ABSTRACT: An increasing number of farms with automatic milking systems (AMS) has resulted in large amounts of data available and new requirements of cows in these systems. Possibilities of creating new traits, based on AMS data, need examination. Records from 1674 first-lactation Swedish Holstein cows from 17 AMS herds were used to estimate heritabilities for 2 different teat cup attachment failure (AtF) traits and milking interval (MI), and their genetic correlations with temperament scores. Heritability estimates were 0.06 for number of AtF per milking, 0.31 for proportion AtF, 0.17 for MI, and 0.14 for temperament. Genetic correlations with temperament were moderate for the two AtF traits, -0.38 and -0.50, indicating that cows deemed “calm” have fewer AtF. The genetic correlation between MI and temperament was not significant. Results suggest that data from AMS could provide an objective method to measure temperament or behavior traits.

Keywords: Temperament; Heritability; Automatic milking systems

Introduction

The increasing popularity of automatic milking systems (AMS) on dairy farms beginning in Northern Europe and spreading to other parts of the world requires a reevaluation of the breeding goal. Approximately 25% of Swedish dairy farms are equipped with AMS (de Koning et al. 2010). The substantial amount of data routinely recorded by AMS has the potential for use to improve genetic evaluations. Behavior traits may become of higher importance in AMS because cows must make their own way to the milking unit and stand calmly while being milked; improving behavior would also help to fulfill one of the aims of milking robots, to reduce the labor requirement on farms. “Fetching” or retrieval of cows when they do not visit the milking unit on their own occurs at a frequency of 8% of all visits (Stefanowska et al. 1999). Fetching has been shown to increase adrenaline and noradrenaline concentration in the blood (Hopster et al. 2001) and therefore may present an animal welfare issue.

In one study, kicking in the milking unit occurred at a rate of 13% (Rousing et al. 2006). In another, kicking just as the teat washing process began or during milking resulted in 55% of milking failures (Kaihilahti et al. 2006). This signifies that kicking in AMS is a significant enough issue to examine further and find the underlying causes.

Heritability of temperament has a wide range of estimates, ranging from 0.06 (Thompson et al. 1981) to 0.53 (Dickson et al. 1970). Most of these have been based on farmers’ observations of their cows. Currently in Sweden, general temperament (TEMP) of dairy cows is evaluated on a scale from 1, very nervous, to 9, very calm, and scored by the farmer. The heritability is estimated at 0.14 for Swedish Holsteins. The trait TEMP currently has a relative weight of 0.03 in the total merit index and each additional index unit results in a gain of €8.50 (NAV 2013).

The purpose of this project was to evaluate if data routinely recorded by AMS could be used for genetic evaluation of cow behavior. The aim was to estimate heritabilities of two different definitions of teat cup attachment failures (AtF) and milking interval (MI) and their genetic correlations with TEMP in order to determine a more objective method of measuring behavior than the current scoring process.

Materials and Methods

The data from individual milkings came from 17 commercial AMS herds milked by DeLaval robots in Sweden from 2004-2009. The data were edited using the same criteria as in Carlström et al. (2013), and the first 4 milkings and any milkings taking place after 400 days in milk were removed. Automatic milking system sensors record the number of premature removals of teat cups from each udder quarter during the occupation time. Removals could be due to the robot arm dropping the teat cup, e.g., during attachment. The robot arm will then pick up the teat cup and try to attach it again. It could also be due to the cow kicking off the teat cup during milking. For this study, all milkings including at least one removal or dropping of teat cup(s) from any quarter were considered a record with an attachment failure. The trait proportion teat cup attachment failures (pAtF), was defined as the proportion of all milkings with at least one attachment failure, throughout the lactation, resulting in one value per cow per lactation. Another trait was defined as number of teat cup attachment failures per milking (nAtF) (0, 1, …, ≥2). Milking interval (MI) was defined as the number of hours between two consecutive milkings and could be considered a measure of if the cow is more or less eager to visit the robot.

After editing, the data consisted of 921,904 milking events of 1,674 Swedish Holstein cows. A dataset with TEMP from routine evaluations contained records on 1833
cows from 15 of the 17 herds. 596 cows were in both datasets. See Table 1 for descriptive statistics of the data.

Table 1: Descriptive statistics for number and proportion of teat cup attachment failures (nAtF, pAtF), milking interval (MI) and temperament (TEMP).

<table>
<thead>
<tr>
<th>Trait</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>nAtF</td>
<td>921,904</td>
<td>0</td>
<td>6</td>
<td>1.18</td>
<td>2.17</td>
</tr>
<tr>
<td>pAtF</td>
<td>1674</td>
<td>0</td>
<td>1</td>
<td>0.30</td>
<td>0.22</td>
</tr>
<tr>
<td>MI</td>
<td>921,904</td>
<td>5</td>
<td>29.98</td>
<td>9.72</td>
<td>2.92</td>
</tr>
<tr>
<td>TEMP</td>
<td>1833</td>
<td>1</td>
<td>9</td>
<td>5.33</td>
<td>1.26</td>
</tr>
</tbody>
</table>

The pedigree file included information on the 1659 animals from the AMS dataset and the 1833 animals from the temperament score dataset and their pedigree traced back three generations.

Univariate animal models were used to estimate heritability and repeatability of MI, TEMP and the two teat cup attachment failure traits (pAtF and nAtF). Bivariate models were used to estimate correlations between the various traits, with the same fixed effects as those in the univariate analyses. We were most interested in finding genetic correlations between temperament on one hand and pAtF, nAtF, and MI on the other hand.

