Feeding and Management Practices for Robotic Milking Success

Jim Salfer[1] and Marcia Endres[2]
University of Minnesota
[1]St. Cloud, MN 56301
[2]St. Paul, MN 55108
salfe001@umn.edu, miendres@umn.edu

Introduction

Dairy producers install robotic milking system (RMS) for a variety of reasons, but surveys have shown that one of most common reasons relates to labor (flexibility maybe more than labor cost) and lifestyle or quality of life. de Jong et al. (2003) conducted a survey of North American dairy producers who had implemented RMS. They reported that for many smaller farms, using RMS improved flexibility of their schedule and reduced the physical intensity of labor, which was primarily provided by the family owning the farm. In fact, 84% of the producers surveyed mentioned having a more flexible work schedule as a reason for making the decision to install RMS. However, producers did not report a reduction in hours of work on the farm but they did have a reduction in physical labor, and decreased cost of hired labor was reported by 70% of farms. We found similar results in our survey of RMS dairy farms in Minnesota and Wisconsin. For larger farms, the challenge to find, train and retain high quality milking labor is causing them to consider RMS. RMS may also improve quality of life for the employees they hire. Larger farms are adopting RMS. These include TDI Farms in Michigan with 24 DeLaval (Tumba, Sweden) VMS units and Chilean Dairy, Fundo El Risquillo, milking 4,500 cows with 64 DeLaval VMS units (delaval.com). Other examples include Hemdale Farms in New York with 19 Lely (Maassluis, Netherlands) RMS and Corner's Pride in British Columbia with 30 Lely RMS (Lely.com). We are also beginning to see fully automated rotary robots installed in the upper Midwest.

One of the most important factors for success in RMS is how cows are fed. When we feed dairy cows, we aim to develop a low cost diet that meets the nutritional requirements of cows while optimizing milk production and cow health. In most conventional confinement herds, we accomplished this by feeding a totally mixed ration (TMR) where all ingredients are mixed together and delivered to the cows. For box RMS herds, a partial mixed ration (PMR) containing all the forage and some of the concentrate is offered in the feed bunk. Additional concentrate is fed through the RMS milking station. This amount is determined by the management and varies according to the cow's stage of lactation, lactation number and milk production. This appears on the surface to be a simple concept, but achieving the optimal combination of nutrients from the PMR and the concentrate pellet is not necessarily an easy task and it takes some trial and error in some instances.

Enticing Cows to Visit the Milking Station

Prescott et al. (1998) demonstrated that a palatable feed offered in the RMS milking station is the main motivating factor for cows to visit the RMS. The interaction between cow behavior, activity, feed consumption, health and milk production is complicated (Rodenburg, 2011). Cow's attendance to the milking station is not only dependent on the PMR delivered in the feed bunk and concentrate pellets offered in the RMS, but also on feeding management, cow comfort, cow health, and social interactions among cows. A poor performing RMS can cause frustration for both the farmer and their nutritionist.

We asked nutritionists to rank five feeding factors they thought were keys to RMS feeding success: PMR energy content, PMR starch content, consistent mixing of the PMR, consistent delivery and push-up of PMR, and palatability of the pellet. Nutritionists working with these dairies indicated that palatability of the pellet and consistent PMR mixing were the two biggest feeding factors contributing to RMS success. These results agree with comments made by dairy producers on our visits and existing research. Rodenburg and Wheeler (2002) showed that in a free flow RMS, feeding a high quality pellet (hard pellet with few fines made from palatable ingredients) increased the number of voluntary milkings from 1.7 to 2.1/cow per day compared with feeding a low quality pellet. We observed that at start-up of a new RMS, nutritionists and farmers focused on developing a pellet formula that encouraged milking station visits. Once they had a pellet that worked

well, other factors became more important. Many producers commented that even minor changes in the PMR moisture, consistency of the mix (i.e., long hay that is difficult to process to a consistent length), and changes in forage quality affected visits. Visits may drop if forage moisture changes and rations are not adjusted promptly. The drop in visits will result in a decrease in milk production and an increase in the number of fetch cows. The increase in fetch cows may disrupt other cow behaviors, resulting in even greater decreases in visits and milk production, leading to a downward spiral that creates much frustration for the producer. These complicated interactions between feeding management, voluntary visits and milk production can be challenging.

