Impact of parity and days in milk on fetch cow status in automated milking systems

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Abstract

Fetch cows, dairy cattle that do not voluntarily enter automated milking systems (AMS), increase labor costs and decrease efficiency. The objective of this study was to describe fetch cows based on fetch lists and herd-management software data. This study was conducted on a commercial dairy (n = 528 cows) using 8 AMS from October 1, 2021 to May 10, 2022. Data were collected via PCDART, DairyComp, and a proprietary interface. Two fetch categories, EverFetch (EF) and NeverFetch (NF), and three status groups, Yes (on fetch list and fetched), No (on fetch list and not fetched), and NA (not on list), were created. The impact of health events (no event, reproduction, general health, veterinary checks, and miscellaneous) and parity (1, 2, and 3+ lactations) on fetch category and status were analyzed using the GLIMMIX procedure of SAS 9.4 ($P \leq 0.05$). Cows that experienced general health events compared to no events were more likely (odds ratio (OR), confidence interval (CI) = 3.8, 2.2 to 6.4; $P < 0.01$) to be EF. Compared to 2nd, 1st lactation cows were more likely (OR, CI = 2.1, 1.2 to 3.4; $P < 0.02$) to be EF. Second and 3+ lactation cows were more likely (OR, CI = 1.7, 1.0 to 2.8; 1.26 to 3.5, respectively, $P < 0.01$) to be fetched than 1st lactation. Cows that experienced a health event and younger cows had a greater chance of being on the fetch list. However, 2 and 3+ lactations were more likely to be fetched.

Keywords: Farm management software, Automated milking systems, Farmer usefulness

Introduction

Automated milking systems (AMS), voluntary milking systems (VMS), and robotic milkers are analogous for a stand-alone system that uses robotics to milk dairy cattle with minimal to no human intervention. These systems employ laser sights, udder mapping technology, individual teat attachment systems, feed delivery systems, and individual cow identification with record-keeping capabilities. These complex and costly machines can be advantageous for both labor and management. Automated milking systems were developed in Europe in the early 1990s to assist with labor issues on dairy farms (Rodenburg, 2017). Since March 1999, AMS have been used in Canada (Rodenburg and House, 2007) and since July 2000 in the United States (Lely, 2020), with continued growth worldwide (Koning, 2010). As of 2014, there were > 2,500 AMS units in North America on ≥ 1,000 farms (Rodenburg, 2017).

The two primary drivers of adopting AMS were (1) labor or labor costs reduction and (2) more time for farmers (Kimpel, 2016). After the start-up process, the AMS reduced hours in a parlor and allowed for more time on other job responsibilities like new AMS maintenance tasks or reduced total employees. However, employees should have or must acquire AMS knowledge which could lead to greater costs per employee (Kimpel, 2016). Surveys have shown improvement in farmer quality of life after adopting AMS. A quality-of-life survey conducted by Tse et al. in 2018 was sent to 530 AMS Canadian farms with a 41% response rate (n = 217). Their survey showed AMS provided 97% of the farmers with an increase in time for family, meetings, sleep, other chores and crop duties (Tse et al., 2018). Another survey in 2013 showed similar results that 88% of respondents agreed that AMS provided more time for family and friends and 70% agreed that it decreased a need for hired employees (Bergman and Rabinowicz, 2013).

However, fetch cows have caused negatively impact labor cost and flexible time for the farmer. When a cow does not voluntarily enter the robot during a farm-specific criteria, they appear on a fetch list. This list informs the operators to go and "fetch" the cow and bring her to the AMS for milking. This requires labor (cost and time) which could be better spent towards other duties. Fetching the cow requires minimal effort; however, the time spent on identifying and bringing cows to the AMS can take many hours each day. Fetched cows have been defined as lame, injured, or infected by mastitis, but other factors like improper training, behavior, and personality can also lead to a fetch cow (Rodenburg and House, 2007). In 2001, Canadian farmers recorded that 10 to 15% of the herd did not voluntary milk in the AMS and 19 ± 13% of cows were fetched by the farmer (Rodenburg and House, 2007). The same study indicated 15 ± 10% of cows were fetched at least one to two times per day (Rodenburg and House, 2007). Rodenburg and House (2007) found most fetch cows in their study had no identifiable reason to not use the AMS.

