# Collecting milking speed data as part of official milk recording

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## Abstract

Due to the growing use of robotic milking systems, the interest in optimizing the milk output of the robotic milking unit has added a new dimension to breeding and managing dairy cows. Milking speed, milking unit attachment speed and time required for cows to enter the robotic milking unit are three major factors in determining which cows are more suitable for robotic milking systems and maximize returns on investment. Milking speed also has application in conventional parlors, and can have a direct factor on operational expenses associated with milking the herd. High producing cows with consistent milking speed will optimize parlor throughput and increase the amount of milk collected on a daily basis. Dairy producers have had the opportunity to purchase in-parlor milk meters and collect data that would help in the optimization of parlor performance, however costs and maintenance concerns have limited the adoption in the United States. The data that is produced from existing systems varies in format and archive history and is rarely transmitted as part of milk recording services, thus no national genetic evaluation of milking speed currently exists in the United States.

AgSource has been a long-time user of Tru-Test (Tru-Test Inc, Mineral Wells, TX) Electronic Milk Meters (EMMs). EMMs are used to collect monthly DHI milk weights, milking durations and milk samples. Due to the growing interest in parlor efficiency, in 2015, AgSource started collecting the milking duration times using its EMMs. Milking speed records in the form of milk weight and milking duration data are collected on approximately 100 large farms totaling over 100,000 cows. Beneficial to analysis and utilization, data is measured as a continuous variable (kg/minute) versus a standard categorical measurement. AgSource milking speed data proved to be a consistent measure based on stage of lactation and parity.

Milking speed values averaged 2.6 kg/minute and ranged from 1.4 to 4.5 kg/minute. Further analysis showed that milking speed data was positively correlated to DHI Mature Equivalent (ME) 305-day milk production and negatively correlated to somatic cell score at low and high milking speeds. Using genotypes supplied by the USA A.I. cooperative, Genex, resulting breeding values were calculated on over 60,000 cows and bulls.

Employing new technologies in regular DHI recording result in new reliable and consistent phenotypic measures that can be combined with genotype data to identify new markers, new genetic traits of economic importance and be incorporated in DHI value-added management reports.

*Keywords: milking, speed, parlor, efficiency.*

## Introduction

The United States continues to see increased adoption of robotic milking systems. Maximizing the amount of milk collected from a robotic milking system is a key element in being more profitable. There are three components that have a significant impact on robot efficiency: amount of milk collected per minute, time required to attach the milking unit and time required to move the cow in and out of the robotic milking system. Although not a new concept, analysis of milking speed data on individual cows has gained more interest in recent years. Cows that milk faster while maintaining good udder health will be more efficient and profitable than slow milking cows. Although the interest in milking speed data has increased due to increased use of robotic milking systems, the same principle applies to conventional parlor systems as well. Farms that milk cows 24 hours a day can also optimize milk output by analyzing parlor flow and grouping slow milking cows or potentially even remove them from the herd.

Dairy producers using conventional parlors have had the option to purchase in-parlor electronic milk meters and utilize data collected by the meters to manage individual cows. Adoption in the United States has been slow due to costs and maintenance concerns. Dairy Herd Improvement (DHI) programs allow for the use of milk weights from in-parlor based milk meters, however there is a wide variety in how data is formatted and transmitted between systems. In addition, producers are required to make sure meters are calibrated and always functional. Milking speed or milking duration data from in-parlor systems is typically not transmitted to DHI and therefore not utilized in any national genetic evaluations.

AgSource has been a long-time user of Tru-Test (Tru-Test Inc, Mineral Wells, TX) Electronic Milk Meters (EMMs). EMMs provide additional data over conventional DHI milk meters. In addition to the milk weight, the system also provides start time, milking duration and stall number. Due to the growing interest in parlor efficiency, in 2015, AgSource started collecting the milking duration times using its EMMs. Over 900,000 individual milking speed records have been collected on approximately 100 large farms totaling over 100,000 cows as of May 2017. Data are transmitted as part of the monthly test day data flow to the AgSource Dairy Record Processing Center. Beneficial to analysis and utilization, data is measured as a continuous variable (kg/minute) versus the current standard categorical measurement.

