Northern New York Agricultural Development Program
2018 Project Final Report

Assessing Automatic Cluster Remover Settings on Milking Unit-On Time, Total Milk Yield, and Teat Condition in NNY Dairy Herds

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- Bill Fowler, Mike Hill, Hillcrest Holsteins LLC, 6763 County Rte 78, Henderson, NY, 13650

Cooperating Producers:

Lewis County	Jefferson County	St. Lawrence	Clinton
Beller Farms	Birch Creek Farms	Chambers Farm	Adirondack Farms
Bob Hanno Farm	Deer Run Dairy	Greenwood Dairy	Three L Farms
Butler Creek Dairy	Dennis Forrester	Maple View Dairy	**Franklin**
Demko Farms	Doubledale Farms	Twin Mills Farms	Bilow Farms
Graceway Farm	HiCrest Farms		
Jones Family Farm	Hillcrest Farms		
Moserdale Farm	Murcrest Farms		
Woods Hill Farm	Murrock Farms		

Background:

The ultimate goal of most dairy producers is the efficient production of high quality milk. While many factors influence milk production and thus overall efficiency of dairy operations, parlor efficiency is particularly important. Optimal parlor management ensures that high quality milk is harvested as quickly, completely, and gently as possible while maintaining udder health. Practical metrics to monitor milking speed, completeness, and gentleness of milking, respectively, are milking unit-on time, total milk yield, and teat tissue condition.

The milking unit-on time can be altered by changing the switch point setting for the automatic cluster remover units (ACR). The operating principle for ACR is to detach the unit once milk flow has dropped below a preset threshold or switch point [(lb/min) *Armstrong et al. 1970*]. The implementation of ACRs has led to a significant reduction in milking unit-on time and over-milking.

Historically, cows were considered milked out when the milk flow rate decreased to 0.44 lb/min. This threshold was arbitrary but used for most ACRs. Early studies by Sagi (1978) and Rasmussen (1993) concluded that the cluster can be detached at a flow rate of 0.88 lb/min. Milking time was significantly shorter, with no negative effect on the milk yield and the incidence of clinical and subclinical mastitis. More recent studies with different management strategies and goals using ACR settings of up to 1.80 lb/min supported the results of the earlier work *(Stewart et al., 2002; Magliaro and Kensinger, 2005).*

Results from multiple parlor evaluations during extension surveys at Quality Milk Production Services indicate that the majority of Northern New York State (NNY) dairy producers with a thrice-daily milking schedule operate the milking parlor with ACR settings at or below 1.8 lb/min. Because the termination of milking is set at the udder level, these settings result in a significant amount of over-milking of individual quarters. This causes discomfort and damage to the teat tissue (*Neijenhuis et al., 2001; Berglund et al., 2002)* and thereby increases the risk of mastitis (*Natzke et al., 1982*).

Our field experience suggests that a gradual increase of the ACR settings from 1.8 lb/min to 2.8 lb/min results in a remarkable reduction in milking unit-on time while maintaining the quality and amount of milk harvested. Additionally, we observe a significant improvement of teat tissue condition such that the proportion of cows that exhibit machine milking-induced changes diminishes from up to 50% to below 20%.

In the scientific literature, however, there are no reports using ACR settings of such increased magnitude to validate these observations under controlled conditions. Therefore, the objective of this study was to evaluate the effect of two different ACR settings on 1) milking unit-on time, 2) total milk yield, 3) teat tissue condition, and 4) somatic cell count (SCC). We hypothesized that a higher ACR setting (i.e., 2.8 lb/min) increases milking efficiency and improves teat tissue condition without sacrificing milk yield or udder health (i.e., SCC) compared to a lower ACR setting (1.8 lb/min).

Methods:

This randomized field trial was conducted on a commercial dairy farm (Hillcrest Holsteins LLC, 6763 County Route 78, Henderson, NY, 13650) in Northern New York between June and August 2018. The study protocol was reviewed and approved by the Cornell University Institutional Animal Care and Use Committee (*protocol no. 2018-0003*). A supporting letter from the farm owner was obtained prior to the start of the study.

Animals and Housing

The lactating herd consisted of approximately 800 Holstein cows. Cows were housed year-round in six free-stall pens with sand bedding and fed the same total mixed ration that was formulated to meet or exceed the requirements outlined by the National Research Council (2001). The rolling herd key performance indicators were as follows: average milk production, 25,368 lbs; monthly clinical mastitis incidence, 2.5%; 21-day pregnancy rate, 25%; and culling rate, 33%. All cows were milked three times per day, except for animals milked twice per day in the hospital pen. The farm did not use DHIA services on a monthly basis.

