Using box time indicators to rank cows according to their efficiency in robotic milking systems

L. Fadul[1], R. Cue[2], G. Bisson[1], R. Moore[1] and R. Lacroix[1]

[1]Lactanet, 555 Boulevard des Anciens-Combattants, H9X 3R4, Sainte-Anne-de-Bellevue, Quebec, Canada
Corresponding Author: lfadul@lactanet.ca
[2]McGill University, 21111 Lakeshore Road Sainte-Anne-de-Bellevue, H9X 3V9, Quebec, Canada

Abstract

Large amounts of data are generated by robotic milking systems (RMS), creating an opportunity to add-value to these data by developing tools that can help improve decision making and RMS management. One of the strategies to improve RMS efficiency is to select cows based on their performance at the RMS (kg of milk produced per total time spent in the RMS; kg milk/minute of box time). The objective was to develop box time-based indicators to rank the cows according to their performance at the RMS. Data was collected for 8 months (October 5, 2020, until June 14, 2021) from 41 RMS Holstein herds, for a total of 5,429 cows and 411,405 records. Data included milk production, box time, preparation time, DIM, parity, milking start and end time, milk composition and milk prices. Calculations were done based on the ICAR standards (i.e., 4-day average). Preliminary analysis has shown that box time and hence the indicators vary significantly across and within lactation. Variability was very high during early lactation, presumably associated with the important increase of production during that period. The variability was also very high in late lactation, because of a decreasing number of observations due to ended lactations, thus data were limited to DIM between 28 and 365. Regression analysis was performed to generate factors to correct indicators for parity groups (1,2 and +3) and stage of lactation (DIM). Herd was considered as a random effect. The best fittings were obtained with quadratic polynomials. The resulting equations can be used to generate a factor to correct the data to 150 DIM within each parity, and to adjust to parity 2 for data in the other two parity groups. In addition to the amount of milk produced per minute of box time an economic indicator was also developed: dollars per minute of box time. The average of box time was 7.22 min/cow, and the average of the indicators were 1.86 kg milk/min of box time and 1.50 Can$/min of box time. The box time indicators can be used to rank and subsequently select cows according to their performance at the RMS, in addition to other indicators such as somatic cell count. They can also be used to calculate benchmarks for comparative analysis across RMS herds, as the RMS efficiency is key for the economic success of the farms.

Keywords: Box time, robotic milking systems, efficiency.

Introduction

Data produced by robotic milking systems (RMS) is an opportunity to personalise the milking management, as the RMS generates a large amount of individual cows' data. These data also allow the development of tools that can help the overall RMS management. One of the key factors of RMS management and hence the successful economic use of the robots is to improve their efficiency, (i.e., maximise the amount of milk produced per robot per day) (Carlstroem *et al*., 2013). Studies had suggested that the most important factor to achieve this is the total of kg of milk produced per total time spent in the RMS; kg milk/minute of box time (Carlstroem *et al*., 2013; Vosman *et al*., 2014). Box time is composed of the milking time and the preparation or treatment time (e.g., cleaning, attachment etc.), in other words is the time the cow spends in the robot and is expressed per milking or can be aggregated by day.

Genetics is also an important factor of RMS efficiency as milking time is related to cows' genetics (e.g., milkability) and preparation time to a lesser extent too (e.g., udder conformation and cows' temperament). However, it is known that genetic decisions have a medium to long term impact. For short term decision-making using data from the RMS is an opportunity. Nevertheless, in the future the integration of genetic data and RMS data could help improve the decision management tools. The objective was to develop box time-based indicators to rank the cows according to their performance at the RMS.

Material and methods

Data was collected for 8 months (October 5, 2020, until June 14, 2021) from 41 RMS Holstein herds, for a total of 5,429 cows and 411,405 records. Data included milk production, box time, preparation time, DIM, parity, milking start and end time, milk composition from the RMS sensors and milk prices. Calculations were done based on the ICAR standards (i.e., 96 hours average). The RMS efficiency per cow was calculated as the average of milk production (kg) per minutes of box time for a 96h period. To have an economic box time indicator the dollar per minute of box time was calculated as follows: dollar value of milk produced per minute of box time for a 96h period; where the dollar value of milk was calculated as a linear combination of milk component yields. Milk components were available from the RMS sensors and a constant was used for lactose content.