Guided Flow Versus Free Flow

Free flow cow traffic (cows have unrestricted access to the feeding area, resting area, and AMS unit) was associated with greater milk yield per cow per day (Tremblay et al., 2016) compared to guided flow (cows must visit areas of the barn in sequence, such as from resting area to the AMS unit to the feeding area, using a combination of pre-selection and one-way gates); their study included only Lely RMS farms. On another study, guided flow was associated with increased number of milkings per day and reduced number of cows being overdue for milking and needing to be fetched (Bach et al., 2009).

There are two types of guided flow traffic - milk first and feed first. In the milk first system, cows leaving the resting area must pass through a pre-selection gate that determines if she is eligible for milking. If she meets the requirement to be milked she is guided to a commitment pen that contains the RMS unit. If she is not eligible for milking she is allowed to enter the feeding area and can only enter the resting area through a one-way gate. In the feed first system, cow traffic is the reversal of the milk first system. After eating the PMR, cows enter a selection gate that determines if she is eligible for milking. The gate either guides her to the commitment pen for milking or to the resting area.

Farmer comments and our observations indicate that the milk first system is superior with the US style of dairying where economics demand high production. Our observation is that in feed first systems cows fill up on PMR and tend to stand in the feed alley or commitment pen chewing their cud without entering the selection gate or visiting the RMS. Feed first systems work best in farms where the PMR is very low in energy and there is a drive for cows to consume the concentrate in the milking station (Rodriguez, 2013).

Free flow feeding strategies

Our survey indicated that amount of pellets offered through the milking station averaged 11.2 lbs/cow per day and ranged from 2 to 25 lbs/cow per day. In free flow herds the PMR was balanced for milk production levels of 10 to 30 lbs less than the herd's bulk tank average production.

Lead feeding is generally used in early lactation. To 14 to 28 days in milk, cows are fed for 75 to 90 lb/day of milk. From 14 to 28 days in milk through peak lactation, cows continue to be fed nutrients that support 75 to 90 lb/day of milk or for actual milk production, whichever is higher. After this time, the feed delivery changes to feed cows for actual milk production and regaining body condition. Some farms with very high producing late lactation cows close to dry-off develop a feed table for late lactation cows that decreases RMS station feed so cows drop in production before dry off. One challenge of free flow systems is that late lactation cows can become fetch cows. A field survey in 2002 showed that as energy of the PMR increased, the number of late lactation fetch cows increased (Figure 1). The key to preventing this is to have an excellent reproductive program that maintains high milk production through the end of lactation.

Guided flow systems

Feed first and milk first guided flow RMS employ different feeding strategies. Feed first systems use a feeding strategy that is very similar to free flow milking systems and will not be discussed further.

Our survey indicated that dairy producers using a milk first guided flow system have a different feeding philosophy than free flow. The amount of feed offered in the milking station is minimal and only used to entice cows to attend the milking station. A higher percentage of the cow's feed intake is delivered through the PMR. One main reason farmers install guided flow RMS is the desire to feed less of the more expensive pelleted feed in the milking station. Farmers with milk first guided flow systems were feeding from 2 to 12 lb of pellets/cow per day. The average amount fed across all herds was approximately 8 lb/cow per day. Commonly, 1.3 to 3 lb of pellets was fed at every milking visit. Because earlier lactation, higher producing cows are guided to the milking station more frequently, they receive more RMS pelleted concentrate.

Research on guided flow systems consistently show a decrease in the number of cows that require fetching. Older research shows that that the number of

daily PMR meal events are lower in guided flow (6.6) compared to free flow (10.1) systems (Bach, 2009). However, observations from 18 more recently designed guided flow systems indicate they are able to achieve high numbers of gate passes (9.3) from the resting area to the feeding area (Peissig, personal communication)

The PMR in guided flow systems included in our survey tended to be slightly higher in energy (0.015 Mcal/b) and lower in NDF (2.1%) than the PMR in free flow systems. For guided flow herds the PMR was balanced for 9 to 20 lbs less than the average of the herd. This difference should probably be expected between the two systems. High energy density of the PMR in free flow barns may lead to decreased milking, whereas in guided flow systems selection gates help guide cows to the RMS.

Other Feeding Considerations

Pellet composition and feeding

Pellets that are made from high quality, palatable ingredients and with a very hard sheer force promote increased visits and more rapid feed consumption. Milking station pellets should be designed to complement the farms' forages and other ingredients in the PMR. For example, if the PMR is high in corn silage and thus high in starch, a pellet with highly digestible NDF from by-products should be considered to minimize the risk of sub-acute ruminal acidosis.