Milking System
Cows were milked in a double-12, parallel milking parlor. The milking unit consisted of the parallel top unload claw from Boumatic with a 19 mm outlet and the Impulse IP4-LM milking liner (Milkrite, Johnson Creek, WI). The pulsator (HiFlo, Boumatic) was set to a pulsation rate of 65 cycles/min, a pulsation ratio of 65:35, and a front-to-back alternating pulsation.

The pulsation phases under load as assessed with the VaDia vacuum recorder (BioControl, Rakkestad, Norway) were as follows:
a-phase, 100;
b-phase, 505;
c-phase, 104; and
d-phase, 214 ms, respectively.

The system vacuum was set to 13.6 inches Hg, yielding to an average claw vacuum of 12.4 inches Hg during the peak milk flow period. The milk line was installed 27.6 inches below cow standing level. All milking system settings were verified and assessed by the investigators according to the guidelines outlined by the National Mastitis Council (NMC, 2012) prior to the start of the study.

Milking routine was performed by one milking technician per milking session in sets of six for most cows (five pens), while late lactation animals in one pen were prepped in sets of 12. Pre-milking udder preparation and teat sanitization were performed in four steps as follows:

1) dip with an iodine-based teat dip (Eco-Plus 50 S.A., Ecolab, St. Paul, MN);
2) forestrip all four teats;
3) dry the teats with a separate clean cloth towel; and
4) attach the milking unit.

After unit detachment, postmilking iodine-based teat dip (Eco-Plus 50 S.A., Ecolab, St. Paul, MN) was applied.

Treatment allocation
The two central components of the treatment allocation were a dairy farm management software program AfiFarm (Afimilk, Kibbutz Afikim, Israel) and electronic on-farm milk meters (AfiMilk MPC Milk Meter, Afimilk). With AfiFarm, different milking machine settings can be applied to individual cows. For this purpose, a code entailing specific settings for operational parameters can be assigned to a cow for a specified duration. The automatic cluster remover of AfiFarm (Afimilk) is based primarily on the F2, the 'ACR delay' that determines the milk flow rate at which milking will be terminated.

All cows that were expected to lactate throughout the entire study period based on the expected dry-off date were eligible for enrollment. Eligible cows were randomly assigned using simple randomization with the random number function in Microsoft Excel (2013 version, Microsoft Corp., Redmond, WA) into one of two treatment groups. Treatments consisted of two different F2 settings: group **LOW** (F2 = 15) and group **HIGH** (F2 = 10), respectively corresponding to a cluster remover take-off milk flow threshold of 1.8 lb/min (LOW) and 2.8 lb/min (HIGH). The other 3 parameters were consistent for all cows and set as follows: 'ACR pre-milk time' (F1), 14 corresponding to 140 seconds (s); 'vacuum decay time' (F3), 0 s; and 'auto adjust quick removal' (F4), false.

Cow Characteristics
Cow characteristics such as parity and days in milk (DIM) were obtained from the dairy management software program (Dairy Comp 305, Valley Agricultural Software, Tulare, CA).

Milking Characteristics
Milking unit-on time (MUOT, s) and total milk yield (TMY, kg) were assessed at each milking with electronic milk meters (AfiMilk MPC Milk Meter, Afimilk, Kibbutz Afikim, Israel) and recorded using the dairy farm management software AfiFarm (Afimilk).

Presence of Non-Lactating Quarter and Teat Tissue Condition
Two trained investigators, blinded to the treatment applied, conducted the assessment of the presence of a non-lactating quarter and evaluation of the teat tissue condition. Presence or absence of a non-lactating quarter was visually assessed during milking on days (d) 1 and 57. A non-lactating quarter was considered present if one teat cup was not attached to the respective quarter at any of the two days.

Machine milking-induced short-term changes to the teat tissue condition (STC) were visually assessed on d 15, 29, and 57 according to the scoring system described by Hillerton et al. (2000). Briefly, approximately 60 s after unit detachment the condition of the teat base was classified as:

> no visible mark present (score 1),
> visible mark present (score 2), and
> significant swelling (score 3).

Evaluation of consistency of the teat-end was scored:

> soft (score 1),
> firm (score 2), and
> wedging present (score 3).