## Materials and methods

The goal of the research was to utilize the raw data provided by the EMMs, by first calculating milking speed values on individual milking observations and analyzing the results for data quality and consistency within lactation and across lactations. After analysis, data filters were defined to remove observations that were considered in error. Utilizing the filtered milking speed values, further data analysis was conducted looking at the overall dataset to develop a management report that incorporates the milking speed data and to develop genetic evaluations for milking speed.

### *Overall data set*

Using Microsoft SQL Server 2012© individual cow data was obtained from the AgSource Dairy Records Processing Center database. The overall data set includes individual test day information (days in milk, milk weight, milking speed, fat and protein percent, and somatic cell score), and was combined with 3-generation pedigree information, calving date, parity, 305-day mature equivalent milk production, and lactation linear somatic cell score. The resulting data set was further analyzed using Microsoft Excel©.

### *Genetic evaluations*

Test day records (n=681,029) were extracted from the AgSource Dairy Records Processing Center database. Data was used from cows with complete individual and sire IDs, and at least five records existed where milk duration was less than 20 minutes, and milking speed less than 9 kg/min). A cow had to have either first or second lactation data to be included in the analysis. After quality control, there were 351,341 records on a total of 35,693 cows, from 3,216 sires. The pedigree consisted of 93,664 animals. A population of 109,732 animals with 50K genotypes were used to estimate genomic breeding values. Breeding values were estimated for all individuals in the pedigree using BLUPF90, and variance components were calculated using the AIREML procedure within the BLUPF90 suite of programs (Misztal *et al.*, 2015).

## Results and discussion

### *Data quality*

Prior research related to milking speed has generally used categorical data. Since the EMM data is continuous data, it was key to ensure we have good quality data. Cows with extreme milking speeds both positive or negative could point at problems related to milking equipment attachment. The milking speed value is not a measurement made by the EMM, milking speed is calculated by using the EMM milk weight and milk duration. One of the concerns regarding the milking speed calculation was related to what value the EMM returned for milking duration if the milking unit suddenly disconnects and then is reconnected. Based on the data, any observations where milking speed was less than 0.45 kg/min or greater than 6.8 kg/min or milking duration was greater than fifteen minutes could be considered suspect. The number of observations outside the criteria only accounted for 1.4% of the total dataset. When removing these outliers, the average milking speed value remained unchanged at 2.6 kg/min.

### *Data variability*

DHI milk recording typically collects a single milk sample and milk weight per month. Not knowing if milking speed data varies per milking or within lactation, it was important to find out if there are other factors such as days in milk or lactation that need to be considered. If milking speed data changed based on days in milk or lactation, its use in a management report grouping cows would be considerably more complex. Based on the data collected, it was decided to require a minimum of five milking speed observations per cow. After excluding cows with less than 5 observations, 790,294 observations on 72,614 cows remained. Results are shown in Table 1, and provide various statistics on the distribution of milking speed values and corresponding standard deviations.

*Table 1. Milking speed distribution.*

| | Milking Speed (kg/min) | Standard Deviation (kg/min) |
|---|---|---|
| 1st Quartile | 1.9 | 0.4 |
| 2nd Quartile | 2.4 | 0.5 |
| 3rd Quartile | 3.1 | 0.6 |
| 4th Quartile | 3.4 | 0.6 |

*Table 2. Variance components and heritability estimates for milking speed.*

| | Variance est. | Var SE |
|---|---|---|
| Additive (animal) | 0.3630 | 0.0199 |
| PE | 0.4349 | 0.0161 |
| Residual | 1.2204 | 0.0031 |
| **Total** | **2.0183** | |
| Heritability | 17.99% | |
| Repeatability | 39.53% | |

Based on the results in Table 1, the spread in milking speed between cows is quite large. The 4th quartile cows (fast) produce on average 1.5 kg more milk per minute than the 1st quartile cows (slow). In addition, the average standard deviation for each cow is only 0.2 kg/min larger for the 4th quartile cows versus 1st quartile cows. Statistical analysis showed that a 95% confidence interval variation between lactations was 0.003 kg/min and within lactation was 0.57 kg/min. Based on these results, the variation per cow within lactation is relatively small and across lactation is negligible.