Our preliminary analysis has shown that box time and hence the indicators vary significantly across and within lactation (Figure 1a), which has been also reported by Heringstad and Bugten (2014). The variability was also very high in late lactation, because of a decreasing number of observations due to ended lactations, thus data were limited to DIM between 28 and 365. Regression analysis was performed to generate factors to correct indicators for parity groups (1,2 and +3) and stage of lactation (DIM). Herd was considered as a random effect. Analyses were conducted in SAS version 9.4 (SAS Institute Inc.).

Results and discussion

The best fittings were obtained with quadratic polynomial equations. The resulting equations can be used to generate a factor to correct the data to 150 DIM within each parity, and to adjust to parity 2 for data in the other two parity groups (Figure 1a, b). The average of box time was 7.22 min/cow, and the average of the indicators were 1.86 kg milk/min of box time and 1.50 Can$/min of box time.

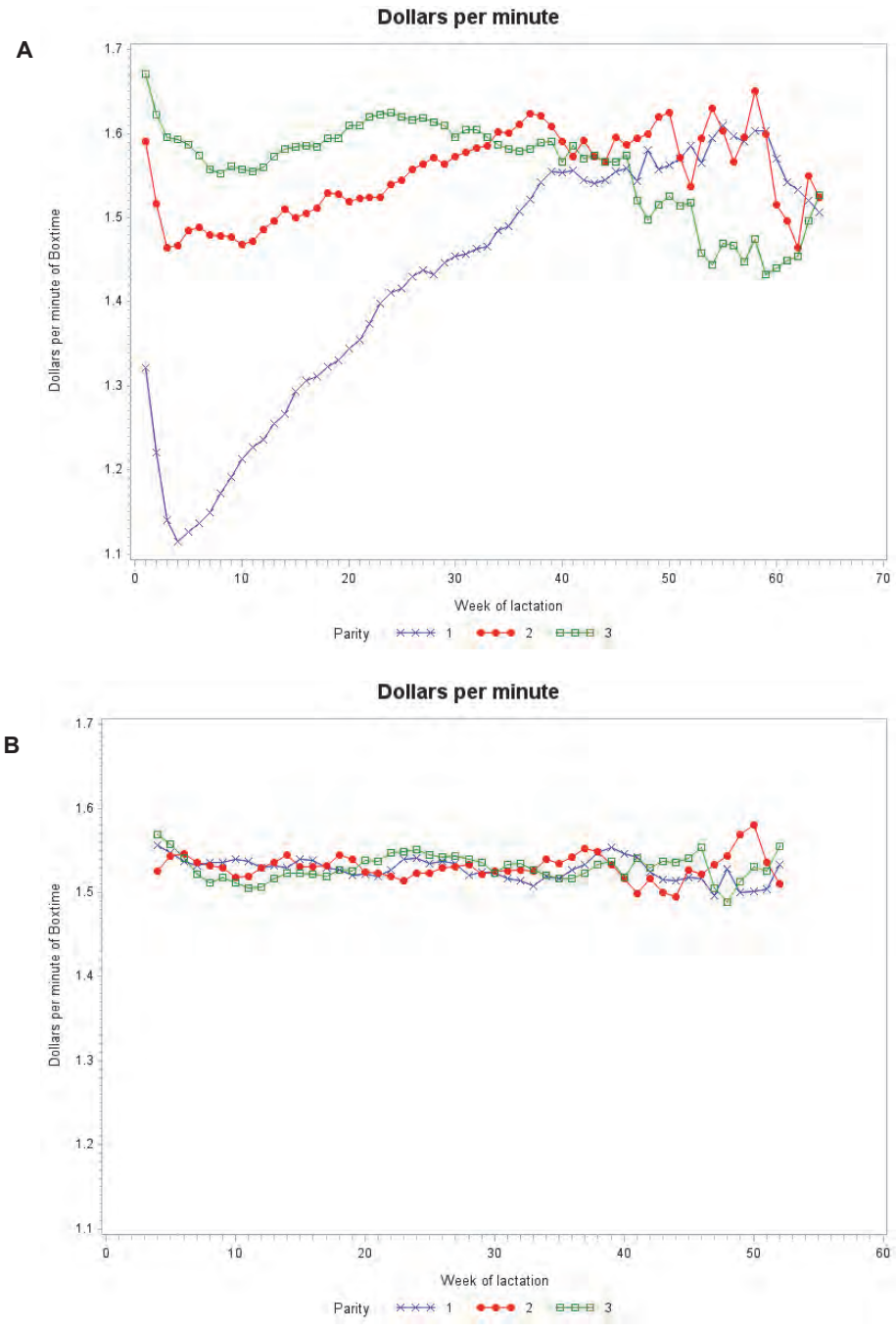

Figure 1. a) Raw data of the indicator dollar per minute of box time by parity groups (1,2, +3). b) Adjusted values of dollar per minute of box time by parity groups (1,2, +3). The DIM were converted to weeks in milk to facilitate the visualisation of the different points.

Studies have reported the importance of RMS efficiency in the management of robotic milking (Carlström *et al*., 2013; Heringstad and Bugten, 2014). Therefore, developing an indicator to rank the cows according to their performance has become a valuable decision support tool for RMS management, as shown by the implementation of these indicators among others in the interactive robot report by Lactanet.

Selecting cows for improving efficiency using the milkability trait could be a complementary approach. Milkability heritability ranges between 0.21 and 0.44 (Carlstroem *et al*., 2013; Cesarani *et al*., 2021) depending on the breed.

Conclusion