Presence of STC was considered if the condition of the teat base score was 3, or the consistency at the teat-end score was ≥2 of 1 or more teats, whereas STC was absent otherwise.

Teat end callosity was scored on d 1, 15, 29, and 57 according to the 4-point scale as previously described by Mein et al. (2001); briefly:

> no callosity ring present (score 1);
> callosity ring but no roughness present (score 2);
> callosity ring and roughness present, keratin fronds extending 1 to 3 mm from the teat orifice (score 3); and
> callosity ring present with excessive keratin fronds extending ≥4 mm from the teat orifice (score 4).

Presence of hyperkeratosis (HK) was considered if 1 or more teats had a score ≥3, whereas HK was absent otherwise.

Milk Sampling and Analysis
Milk samples were collected from all cows 14 d prior to the start of the study, on d 16, d 48, and d 80 and analyzed for fat, true protein, and lactose using infrared analysis on an automated Fossomatic FT+ [Foss, Eden Prairie, MN; method 972.160; AOAC International (2012)], and SCC (cells/mL) using optical fluorescence [Fossomatic FC, Foss, method 972.160; AOAC International, (2012)] at Dairy One Cooperative Inc. (Ithaca, NY). For subsequent analyses, linear SCS (LS) were calculated according to Ali and Shook (1980) as follows: $LS = \ln[(SCC/100{,}000)/\ln(2)] + 3$.

Analytical Approach
Data were maintained in a commercially available spreadsheet (Microsoft Office Excel 2013; Microsoft Corporation, Redmond, WA) and analyzed using SAS 9.4 (SAS Institute Inc. Cary, NC).

Prior to statistical analyses, data was investigated for missing and erroneous values. Further, the following milking observations were excluded from the analyses: cow milking observations that 1) were milked on manual milking mode, 2) reattached, or 3) manually detached.

Separate general linear mixed models were applied to study the effect of the two different ACR settings on the milking unit-on time, total milk yield, and LS. To investigate the effect of treatment on STC and HK, two separate generalized linear mixed models with a logit link and a binomial distribution were used.

Results:

Data from 657 cows (LOW, 325; HIGH, 332) were used for the final analyses. Milking unit-on time was significantly ($P < 0.0001$) shorter in cows in group HIGH (ACR setting of 2.8 lb/min) compared with cows in group LOW (ACR setting of 1.8 lb/min) with least squares means (LSM) and standard errors (SE) of 259 (3) s and 286 (3) s, respectively (Figure 1 in Appendix). By contrast, total milk yield was not different between treatment groups ($P = 0.73$) with LSM (SE) of 25.75 (0.52) lb in group HIGH and 25.88 (0.56) lb in group LOW (Figure 2 in Appendix). Further, there was no difference in LS among treatment groups ($P = 0.77$). Linear scores were 1.76 (0.1) in group HIGH and 1.74 (0.1) in group LOW.

Cows that were milked with the LOW ACR setting were more likely to exhibit STC after machine milking. The odds ratio and 95% confidence interval was 1.3 (1.02-1.65). By contrast, treatment had no effect on HK ($P = 0.46$).

Demonstration Herds

During the months of September 2018 to January 2019 a total of 22 additional farms were visited as demonstration herds for the project based on recommendations from local veterinary clinics. For each of these farms, an extension survey was performed which consisted of assessment in the following areas: claw vacuum, pulsation under load, milk line vacuum for 30 minutes, unit alignment, milking routine timing, milk flow rate analysis, teat end cleanliness, strip yields, teat scoring, udder hygiene, and facilities. The primary goal of these surveys was to assess the current ACR settings and based on the findings of the survey to have a detailed conversation with the farm about whether there was a benefit to change the ACR settings.

The range of ACR settings on these 22 additional herds was from 0.8 lb/min to 2.6 lb/min. After analyzing all the data from each individual herd, the recommendation was that 20 out of the 22 herds could benefit from an ACR setting change that would remove the cluster faster. **After the farm meeting, 100% of the 20 farms that we recommended should make a change did adjust the ACR settings.** The feedback from these farm meetings was very positive with many of the farm teams expressing that they had not realized there was an opportunity area for improvement on their farm by adjusting the ACR settings.