Halachmi et al. (2006) found that both pellets high in starch (high inclusion of ground barley, corn, sorghum, and wheat bran) and pellets high in digestible neutral detergent fiber (high inclusion of soy hulls, corn gluten feed, and soybean meal) could be used successfully to attract cows to the RMS. The two pellets resulted in similar daily milk visits, milk yield, and fat-corrected milk yield. However, concentrate allowance was kept low. Miron et al. (2004) reported a difference in milk components with a higher concentrate allowance - concentrates high in starch resulted in greater milk protein percent whereas concentrates high in digestible fiber resulted in greater milk fat percent. However, results of these studies may indicate that palatability can be maintained even when significant changes are made to the ingredient composition of the pelleted concentrate.

However, it does not appear that offering more concentrate will necessarily increase visits to the milking station. An observational study (Bach et al., 2007) showed that increasing the amount of pellets offered in the milking station from 6.6 lbs/cow per day to 17.6 lbs/cow per day increased the frequency of visits from 2.4 to 2.7 milkings per day for cows not being fetched. However, increasing the feed offered in the milking station did not decrease the number of fetch cows. Something other than the amount of concentrate offered such as lameness, or fear was affecting the number of fetch cows. Bach (2007) also showed that for every 1 lb increase in robot pellet consumed, the PMR intake decreased by 1.14 lbs. More recent research in a guided flow system showed dry matter intake averaged 5.9 lbs lower for cows fed 11 lbs of robot feed compared to 1.1 lbs (Hare et al, 2018).

Precision feeding

One potential advantage of RMS is the opportunity to feed each cow closer to her nutrient requirements by providing nutrients through a combination of the PMR and milking station pellet. Even though RMS allow for feeding more than one concentrate feed in the milking station, many producers in our survey only used one feed. Our observations indicate that producers are more recently using more than one feed to better target cows' nutrient requirements. Feeding a combination of concentrates in the milking station at different proportions and amounts according to milk yield, body weight, stage of lactation, and potentially milk components may maximize returns from RMS (Bach and Cabrera, 2017). These authors suggested that concentrate meal sizes should be limited to about 3 lb or less per visit so that cows consume all the feed that is allocated to them at each visit (Bach and Cabrera, 2017).

There are other benefits of precision feeding. Feeding cows more closely to their nutrient requirement will result in a more consistent body condition. High producing cows are fed the higher energy that they need to sustain high production while not overfeeding late lactation cows.

PMR automated feeding systems

Several manufacturers are promoting PMR automated feeding systems and speculate they will improve performance of the RMS. Belle et al. (2012) compared 20 free flow RMS, nine feeding the PMR with a conventional mixer and 11 using an automated PMR feeding system. There was no difference in number of milkings per cow (2.6 each). Refused visits to the RMS were 20.8% higher for the automated feeding barns (2.5 vs 2.0). Although this was not statistically different because of the large variation between farms, the authors suggested this meant that t the automated feeding stimulated higher cow activity. No milk production data were reported. However, more research is needed, especially in a US farming context.

Fresh cow management

Most RMS facilities do not have a separate fresh/early lactation group. Suggestions to consider that may increase the likelihood that all cows have a successful transition and high production include:

1. Use of multiple feeds through the milking station which allows the producer to use feed additives specifically targeted to fresh cows. As mentioned earlier, this will allow more precise targeting of nutrients to meet the cow's needs.
2. Special observation and monitoring of fresh cows. Fresh cows that are not feeling well may continue to consume all the milking station pellet but decrease intake of the PMR. This can potentially lead to sub-acute rumen acidosis, digestive upsets, and increase the risk for other diseases.
3. Rumination and activity on all fresh cows should be observed daily. The RMS software (depending on the system) creates a daily list of cows that are not meeting rumination and activity goals compared to herd mates. If these metrics are deteriorating, producers need to intervene rapidly and consider making adjustments to the milking station feed offered.
4. It is important to have a high quality PMR to encourage intake at the feed bunk.
5. Achieving frequent visits by cows in early lactation should be a priority. Research in conventional systems has shown that high milking frequency in early lactation increases milk production throughout lactation.

   Our research from 32 free flow showed that multiparous cows milking frequency increased rapidly after calving and averaged over three visits per cow per day by the second week in lactation. However, primiparous cows milking frequencies increased much more slowly, did not reach 2.5 visits until the third week of lactation, and did not peak until 4 to 5 months after calving (Figure 2). Farmers that design systems that allow them to pre-train heifers to the robot before calving report that milking frequencies in early lactation are higher and the number of days to train heifers to visit on their own is decreased.