This study investigated the ability to determine fetch cow status based off data collected from the fetch list and dairy herd records management software (PCDART and DairyComp). We hypothesized that fetch cows could be predicted based on milk production, days in milk, parity, and overall health.

Materials and methods

Data were collected from October 1st, 2021 to May 10th, 2022 on a Holstein 1,500 herd commercial dairy farm in East Tennessee. The farm had two Lely AMS units in each of the four pens (31, 32, 33, and 34) for a total of eight AMS units. One hundred and twenty to one hundred and forty cows were in each pen throughout the study. Data were collected from PCDART (Dairy Records Management Systems, Raleigh, NC USA) and DairyComp (Valley Agricultural Software, Tulare, CA USA). PCDART was used for the first six months (October 2021 – March 2022) and DairyComp was used the last two months (April - May 2022). Data collected from PCDART and DairyComp included: cow identification, breed, parity, reproduction status, calving date, and dry-off date. Additional information included disease events (abscess, digit issues, foot rot, general lameness, warts, retained placenta, ketosis, subclinical ketosis, left displaced abomasum, metritis, milk fever, respiratory issues, mastitis and general sickness); reproductive events (breeding, synchronization, abortions breeding, and estimated breeding date); scheduled health intervention (vaccinations, veterinary checks, and hoof trimming); and any miscellaneous events that occurred. Fetch lists were collected every six hours (four times a day) at 7:00am, 12:30pm, 6:00pm, and 11:00pm EST from October 1, 2021, to May 11, 2022. Screenshots of the fetch list were taken 30 minutes before fetching to include all cattle who showed up on the list but may have not been fetched. Cows 10 to 25 days in lactation (DIM) were considered "Fresh" by the producer and those > 25 DIM were considered "Collect" by the producer. Cows on the "Fresh" list were reviewed every six hours (four times a day) and cows on the "Collect" list were reviewed every 12 hours (twice a day). The criteria for fresh-list cows being fetched were (1) not visiting the robot in the last 3 hours and (2) < 4 milkings a day. For collect-list cows, criteria were (1) not visiting the robot for the last 6 hours and (2) an expected milk yield > 13.6 kg.

Statistical analysis

Data were collected for 4,873 cows over 1,048,576 cow-days. Cow-days referred to the number of calendar days an individual cow was in the herd. These cow and cow-day numbers came from the total herd of the farm including non-AMS cows. Exclusions were sequentially applied as follows:

1) Data were limited within the start (October 1, 2021) and the end (May 10, 2022) dates of the project (n = 4,873 cows and n = 1,048,576 cow-days).
2) Dry cow-days and days after a cow left the herd were removed based on herd management software records (n = 4,384 cows and 1,078,536 cow-days remaining in the data set).

3) The herd data were limited to the four robot groups (n = 528 cows and 103,720 cow-day). This removed cows in temporary groups, cows milked conventionally, and non-lactating heifers.

Therefore, the total data for this project consisted of 528 cows and 103,720 cow-days. Cows were divided into two overall fetching groups: appeared on the fetch list at least once (EverFetch; n = 421) and never appeared on the fetch list (NeverFetch; n = 107). The cows were also divided into two groups based on ever experienced an event (EverEvent; n = 449) and never experienced an event (NeverEvent; n = 79). Three fetch status categories were also created: Yes (on fetch list and fetched), No (on fetch list and not fetched), and NA (not on list).

The events were divided into five different groups by cow by day. The first category was no events occurred (NE; n = 102,218). The second category was reproduction events (RE; n = 602) including abortions, breeding, synchronization, and estimated breeding date. The third category was general health (GE; n = 152) issues including abscesses, digit issues, foot rot, general lameness, warts, retained placenta, ketosis, subclinical ketosis, left displaced abomasum, metritis, and milk fever, respiratory issues, mastitis, and general sickness. The fourth category was scheduled health intervention (SE; n = 503) included vaccinations, veterinary checks, and hoof trimming. The final category was other (ME; n = 2) which was composed of miscellaneous events. Days in milk ranged from early (≤ 100 DIM; n = 222) to post (> 100 DIM; n = 305).