Conclusions/Outcomes/Impacts:

We saw a decrease of 27 s in average milking unit-on time. If one assumes that a modern milking parlor turns over every 12 minutes (5 turns/h), milks 7 hours per milking shift, and that an ACR setting of 2.8 lb/min will save 0.45 min/turn; then this setting will save 15.8 min/shift (= 5 turns/h × 7 h/shift × 0.5 min/turn). This would allow a producer to milk an extra turn of cows at each milking shift with no additional labor cost and no detrimental effects on milk production or udder health.

Our results further indicate that higher ACR settings alleviate the negative impact of machine milking on the teat tissue condition and thus enhance animal well-being. We are convinced that our results will have a substantial impact on proposed machine milking strategies and create a unique advantage for Northern New York dairy farmers in the market place.

Education and Outreach:

Information on the results of the clinical trial has been presented so far at:

- Lewis County Dairy Day Cornell Cooperative Extension meeting
  January 15, 2019; Lowville, NY; 10 attendees
- Jefferson County Dairy Day Cornell Cooperative Extension meeting
  January 16, 2019; Watertown, NY; 24 attendees
- Short course at National Mastitis Council annual meeting
  January 30, 2019, Savannah, GA; 22 attendees

Additional presentations of the results of the clinical trial and a summary of the demonstration herds' response will be presented at:

- Franklin County Dairy Day Cornell Cooperative Extension meeting
  February 13, 2019; Malone, NY
- St. Lawrence County Dairy Day Cornell Cooperative Extension meeting
  February 14, 2019; Canton, NY
- QMPS Assessing Udder Health Course
  March 4-8, 2019; Ithaca, NY
- Summer Dairy Institute Course
  July 8-12, 2019; Ithaca, NY
- Milk Quality Preconference Seminar at National AABP/NMC meeting
  September 8-10, 2019; St. Louis, MO.

A journal article will be submitted to Journal of Dairy Science in March 2019. Lay press articles will be submitted mid-summer 2019 to Hoards Dairyman and Progressive Dairyman. A research abstract will be submitted for AABP in September 2019. A poster will be submitted to the National Mastitis Council for January 2020.

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Appendix:

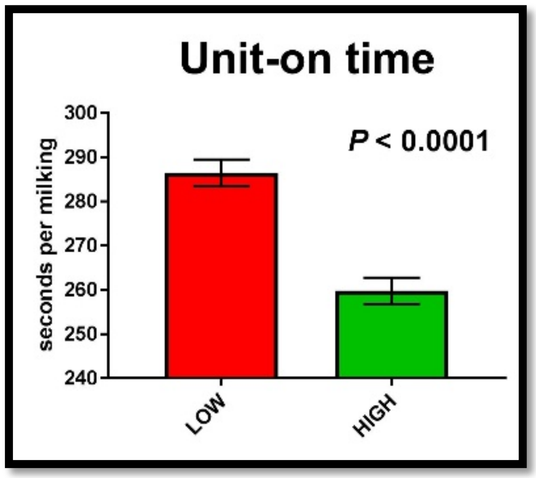

Figure 1: Comparison of Unit-on time per Milking (s) between LOW (1.8 lb/min) and HIGH (2.8 lb/min) ACR setting; Assessing the Effect of Two Different Automatic Cluster Remover Settings on Milking Unit-On Time, Total Milk Yield, and Teat Condition Project, NNYADP, 2018.

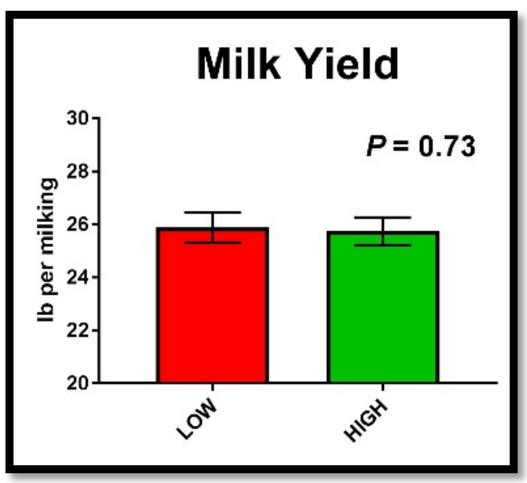

Figure 2: Comparison of Milk Yield per Milking (lbs) between LOW (1.8 lb/min) and HIGH (2.8 lb/min) ACR settings; Assessing the Effect of Two Different Automatic Cluster Remover Settings on Milking Unit-On Time, Total Milk Yield, and Teat Condition Project, NNYADP, 2018.