## Milking speed analysis

To understand more about the value of milking speed data and how it relates to overall lactation, milk production, and udder health, cows were grouped in 9 categories. The first category includes cows milking less than 1.4 kg/min. Subsequent groups were generated at 0.45 kg/min increments. The last group were cows milking 4.5 kg/min or higher. Figure 1 shows the distribution of cows across the 9 groups. The distribution is a typical normal distribution. Figure 2 shows the actual lactation ME 305 day milk production and the LSSCC score for the same 9 groups. Initial expectation were that the lactation average LSSCC would be lowest for the slowest milking cows and highest for the fastest cows, however the distribution in Figure 2 shows that both slow and fast milking cows had a slightly higher LSSCC. ME 305 day milk production had a strong relationship with milking speed where by the fastest cows also tended to produce the most milk in the lactation.

## Producer opportunities

As indicated prior, milking speed data can provide a valuable tool to optimize parlor performance. U.S. herds typically house and manage cows in groups. Milking schedules are based on bringing a single group of cows through the parlor. Grouping strategies are typically based on nutritional needs, reproductive status and sometimes health status. Adding milking duration and milking speed to the decision criteria can further optimize parlor throughput. Table 3 shows an example of a large herd group report

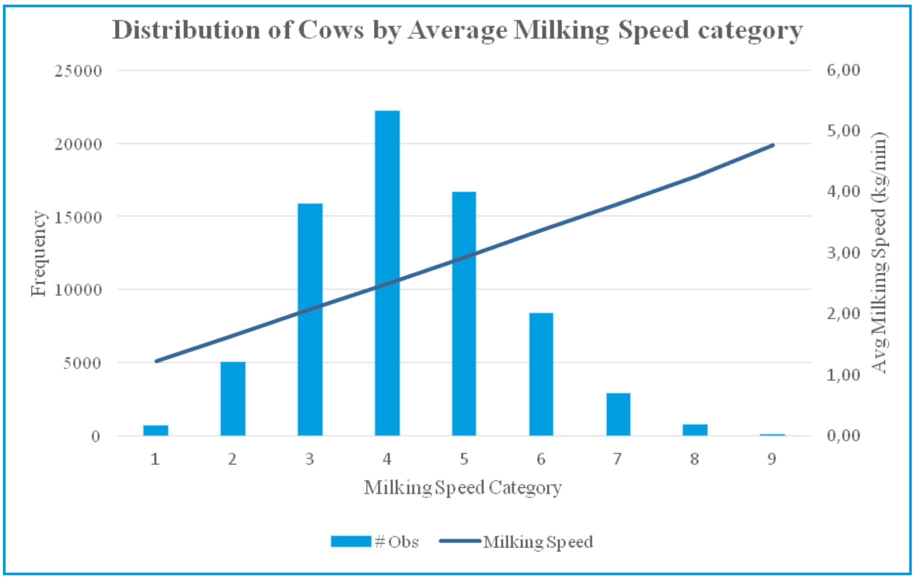


*Figure 1. Cow distribution by milking speed category*

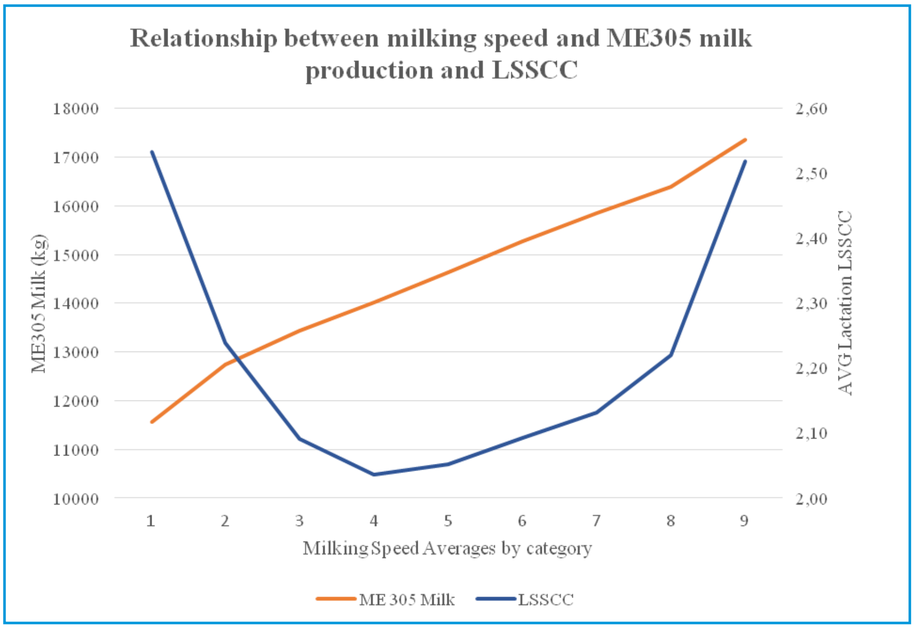


*Figure 2. Relationship between milking speed and ME 305 Milk and Lactation Average LSSCC*