The box time indicators can be used to rank and subsequently select cows according to their performance at the RMS, in addition to other indicators such as somatic cell count. They can also be used to calculate benchmarks for comparative analysis across RMS herds, as the RMS efficiency is key for the economic success of the farms. Future work will focus on the possibility of adding genetic tools to refine the box time indicators and on the development of the adjustment factors for different breeds, as sufficient data becomes available to calculate robust adjustment factors.

Acknowledgement

Ce projet est financé en vertu de l'Accord Canada-Québec de mise en œuvre du Partenariat canadien pour l'agriculture. Ensemble, le gouvernement fédéral et le gouvernement du Québec ont investi 293 millions de dollars répartis sur une période de 5 ans, soit de 2018 à 2023.

Cet accord appuie des initiatives stratégiques qui aideront les secteurs à croître, à innover et à prospérer.

References

Carlstroem C, G. Pettersson, K. Johansson, E. Strandberg, H. Stålhammar and J. Philipsson, 2013. Feasibility of using automatic milking system data from commercial herds for genetic analysis of milkability. Journal of Dairy Science 96, 5324–5332.

Carlstroem C, E. Strandberg, K. Johansson, G. Pettersson, H. Stålhammar and J. Philipsson, 2016. Genetic associations of in-line recorded milkability traits and udder conformation with udder health. Acta Agriculturae Scandinavica, Section A — Animal Science 66, 84–91.

Cesarani A, A. Garcia, J. Hidalgo, L. Degano, D. Vicario, N.P.P. Macciotta and D. Lourenco, 2021. Genomic information allows for more accurate breeding values for milkability in dual-purpose Italian Simmental cattle. Journal of Dairy Science 104, 5719–5727.

Gäde S, E. Stamer, J. Bennewitz, W. Junge and E. Kalm, 2007. Genetic parameters for serial, automatically recorded milkability and its relationship to udder health in dairy cattle. Animal 1, 787–796.

Heringstad B and H.K. Bugten, 2014. Genetic evaluations based on data from automatic milking systems. In Proceedings, 10 th World Congress of Genetics Applied to Livestock Production (WCGALP). Vancouver, Canada.

Vosman J, G. de Jong and H. Eding, 2014. Breeding of Cows Suitable for an Automatic Milking System. In Interbull Bulletin. Berlin, Germany.