One third of culling occurs in the first 100 days (d) of lactation (4). Greater than half of these culls are related to diagnosis of disease (2). Periparturient disease negatively affect production (1) and reproductive performance (6) resulting in culls later in lactation (5). Periparturient cow disorders are risk factors for displaced abomasums (8), mastitis (7), reproductive tract (9) and other diseases (3). Early detection of disease onset could reduce cost of treatment, minimize the negative impact of disease and reduce cull rates. Modern milking systems provide a steady source of data at each milking for every cow. Both milk production (MY) and electrical conductivity (MEC) are sensitive to changes in cow health status. The object of this study was to develop and test a novel statistical process control (SPC) monitoring technique for early detection of postpartum disease onset.

Materials and Methods

Milk production and MEC measures were collected at every milking from January 2004 until November 2006 for 587 cows representing 1,048 partial or full lactations resulting in 395,786 useable records. All health and reproductive events were also collected. Mixed model was used to examine the effect of diseases on MY and MEC during the first 24 mo (January 2004 until December 2005). Days in milk (DIM), DIM × DIM, and ambient temperatures were entered as quantitative variables. Number of calves, parity, calving difficulty, day relative to breeding, day of somatotropin treatment, and 25 variables representing 25 different health event categories were entered as categorical variables. Each health event variable had 24 levels representing days or weeks relative to day of diagnosis (from 10 days before diagnosis to 7 weeks post diagnosis). Autoregressive models were developed to describe MY and MEC in healthy cows. Residuals from the models plotted on a cumulative sum SPC chart constituted the basic structure of the health monitoring scheme. The remaining 11 mo of data (January to November 2006) were used to compare the performance of the developed health monitoring schemes to the disease detection system currently used on the farm in terms of sensitivity, specificity and timeliness of health alerts.

Results and Discussion

Significant changes in MY and MEC were observed as early as 10 and 9 d before diagnosis. Greatest cumulative effect on MY over the 59-d evaluation period was estimated for miscellaneous digestive disorders (mainly diarrhea) and udder scald, at −304.42 and −304.17 kg, respectively. The greatest average daily effect was estimated for milk fever with a 10.36-kg decrease in MY and 8.3% increase in MEC. Milk yield and MEC was modeled by an autoregressive model using a subset of healthy cow records. Six different self-starting cumulative sum and Shewhart charting schemes were designed using 3 different specificities (98, 99, and 99.5%) and based on MY alone or MY and MEC. Monitoring schemes developed in this study issue alerts earlier relative to the day of diagnosis of udder, reproductive or metabolic problems, are more sensitive, and give fewer false-positive alerts than the disease detection system currently used on the farm.

Conclusions

The current study demonstrated that significant changes in MY and MEC can be observed as early as 10 d before clinical diagnosis of a health event. By introducing the cow health monitoring scheme developed in this study, the herd manager would be alerted earlier with twice the odds of correctly identifying an emerging udder, reproductive or metabolic disease problem than the disease detection system currently being used on the farm. However, the signals issued up to 10 d before the clinical phase of the disease are not disease specific. Since the usual post partum diseases (MF, ketosis, RP, metritis, mastitis) have common predisposing causes, timely signaling of emerging disease provides the herd manager with an opportunity to make management interventions, thus removing cow stressors with the prospect of avoiding the clinical phase altogether before more profound biological changes or consequences occur. This paradigm shift away from a treatment focus to proactive preventative strategies is more in tune with modern dairy herd productivity, profitability and animal well being goals.

References

1. Bareille, N., F. Beaudeau, S. Billon, A. Robert, and P. Faverdin. 2003. Effects of health disorders on feed intake and milk production in dairy cows. Livest. Prod. Sci. 83:53-62.
2. Beaudeau, F., A. Henken, C. Fourichon, K. Frankena, and H. Seegers. 1993. Associations between health disorders and culling of dairy cows: A review. Livest. Prod. Sci. 35:213-236.
3. Correa, M. T., H. Erb, and J. Scarlett. 1993. Path analysis for seven postpartum disorders of Holstein cows. J. Dairy Sci. 76:1305-1312.
4. Godden, S. M., S. C. Stewart, J. F. Fetrow, P. Rapnicki, R. Cady, W. Weiland, H. Spencer, and S. W. Eicker. 2003. The relationship between herd rBST-supplementation and other factors with risk for removal for cows in Minnesota Holstein dairy herds. Proc. Four-State Nutr. Conf. MidWest Plan Service, Ames, IA. pp. 55-64.
5. Grohn, Y. T., P. J. Rajala-Schultz, H. G. Allore, M. A. DeLorenzo, J. A. Hertl, and D. T. Galligan. 2003. Optimizing replacement of dairy cows: Modeling the effects of diseases. Prev. Vet. Med.61:27-43.
6. Loeffler, S. H., M. J. de Vries, and Y. H. Schukken. 1999. The effects of time of disease occurrence, milk yield, and body condition on fertility of dairy cows. J. Dairy Sci. 82:2589-2604.
7. Oltenacu, P. A., and I. Ekesbo. 1994. Epidemiological study of clinical mastitis in dairy cattle. Vet. Res. 25:208-212.
8. Rohrbach, B. W., A. L. Cannedy, K. Freeman, and B. D. Slenning. 1999. Risk factors for abomasal displacement in dairy cows. J. Am. Vet. Med. Assoc. 214:1660-1663.
9. Walsh, R. B., D. F. Kelton, T. F. Duffield, K. E. Leslie, J. S. Walton, and S. J. LeBlanc. 2007. Prevalence and risk factors for postpartum anovulatory condition in dairy cows. J. Dairy Sci. 90:315-324.