Feeding consistency

Cows in all systems like consistency. This is even more important in a RMS. Farms that achieve consistently high production have the following attributes:

1. Consistent PMR dry matter
2. Consistent mixing and delivery of the PMR
3. Consistent feed push ups
4. Consistent and frequent cow fetching
5. Consistently high visits by fresh cows
6. Highly palatable PMR
7. Highly palatable, consistent, high quality, milking station feed

Factors affecting RMS productivity

Milk production per robot is one factor affecting profitability of RMS systems. Our research on 32 farms with free flow systems showed that herds using automatic feed pushers had higher milk production per robot (4581 lbs) as compared to herds that did manual feed push-ups (4178 lbs) (Siewert et al, 2018). Factors associated with increased milk per robot included average robot milkings day, milking speed, cows per robot and the amount of robot feed offered. Factors associated with lower milk per robot included higher residual feed and the number of failed and refused visits to the robot (Siewert et al., 2018). Residual feed is the concentrate feed/cow programmed by the feed tables but not offered because the total time in the milking stall was less than the time required to feed this amount at the preset feed delivery rate.

Similar to milk per robot, factors associated with more daily milk per cow included higher successful milking visits per cow per day, faster milking speed and increased robot feed offered. Lower milk production per cow was associated with higher residual feed, failed visits and refused visits per cow (Siewert et al., 2018).

Feed Cost

One concern is that feed cost will be higher with RMS compared to conventional milking systems because of the pellets fed through the milking station. Matt Haan (2017) recently compared the feed costs of 8 RMS farms with 46 conventional farms (Figure 3). Feed cost was very similar between the two systems. University of Minnesota Finbin data (2017) comparing RMS farms to conventional farms show similar results with average feed cost per day of $6.00 for RMS and $6.35 for conventional herds and feed cost per cwt of $8.83 for RMS and $9.79 for conventional.

Conclusions

The rapid growth on the number of farms using RMS in the US is expected to continue. The complexity of balancing the ration in the PMR and feed offered in the milking station can be a challenging task for nutritionists. Based on research, nutritionist surveys and farmer comments, the most important factors affecting feeding success include a high quality,

palatable pellet and excellent feeding management. Research shows that feeding pellets are better than a meal and that a very hard pellet made from highly palatable ingredients will minimize fetch cows. Focus on maximizing visits and health of early lactation cows. It is important to work with herd managers to educate them on the importance of feed management and to balance energy in the PMR with pellets fed through the milking station to optimize visits and minimize the number of fetch cows.

Acknowledgements

We would like to thank the RMS specialists from Lely and DeLaval and their local dealers for their valuable input and help with RMS data collection. A special thanks to all of the cooperating nutritionists for sharing information with us and the many RMS users that allowed us to visit their farms and collect data and provided their valuable insight into their successes and challenges.

References

Bach, A. and V. Cabrera. 2017. Robotic milking: Feeding strategies and economic returns. J. Dairy Sci. 100:in press.

Bach, A., M. Devant, C. Iglesias, and A. Ferret. 2009. Forced traffic automatic milking systems effectively reduces the need to get cows, but alters eating behaviour and does not improve milk yield of dairy cattle. J. Dairy Sci. 92:1272-1280.

Bach, A., C. Iglesias, S. Calsamiglia, and M. Devant. 2007. Effect of amount of concentrate offered in automatic milking systems on milking frequency, feeding behavior, and milk production of dairy cattle consuming high amounts of corn silage. J. Dairy Sci. 90:5049-5055

Belle, Z., G. Andre, and J. C. A. M. Pompe. 2012. Effect of automatic feeding of total mixed rations on the diurnal visiting pattern of dairy cows to an automatic milking system. Biosystems Engineering. pp. 33-39

Finbin. 2017. Livestock: dairy summary report. Accessed July 31, 2017. https://finbin.umn.edu

de Jong, W., A. Finnema, and D. J. Reinemann. 2003. Survey of management practices of farms using automatic milking systems in North America. ASAE Annual International Meeting Technical Paper No. 033018.

Haan, M. 2017. Feeding in robotic milking systems. http://extension.psu.edu/animals/dairy/news/2017/feeding-in-robotic-milking-systems

Halachmi, I., E. Shoshani, R. Solomon, E. Maltz, and J Miron. 2009. Feeding soyhulls to high-yielding dairy cows increased milk production, but not milking frequency, in an automatic milking system. J. Dairy Sci. 92:2317-2325.