SAS Proc Mixed (SAS, 2002-2010) was used to determine which fixed effects had a significant effect and thus should be included in the model. The software package DMU (Madsen and Jensen 2006) was used to estimate heritabilities and genetic correlations. The models for TEMP, nAtF and MI included a fixed effect of lactation week and in the latter two, also a regression on milk yield at time of observation. Herd-year-season of the observation was included as a fixed effect for MI and nAtF, herd-year-season of calving for pAtF, and herd-year-month of scoring for TEMP.

Results and Discussion

Heritability for the four traits varied from 0.06-0.31 (Table 2). The trait pAtF had a much higher heritability (0.31) than the trait nAtF (0.06). Even if we consider using observations of nAtF from many milkings, based on the repeatability (0.24) it is unlikely that the accuracy of breeding values would be higher than that for pAtF. The trait definition pAtF may be a more straightforward measure of behavior, as it describes the probability of the cow having teat cup attachment problems, possibly due to kick-offs. It may be that there is little added value of knowing how many AtF occur during each milking, and it possibly may only add noise.

Both pAtF and nAtF had a moderate genetic correlation (-0.38 and -0.50, respectively) with temperament (Table 3). This implies that a lower incidence of attachment failures is associated with cows that have calmer temperaments. Therefore, selecting cows for lower pAtF could result in an improvement in overall temperament.

Table 2. Estimated heritabilities (h²) and repeatability (t) for number and proportion of teat cup attachment failures (nAtF, pAtF), milking interval (MI) and temperament (TEMP).

<table>
<thead>
<tr>
<th>Trait</th>
<th>h²</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>nAtF</td>
<td>0.06</td>
<td>0.24</td>
</tr>
<tr>
<td>pAtF</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>MI</td>
<td>0.17</td>
<td>0.61</td>
</tr>
<tr>
<td>TEMP</td>
<td>0.14</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Genetic correlations (r_g) and residual correlations (r_e) between temperament and number and proportion of teat cup attachment failures (nAtF and pAtF) and milking interval (MI)

<table>
<thead>
<tr>
<th>Trait</th>
<th>r_g</th>
<th>r_e</th>
</tr>
</thead>
<tbody>
<tr>
<td>nAtF</td>
<td>-0.50*</td>
<td>0.18</td>
</tr>
<tr>
<td>pAtF</td>
<td>-0.38*</td>
<td>0.57</td>
</tr>
<tr>
<td>MI</td>
<td>-0.21</td>
<td>0.21</td>
</tr>
</tbody>
</table>

* significantly different from zero using a one-sided test at 5% level.

The proportion of AtF observed in the present study, 30%, is higher than what was found in Rousing et al. (2006) so it can be assumed that it is not only kicking of the cow that causes the failures. It is important to note that there are many factors causing AtF: kicking due to an unfavorable temperament or discomfort, unsuitable udder and teat conformation, shuffling of the cow when the machine is trying to attach the teat cups, or machine failure. Distinguishing between different reasons kick-offs occur would not be feasible without video or live observation, but could make the trait definition more exact.

The genetic correlation between MI and TEMP was found to be lower and not significantly different from zero using a one-sided t-test. The correlation still suggested that a more calm cow could have a shorter milking interval (r = -0.21). Selecting cows for a shorter milking interval could be beneficial due to its relation to the number of cows that can be served by one robot. With a decrease in the milking interval, the incidence of fetching could be reduced and therefore could result in economic gains and possibly also calmer cows with lower stress. Selection for MI should also be feasible considering the heritability found (h² = 0.17). This heritability is consistent with previous estimates (König et al. 2006; Nixon et al. 2009).

A recent study by Carlström et al. (2014) using the same dataset as in the present study together with a dataset with records on Swedish Red Cattle estimated the same
heritability of pAtF in Swedish Holstein, 0.31, and a slightly lower heritability for Swedish Red, 0.21. The incidence of AtF observed in Swedish Red was 23%, while it was 30% for Holsteins. Genetic correlations of -0.44 and -0.71 were found between pAtF and TEMP for Swedish Holstein and Swedish Red, respectively. In that study, Carlström et al. (2014) also estimated genetic correlations between pAtF and other traits; pAtF was found to have favorable, moderately high genetic correlations with two other novel AMS traits, box time (r=0.46) and handling time (r=0.73). In the second and third lactations, heritability of pAtF decreased, as well as the average proportion of AtF. This reflects that the cows either become accustomed to the AMS, the cows that are not compatible with AMS are culled, or a combination of both.

About 5-10% of farmers switch back to conventional milking after converting to an AMS (de Koning and Rodenburg et al. 2004). This is mainly due to unrealistic expectations of how machines should function and a high failure rate can be discouraging. Reducing the amount of problems with AMS could be accomplished by selecting for less teat cup attachment failures during the entire lactation, or in other words, the probability that the cow will kick off the teat cups each time she visits the milking robot, has the potential to replace or supplement the current evaluation scheme for temperament and in turn could improve workability of cows in AMS. The pAtF could give information about temperament of cows that otherwise would not get a TEMP score.

**Conclusion**

Records from AMS have the potential for use in genetic evaluations of dairy cows. Using the estimate for a proportion of teat cup attachment failures during the entire lactation, or in other words, the probability that the cow will kick off the teat cups each time she visits the milking robot, has the potential to replace or supplement the current evaluation scheme for temperament and in turn could improve workability of cows in AMS. The pAtF could give information about temperament of cows that otherwise would not get a TEMP score.

Other records from AMS, such as MI, could also be included in the breeding goal in order to increase dairy cows’ suitability for automatic milking systems. The popularity of AMS is increasing not only in Europe but also on other continents, and using automatically recorded traits would be especially favorable on bigger farms where each cow is not routinely paid attention to on an individual basis. Further analyses of AMS data are needed in order to create new trait definitions that can eventually become part of the breeding goal.

**Acknowledgements**

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**Literature Cited**