The frequency procedure with a χ^2 of SAS 9.4 (SAS Inst. Inc., Cary, NC) was used to determine significance between the categorical variables (parity, events, day of the week, and system) across FetchStatus (EverFetched and NeverFetched) and EventStatus (EverEvent and NeverEvent). The GLIMMIX procedure with an odds ratio output of SAS 9.4 was used to determine significance ($P \leq 0.05$) of categorical variables against FetchStatus. EverFetch and NeverFetch were compared against breed, parity, days in milk, events, weekday vs. weekend, milk production, and system (PCDART or DairyComp). Milk production was reported as the average milk production of an individual cow over a 150-day period. The GLIMMIX procedure with an odds ratio output of SAS 9.4 was used to compare fetch outcome (yes, no, and NA) against breed, parity, days in milk, events, weekday vs. weekend, milk production, and system.

Table 1: Descriptive data for a commercial herd utilizing automated milking systems from October 1, 2021 to May 10, 2022.

	Total of cows	Percentage (%)
Bred		
HO[1]	522	98.86
XX[1]	6	1.14
Parity		
1st lactation[2]	60	11.39
2nd lactation[2]	218	41.37
3+ lactation[2]	249	47.25
DIM		
Early[3]	222	42.13
Post[3]	305	57.87

[1]Holstein (HO) and Cross-bred (XX)
[2]1st lactation, 2nd lactation, and 3+ lactation
[3]Early (≤ 100 days in milk) and post (> 100 days in milk)

Results and discussion

This study was conducted on 528 commercial cows including Holstein (HO; n = 522) and cross-bred (XX; n = 6) cows. Cows were 1st (n = 60), 2nd (n = 218), or 3+ lactations; n = 249). Days in milk (DIM) ranged from early (≤ 100 days; n = 222) to post (> 100 days; n = 305). While 80% of cows in the herd were on the fetch list at some point during study, 5% ± 3% of the herd appeared on the fetch list on a given day. Of that 5% ± 3%, only 4% were fetched by the farmer. These result differed from Rodenburg and House (2007) which found a mean of 19% of the herd was fetched by the farmer. However, our results agreed with Tse et al. (2018) who found 4% of the herd was fetched daily. Eighty-five percent had at least one event during the study. By cow-day, the herd had events 1% of the time during the study.

No event, reproduction, general health events, schceduled health events, and other event groups compared fetch list outcomes (Yes, No, NA) were significantly different ($P < 0.0001$; Table 2). Approximately 99% of cows did not experience an event during the project. Fetched cows experienced reproduction (n = 32), general health (n = 22), and scheduled intervention (n = 33) events on the corresponding cow-day of fetching ≤ 2% of the time. The majority of observations came from cows that had no event (Yes = 98.1%, No = 97.8%, and NA = 98.8%) while the least number of observations came from the other event categories (Yes = 0.0%, No = 0.0%, and NA = 0.0%).

Table 2: Events compared to fetch list status.

	Yes[1]	No[1]	NA[1]
	Observations (# (%))	Observations (# (%))	Observations (# (%))
No event	4,532 (98.1%)	945 (97.8%)	96,741 (98.8%)
Reproduction[2]	32 (0.7%)	12 (1.2%)	558 (0.6%)
General health[3]	22 (0.5%)	4 (0.4%)	126 (0.1%)
Scheduled health[4]	33 (0.7%)	5 (0.5%)	465 (0.5%)
Other[5]	1 (0.0%)	0 (0.0%)	1 (0.0%)

[1]Yes = cows on the list and fetched; No = cows on the list and not fetched; NA = cows not on the list and not fetched.
[2]The reproduction (n = 602) category included abortions, breeding, synchronization, and estimated breeding date.
[3]The general health (n = 152) event included abscesses, digit issues, foot rot, lameness, warts, retained placenta, ketosis, displaced abomasum, metritis, milk fever, respiratory issues, mastitis, and general sickness.
[4]The scheduled health category (n = 503) included vaccinations, veterinary checks, and hoof trimming.
[5]The other category (n = 2) included general miscellaneous events.