*Table 3. Sample milking speed grouping report.*

| Control # | Lact # | Number of milking times collected | Avg milk (kg/min) | Avg milk duration (min) | Avg milk (kg/min) | Days in milk | Milk (kg) | LSCC | Avg Milk/Min | Milking Duration (Min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 2 | 3 | 2.58 | 5.07 | 2.37 | 454 | 54.9 | 2.7 | 2.55 | **7.3** |
| 8 | 2 | 2 | 2.58 | 5.07 | 4.11 | 239 | 37.2 | 2.9 | 4.23 | 3 |
| 10 | 3 | 1 | 2.58 | 5.07 | 3.96 | 40 | 54.9 | 4.6 | 3.96 | 4.7 |
| 33 | 2 | 1 | 2.58 | 5.07 | 2.57 | 92 | 50.8 | 0 | 2.57 | 6.7 |
| 37 | 1 | 3 | 2.58 | 5.07 | 3.01 | 199 | 29.5 | 0.1 | 3.33 | 3 |
| 50 | 1 | 2 | 2.58 | 5.07 | 2.29 | 148 | 39.9 | 0.7 | 2.62 | 5.2 |
| 51 | 1 | 3 | 2.58 | 5.07 | 2.51 | 198 | 32.2 | 0 | 2.47 | 4.4 |
| 77 | 4 | 2 | 2.58 | 5.07 | 1.90 | 278 | 20.0 | 2.2 | 2.06 | 3.3 |
| 84 | 2 | 3 | 2.58 | 5.07 | 2.89 | 199 | 41.3 | 2.9 | 2.70 | 5.2 |
| 102 | 4 | 4 | 2.58 | 5.07 | 1.58 | 163 | 38.6 | 2.8 | 1.60 | **8.2** |
| 118 | 2 | 1 | 2.58 | 5.07 | 2.65 | 29 | 56.2 | 0 | 2.65 | **7.2** |
| 119 | 3 | 1 | 2.58 | 5.07 | 2.38 | 100 | 42.6 | 2 | 2.38 | 6.1 |
| 127 | 2 | 1 | 2.58 | 5.07 | 2.32 | 325 | 30.8 | 6.7 | 2.32 | 4.5 |
| 130 | 3 | 4 | 2.58 | 5.07 | 1.76 | 395 | 37.2 | 5.9 | 1.76 | **7.2** |
| 131 | 1 | 3 | 2.58 | 5.07 | 2.29 | 172 | 28.1 | 0 | 2.38 | 4 |
| 132 | 1 | 3 | 2.58 | 5.07 | 1.96 | 103 | 33.6 | 0 | 2.10 | 5.4 |

utilizing individual cow milking speed and milking duration data, and compares against the group average milking speed and milking duration. Cows with red highlights indicate milking speed values that are 0.45 kg/min less than the group average. Cows with yellow highlights indicate milking durations that exceed the group average by 2 minutes.

