Milk yield has an impact on success of milking events in automatic milking systems

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Abstract

Automatic milking systems (AMS) provide the benefit of unassisted milking events, although a proportion might also be deemed incomplete. Minimising their occurrence is key to overall system performance. A database containing records for 773,483 individual milking events from four AMS farms was used to describe the risk of an incomplete milking event. Each record contained information about farm, cow, lactation, days in milk (DIM), milking interval (MI), milk yield (MY, in kg/milking) and if the milking event was complete or not. An incomplete gamma function with a random cow effect on the intercept was used to model variability among cows with incomplete lactations, with adjustment for lactation number (1, 2 and 3 or more) and calving period (warm or cool). The best linear unbiased (BLUP) prediction of cow effect was used to categorise lactations into percentile 33 (P33) and 66 (P66), as either high, medium or low MY level respectively. A proportional hazards model was fitted to describe the risk of a complete milking event happening as a function of MY and calving period. First lactation cows with high MY level were 2.05 times more likely ($P<0.0001$) to have a complete milking event than those with low MY level. The likelihood was only 1.36 ($P<0.0001$) for cows with three or more lactations. Furthermore, lactations that had commenced in the cool period were more likely to have shorter MI than those that commenced in the warm period. Know the milking interval in which complete milking happens for different productive groups would improve the performance of the robot.

Introduction

Automatic milking systems (AMS) are based on voluntary trafficking of cows, which provides the possibility for the cows to set their own milking schedules. Therefore, visitation pattern to the robot varies throughout the lactation (Lyons et al., 2013). This generates variation in milking intervals (MI, defined as the time elapsed between two consecutive milkings, in hours) within and between cows throughout the lactation. This is different to conventional milking systems where MI remains relatively constant both within and between cows. Therefore, cows store different amounts of milk depending on MI. Furthermore, fluctuation in MI have shown to be an attribute of the individual cow (Løvendahl and Chagunda, 2011).

In AMS a robotic arm locates and attaches a cup onto each individual teat. Success of this task depends on several factors, including localisation and insertion of the teats, which in turn is related to the amount of milk in the udder. A complete milking event is defined as that in which the amount of milk harvested is close to the expected yield (around 75 to 80% of expected yield). On the contrary, an incomplete milking event is defined as any milking event where that threshold is not achieved. Unsuccessful attachment of the cups to one or more teats, or premature cup removal, are some of the causes of incomplete milkings (Lyons et al., 2014). Previous studies have highlighted the
negative impact of an incomplete milking on milk production. This effect increases with the degree and frequency of incomplete milking and varies between cows (Wheelock et al., 1965; Peaker et al., 1996; Stelwagen et al., 1997; Albaaj et al., 2018).

The aim of this study was to quantify the risk of a complete milking in relation to milk yield level (MY) and calving period (CP, defined as warm or cool), with the idea of exploring whether there is a MY at which incomplete milkings are minimised.

Materials and Methods

A database containing 773,483 records of milking events for one year (July 2016 – June 2017) from two AMS farms in Australia and one farm from New Zealand and Chile was used. Each record contained farm, cow, lactation, DIM, MI and MY (as the total amount of milk harvested in one milking event, in kg/milking). Daily MY was calculated as the sum of MY within a 24-h period. An incomplete gamma function (Wood, 1967) with a random intercept (adding a random component distributed normally with zero mean and variance to parameter a of the function) was adjusted for each lactation. Daily yields were expected to be auto-correlated. The adjustments were made using PROC NLMIXED in SAS. Predicted curves of average daily MY according to lactation (1, 2 and 3 or more), and CP were obtained. Animals that calved between September and February were considered as warm CP; those calving between March and August were considered as cool CP. We used BLUP to categorise each lactation in three levels, as high, medium or low, in agreement with the value of the P33 and P66 of yield distribution. Finally, a proportional hazards model was used to determine the risk of a milking event being complete in relation to MY level and CP for 1st, 2nd and 3rd or more lactation.

Results and Discussion

First lactation cows with high MY level (22.81 ± 0.03 kg, as mean ± SEM) were 2.05 (95% CI 2.03 – 2.09) times more likely to have a complete milking event during the observation period than those with low MY level (10.42 ± 0.03 kg, as mean ± SEM). This likelihood reduced to 1.36 (P<0.0001) for cows with three or more lactations. Similar results were reported in a study conducted in a pasture-based AMS, in which probability of success at second attempt (after an initial incomplete milking), was about 7.5 times higher in cows with higher production (Kolbach et al., 2012). Additionally, Albaaj et al. (2018) found that the total distance between the 4 teat ends increased as the degree of milk removal in the udder decreased. Given that one of the factors that affects the successful location of the teat by the robot is the insertion of the teat, degree of udder fill might be a key factor behind complete milkings.

Long MI, caused for example by incomplete milkings, result in a remnant of milk in the udder, increasing the possibility that bacteria causing mastitis colonise the quarters causing a spike in the incidence of this health event (Hovinen 2011).

First lactation cows had a median MI for complete milkings of 11.55 h for those with high MY and 13.71 h for those with low MY level. For cows with three or more lactations the median MI was 10.9 h for cows with high MY level and 12.56 h for cows with low MY level. Managing milking intervals to achieve complete milkings, without negative effects on production and udder health, could optimise AMS utilisation. This is important in order to maximise the potential achievable throughput (cow milkings/day) without detrimental effects on queue lengths and time off pasture (Davis et al., 2005). Moreover, regardless of the lactation number, cows that calved in a cool period
were more related to having shorter MI for complete milkings, than those that calved in the warm period ($P<0.0001$).

Conclusion

Our data indicates there is a positive relationship between production level and complete milkings events for cows in pasture-based AMS. This means that if milk production decreases, it is less likely for the robot to successfully attach the teat cups which causes an increase in the percentage of incomplete milkings. To our knowledge this is the first study to quantify this effect, a necessary first step in solving or reducing the problem. Future research will be necessary to determine in the cows with incomplete milking potential health problems, such as mastitis. Additionally, time in which complete milkings are achieved for each productive group would allow the herds to be scheduled to maximise the number of milkings per day per robot.

References