The frequency procedure of SAS 9.4 with a χ^2 was performed to compare the categorical variables EverFetch and EverEvent by cow (Table 3). A significant *P*-value ($P < 0.0001$) was found. Eighty-five percent of cows had at least one health event during the study. Eighty percent of the cows showed up on the fetch list at least once during the study. The majority of observations came from cows that appeared in the EverFetch and Yes event categories (93.35%) while the least number of observations came from the EverFetch and No event categories (6.68%).

Table 3: Cow numbers regarding fetch list and health status.

	EverFetch[1]	NeverFetch[1]
	Observations (# (%))	Observations (# (%))
Yes event[2]	393 (93.35%)	56 (52.34%)
No event[2]	28 (6.68%)	51 (47.66)

[1]EverFetch = cow appeared on fetch list at least once during the; NeverFetch = cow did not appear on fetch list at least once during the study.
[2]Yes event = cow experienced a health event during the study; No event = cow did not experience a health event during the study.

The GLIMMIX procedure of SAS 9.4 was used to compare EverFetch and NeverFetch against breed, parity, days in milk, events, day of week, milk production, and system (Table 4). Significance was not found in breed, days in milk, and milk production. However, 1st lactation cows appeared on the fetch list more often than 3+ lactation cows (odds ratio (OR), confidence interval (CI) = 2.05, 1.2 to 3.4; P = 0.02). This could have been because 1st lactation cows were new to milkings as well as the AMS. The only event groups to show a *P*-value < 0.05 was general health referenced with no event (OR, CI = 3.76, 2.2 to 6.4; P < 0.01) and other event referenced to no event (OR, CI = 17.21, 1.9 to 154.87; P < 0.01). Cows who experienced illness appeared on the fetch list more often than those who did not experience an illness event. Because illness often occurs with changes in behavior, this could have decreased cattle movement and willingness to visit the AMS similar to Rodenburg and House (2007). Cows appeared more on the fetch list on weekdays when compared to weekends. This could have been due to more going on in the barns that took cows away from the AMS systems. Cows also significantly appeared more on the fetch list using the PCDART system than the DairyComp records. This could have been confounded with the longer period of time cows were managed under PCDART compared to DairyComp.

Table 4: Odds ratios and 95% confidence intervals for parity, events, weekday, and system based on EverFetch and NeverFetch.

Categorization and risk factor	Reference Group	Odds Ratio (OR)	95% CI[1] (OR)	*P*-Value
EverFetch vs NeverFetch				
1st lactation[2]	3+ lactation[2]	2.05	1.24 to 3.38	P = 0.02
General health[3]	No event[3]	3.76	2.21 to 6.39	P < 0.01
Other[3]	No event[3]	17.21	1.91 to 154.87	*P* < 0.01
Weekday[4]	Weekend[4]	1.06	1.00 to 1.12	P = 0.04
PCDART[5]	DairyComp[5]	1.27	1.06 to 1.52	*P* = 0.01

[1]Confidence intervals (CI) overlapping the null value (OR = 1) were not reported.
[2]The parity category grouped lactations into 1st lactation, 2nd lactation, and 3+ lactation.
[3]Events were divided into no events (n = 102,218), reproduction events (n = 602), general health events (n = 152), scheduled health events (n = 503), and other events (n = 2).
[4]WE was grouped as weekend (Saturday and Sunday) and WD as weekday (Monday, Tuesday, Wednesday, Thursday, and Friday).
[5]The system was grouped into the old (PCDART) and new (DairyComp).