When reviewing the results in Table 3, cow control # 102, for example, had 4 individual milking speed records collected, and averaged 1.58 kg/min milking speed for her lactation. On her last test date she milked 1.6 kg/min and took 8.2 minutes to milk. Based on her milking speed and production level, she would be a good candidate to place in a separate group of slow milking cows.

## *Milking speed genetic evaluations*

One of the project goals was to utilize the milking speed information and establish breeding values for cows and bulls. Various linear mixed models were tested, the final model used was:

$$Y_{ijklmno} = m + MM_i + LS_j + HYM_k + L_l + DIM_m + 1\%Cow_m + 1\%PE + e_{ijklmno}$$

Where $y_{ijklmno}$ is the milking speed observation for a particular cow, $\mu$ is the population mean, $MM_i$ is the fixed effect of meter milk (kgs of milk produced at the current milking), $LS_j$ is the fixed effect of linear somatic cell score, $HYM_k$ is the fixed effect of herd-year of calving-month of calving, $L_l$ is the fixed effect of lactation (1 to 4), $DIM_m$ is the fixed effect of days in milk, 1|$Cow_n$ is the random effect of cow, distributed as $N(0, I\sigma^2_{Cow})$, and 1|PE is the random permanent environmental (PE) effect, distributed as $N(0, I\sigma^2_{PE})$, which is the non-genetic effect assumed to be common to all observations on the same cow, and eijklmno is the random residual, distributed as $N(0, I\sigma^2_e)$. Variance components and heritability are shown in Table 2.

Genomic estimated breeding values (GEBVs) were standardized by dividing one-fifth of the additive genetic standard deviation ($\frac{\sqrt{0.3630}}{5} = 0.1205$) and deviating from a base of 100. Therefore, a one-unit change on the 100-scale indicates 0.1205 change in

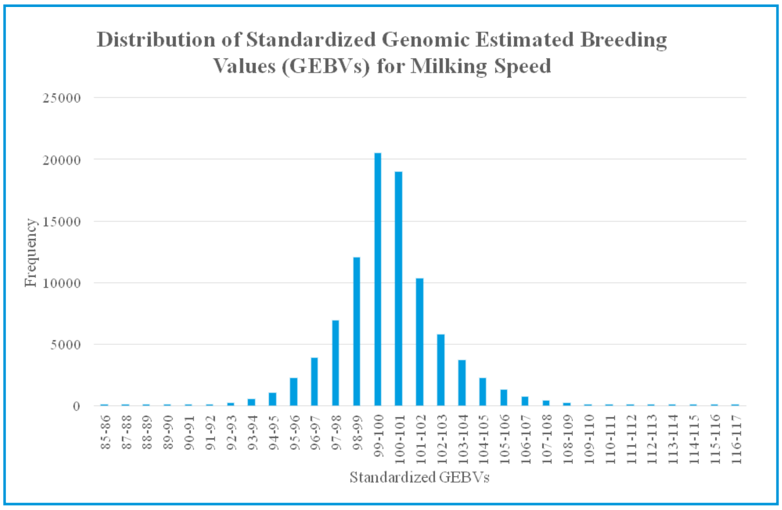


*Figure 3. Distribution of GEBVs for parents and offspring.*

milking speed from the population average. Figure 3 shows the spread of standardized GEBVs for both males and females. Reliability of estimation for breeding values was calculated for both males and females.

## Conclusions

Milking speed data, combined with milk production and milk duration data, can provide a valuable tool to dairy producers for grouping cows or as a consideration for culling. Milking speed data collected through the use of EMMs provides consistent and high quality information and can be turned into an added-value service by DHI milk recording organizations. The use of continuous data recorded through EMMs also provides a valuable tool to estimate genomic breeding values on cows and bulls.

## List of references

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