Hare, K., T. J. DeVries, K. S. Schwartkopf-Genswein, and G. B. Penner. 2018. Does the location of concentrate profision affect voluntary visits, and milk and milk component yield for cows in an automated milking system? Can. J. Anim. Sci. In press – downloaded 05-01-2018.

Harms, J., G. Wendl and H. Schön, 2002. Influence of cow traffic on milking and animal behaviour in a robotic milking system. Proc First North Amer. Conf. on Robotic Milking. pp 8–14.

Miron, J., M. Nikbachat, A. Zenou, and D. Ben-Ghedalia. 2004. Lactation performance and feeding behavior of dairy cows supplemented via automatic feeders with soy hulls or barley based pellets. J. Dairy Sci. 87:3808-3815.

Prescott, N. B., T. T. Mottram, and A. J. F. Webster. 1998. Relative motivations of dairy cows to be milked or fed in a Y-maze and an automatic milking system. App. Animal Behaviour Sci. 57:23-33.

Rodenburg, J., 2011. Designing feeding systems for robotic milking. Proc Tri-State Dairy Nutrition Conference. pp. 127-136.

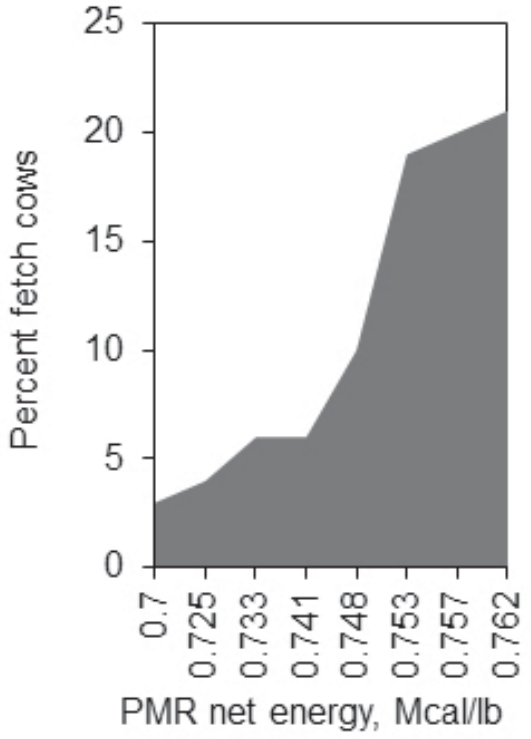
Rodenburg, J., and B. Wheeler. 2002. Strategies for incorporating robotic milking into North American herd management. Proc. First North Amer Conf on Robotic Milking. pp. 18-32

Rodriguez, F. 2013. DeLaval VMS Specialist. Personal communication.

Siewert, J. M., J. A. Salfer, and M. I. Endres. 2018. Factors associated with productivity on automatic milking system dairy farms in the Upper Midwest United States. J. Dairy Sci: 101 (accepted).