The GLIMMIX procedure of SAS 9.4 was used to compare fetch status (yes, no, and AF) against breed, parity, days in milk, events, day of week, milk production, and system (Table 5). Breed, days in milk, day of week, and milk production did not significantly impact fetch status. First lactation cows appeared more on the fetch list and were retrieved when compared to 2nd lactation and 3+ lactation cows (*P* = 0.01, respectively). This could be due to 1st lactation cows being new to milkings as well as the AMS. Cows that experience a general health and other event were more likely to be on the fetch list and retrieved than no event (*P* = 0.01, respectively). Reproduction and other significantly appeared more on the fetch list without being retrieved when compared to no events. Cows retrieved for events showed up more on the fetch list because (1) the cow was at the event that lasted long enough for the system to flag it or (2) the event disrupted the cow's normal routine and caused them to not enter the AMS. Cows appeared more on the fetch list without being retrieved on PCDART when compared to DairyComp (P < 0.01). This could be due to the increased time spent using PCDART during the project.

Table 5: Odds ratios and 95% confidence intervals for parity, events and systems based on fetch status.

	Categorization and risk factor	Reference Group	Odds Ratio (OR)	95% CI[1] (OR)	*P*-Value
Yes vs No vs NA					
Yes	1st lactation[2]	2nd lactation[2]	1.69	1.01 to 2.83	P = 0.01
Yes	1st lactation[2]	3+ lactation[2]	2.109	1.26 to 3.54	P = 0.01
No	Reproduction[3]	No event[3]	2.08	1.16 to 3.75	P < 0.01
Yes	General health[3]	No event[3]	4.04	2.27 to 7.17	P < 0.01
No	Other[3]	No event[3]	0.0001	< 0.001 to 0.008	P < 0.01
Yes	Other[3]	No event[3]	21.26	2.65 to 170.736	P < 0.01
No	PCART[4]	DairyComp[4]	1.96	1.57 to 2.45	P < 0.01

[1]Confidence interval overlapping the null value (OR = 1) were not reported.
[2]The parity category grouped lactations into 1st lactation, 2nd lactation, and 3+ lactation. Parity was not significant amongst 2nd lactation and 3+ lactation.
[3]Events were divided into no events (n = 102,218), reproduction events (n = 602), general health events (n = 152), scheduled health events (n = 503), and other events (n = 2).
[4]The system was grouped into the old (PCDART) and new (DairyComp).

Conclusions

Management decisions and general health issues (illnesses) increased the likelihood of cows being fetched. Demographics or cow-based variables like breed and days in milk had no impact on fetch cow status. However, parity impacted fetch cow status when comparing early (≤ 100 days in milk) to post (> 100 days in milk). Health events also impacted with fetch cow status like we hypothesized. Cows who experienced an event were more likely to show up on the fetch list. Days of the week and milk production also did not show significance with fetch cow status. This research will continue analyzing factors that affected a fetch cow in hopes that a linear model can be made to determine a cow's fetch status before entering the AMS. Limitations of this study included access to only one commercial robotic farm. This came with challenges like duplicate identification or missing data from farm records. The switch from PCDART and DairyComp also complicated cow and data tracking.

Future research

This was a sub-set of our project data. Future analyses will incorporate data from the robots to confirm the current state of the project, to add more variables and statistical outcomes, and to provide more information for current and prospective automatic milking producers.

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References

Bergman, K., and Rabinowicz, E. (2013) Adoption of the automatic milking system by swedish milk producers. *AgriFoods Economics Centre* 7.

Kimpel, S. (2016) Precision dairy technology on the way – and how it can really break through. *Precision Dairy Farming*, 89-93.

De Koning, C. (2010) Automatic milking–common practice on dairy farms. In: *The First North American Conference on Precision Dairy Management 2010*, Toronto, Ontario, USA.
Life, L. (2020) The first robotic milking dairy in the United States: Knigge farms. Lelylife. *https://www.lelylife.com/knigge-farms.*
Rodenburg, J. (2017) Robotic milking: Technology, farm design, and effects on work flow. *Journal of Dairy Science* 100(9), 7729-7738.
Rodenburg, J., and House, H.K. (2007) Field observations on barn layout and design for robotic milking. In: *Sixth International Dairy Housing Conference Proceeding*, Minneapolis, Minnesota, USA, 16-18.
Tse, C., Barkema, H.W., DeVries, T.J., Rushen, J., Vasseur, E., and Pajor, E.A. (2018) Producer experience with transitioning to automatic milking: Cow training, challenges, and effect on quality of life. *Journal of Dairy Science* 101(10), 9599-9607.