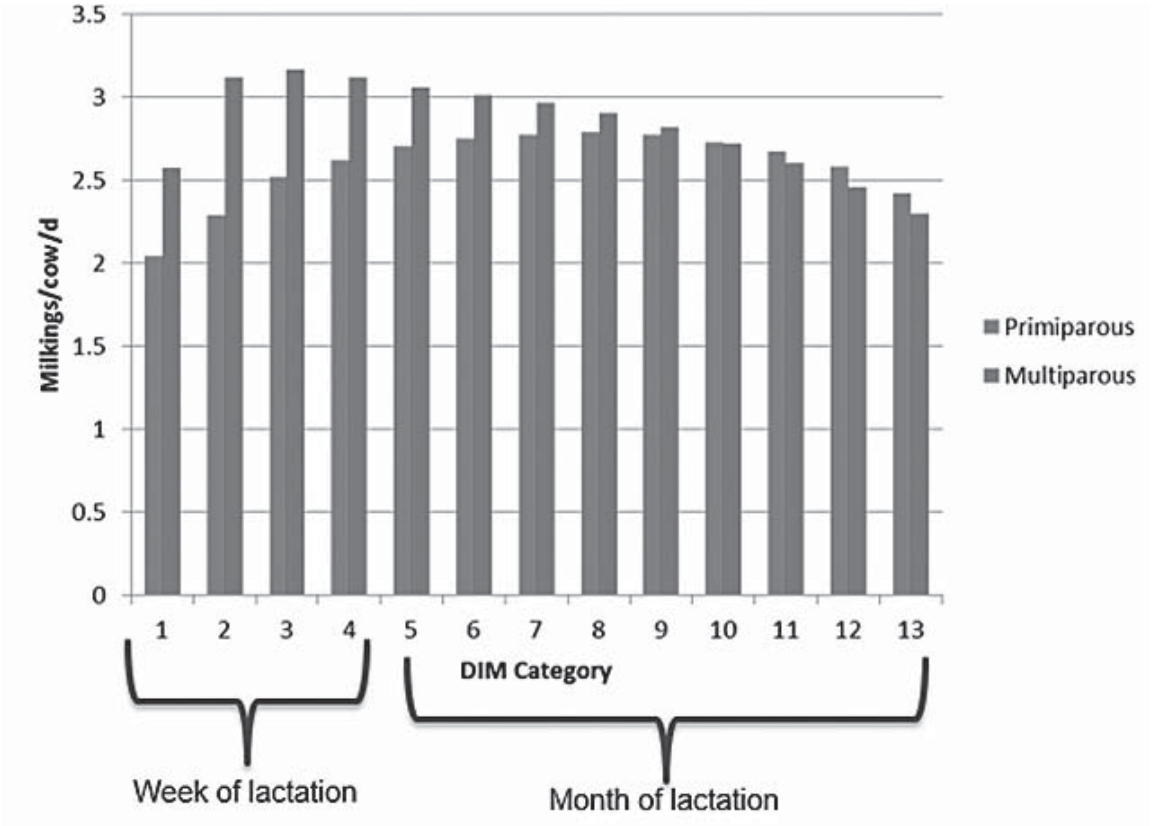
Tremblay, M., J. P. Hess, B. M. Christenson, K.K. McIntyre, B. Smink, A. J. an der Kamp, L. G. de Jong, and D. Döpfer. 2016. Factors associated with increased milk production for automatic milking systems. J. Dairy Sci. 99:3824-3837.

Figure 1. Percent of fetch cows vs. PMR net energy content[1]



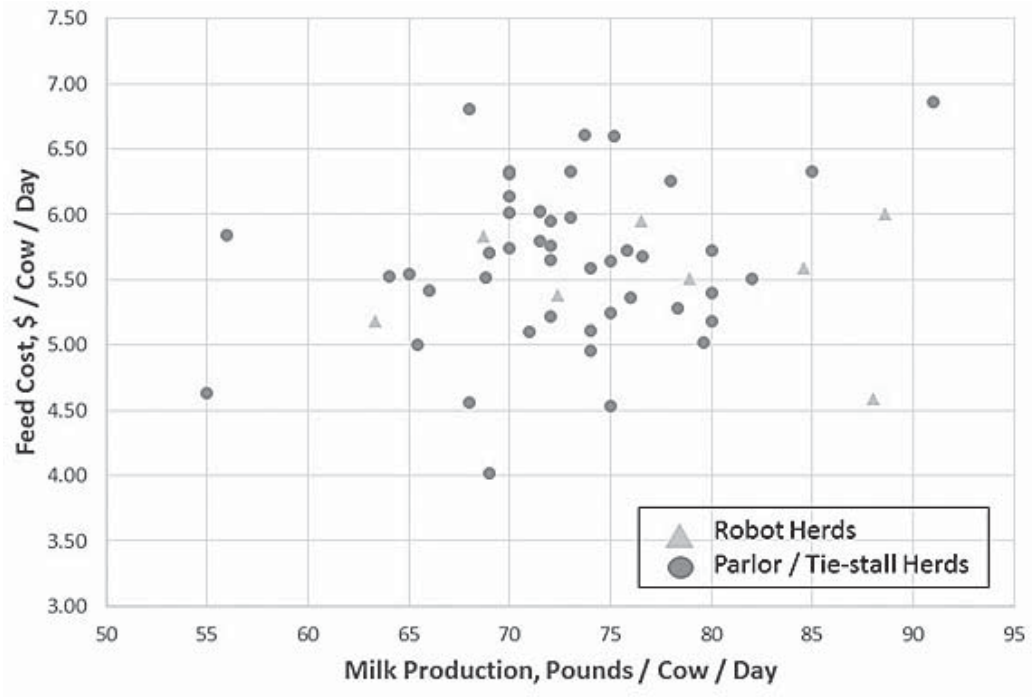
[1]Rodenburg and Wheeler, 2002

Figure 2. Milking frequency of box RMS cows by stage of lacation[1].



[1]Siewert et al., unpublished results.

Figure 3. Comparison of feed cost between RMS and conventional herds[1]



[1]Haan, 2017