Pasture and Automatic Milking

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Abstract

In automatic milking (AM) systems, cows go to visit the milking unit, a robot, by themselves to get milked. Combining pasture with AM can be problematic. High quality grass and longer distances to the robot are factors that can make the cows less motivated to visit the milking unit. This can cause losses in production and extra work for personnel, who might need to fetch cows to the robot. An increased degree of synchronization in cows' behavior can cause periods in the day during which the robot is barely visited and periods where the cows have to spend considerable time waiting to be milked. Some useful methods to make the most of pasture in AM are; give good feed indoors at regular times, limit distance to pasture, strip grazing, limit pasture allowance to daytime and only give recently milked cows access to pasture. Fetching cows should be minimized so that they do not get used to it. Offering water in the pasture might increase the need of fetchings but could, on the other hand, increase the cows' welfare. Many farmers and experimental results have shown that it is possible to combine pasture and AM successfully.

Sammanfattning

Automatisk mjölkning (AM) innebär att korna själva söker upp mjölkningsenheten, en robot, för att bli mjölkade. Att kombinera betesdrift med AM kan innebära problem. Bra beteskvalitet och längre avstånd till roboten är faktorer som kan göra så att korna blir mindre motiverade att besöka mjölkningsenheten. Detta kan orsaka förluster i produktion och extra arbete för djurskötare som kan behöva hämta in korna till roboten. Ökad synkronisering av kornas beteenden kan orsaka perioder på dygnet då roboten knappt blir använd och perioder då köerna till den blir långa. När korna ges tillgång till bete är det upp till bonden att ge systemet rätt förutsättningar för att fungera bra. Några användbara metoder är att; ge kvalitativt foder inomhus vid regelbundna tider, begränsa avståndet till bete, begränsa daglig grästillgång, begränsa betestillgången till dagtid samt endast ge kor som nyligen mjölkats tillgång till bete. Det bör undvikas att hämta in kor så mycket som möjligt för att inte vänja korna vid att bli hämtade. Att erbjuda vatten ute på bete kan öka behovet att hämta in kor men kan å andra sidan öka deras välfärd. Många lantbrukare samt forskningsresultat har visat att betesdrift och AM går att kombinera med bra resultat.

Introduction

Automatic milking (AM) is a relatively new system with the first farm starting up with it in 1992 in The Netherlands (Koning & Rodenburg, 2004). In 1998 the system had spread to other European countries, Japan and North America. At the end of 2003, the system was in use worldwide. The system is meant to free personnel from the time consuming and time fixed work that milking is in other systems. This is done by having a robot to milk the cows without any human interaction. For the system to function, the cows have to go to the robot by own choice. This is usually done by luring them to it with a portion of concentrates as they get milked. In other systems all cows are milked together at fixed times, but in the AM systems the cows are milked one at a time, giving them a chance to be more independent. A cow can choose to get milked when it wishes as long as it happens often enough to keep production at a good level. Klei *et al.* (1997) found that milk yield was about 10 % higher when milking was performed three times per day compared with two milkings/day. Österman & Bertilsson (2003) also found a positive effect on milk yield with three milkings/day compared with two.

If the cows do not come voluntarily to the milking unit and the milking interval becomes too long, personnel have to fetch the cows to the robot. This means that a big advantage of the

system is somewhat lost as it is supposed to free personnel from the milkings. The success of the system thus lies in making the cows visit the milking unit at a high frequency without having to fetch them. An even distribution of visits to the milking unit is also important as an uneven visiting pattern can cause periods of many cows in the waiting area in front of the robot, creating long waiting times to get milked (Spörndly & Wredle, 2002).

When cows are given the opportunity to graze there is a risk that good quality grass, greater distance to the robot, nice resting spots or something else decreases the motivation of cows to visit the robot and access the concentrates. The risk of increased workload and lower milk production could be the answers to why a large proportion of farmers in several European countries limit cows' time on pasture more after having introduced AM (Mathijs, 2004). This is sad, since grazing has positive effects on cow health and welfare (Dooren *et al.*, 2004b). Public also get a more positive picture of farming when they see cows out on the fields.

The purpose of this literature study is to go through the effects pasture has on the AM system, cow health and cow behavior plus how to make the best use of pasture in AM.

Effects of pasture on cow health

Gitau (1996) found that cattle on farms not allowing pasture had 2.9 higher odds of lameness than cattle allowed pasture. Lameness was found for 39 % of all cows that were not allowed pasture and swollen knees on 31 % of the cows. This was compared with 15 % lame cows and 15 % with swollen knees for cows allowed pasture. Knee swellings were thought to be more common in the zero-grazing cows due to a higher pressure on the knees as the cows laid down and rose up. Soft standing areas might counteract the negative effects of zero-grazing. Gait scores for cows were found to be improved by being provided pasture for 4 weeks (Hernandez-Mendo *et al.*, 2007). This effect was greatest for cows with the best initial scores. More comfortable standing and walking surfaces than concrete as well as increased distance to the barn, which forced the cows to exercise more, are possible explanations for the positive effect of pasture. A change in diet might also be a factor for the improvement in gait. Better housing and worse pasture conditions could reduce or reverse the effects of pasture.

At the start of a pasture season, Somers *et al.* (2003) saw no big difference in claw disorders between farms with zero grazing and farms allowing grazing. After a pasture season though, the prevalence of most claw disorders was higher for zero-grazing cows than cows allowed to graze. (A total of nine disorders were looked for, for example heel erosion, digital dermatitis and sole ulcer.)

An investigation on 39 Danish dairy herds showed that cows on pasture had lower odds of being scored as loser cows[1] (Thomsen *et al.*, 2007). The risk of mortality was investigated on 6839 Danish dairy herds and those allowing pasture during the summer were found to have a lower risk of mortality (Thomsen *et al.*, 2006).

Effects of pasture on cow behavior

Cows were found to spend most of their time outdoors and more time eating forage when able to graze (Krohn *et al.*, 1992; Ketelaar-de Lauwere *et al.*, 1999; Ketelaar-de Lauwere *et al.*, 2000). When able to be outdoors, most of their time eating forage and most of their lying

[1] Loser cows were defined as cows with bad health scores considering body condition score, lameness, hock lesions, other cutaneous lesions, vaginal discharge, condition of hair coat and general condition.

down time was spent on the pasture (Ketelaar-de Lauwere *et al.*, 1999; Ketelaar-de Lauwere *et al.*, 2000). Even though there was practically no attractive grass to eat during a large part (January to April) of the winter in Denmark, the cows spent 4.8 hours outdoors each day (Krohn *et al.*, 1992). Irrespective of the weather, the cows preferred to spend a few hours outdoors.

Krohn & Munksgaard (1993) and Hernandez-Mendo *et al.*, (2007) found that cows spent less time lying down and lay down more often when on pasture than when kept indoors. More time needed for searching forage could be a reason for the decreased lying times on pasture (Hernandez-Mendo *et al.*, 2007). Furthermore, the soft freestalls in the barn are designed to encourage the cows to lie down. This might increase lying times in the barn as cows might originally go into the stalls just to avoid standing on concrete. On pasture though, cows are not as hindered from standing on a soft surface. Lack of shade on warm summer days might also have made cows less interested in lying down due to increased risk of thermal stress. Ketelaar-de Lauwere *et al.* (1999) did not find any difference in time lying down when comparing cows allowed pasture with cows not allowed pasture. Cows lay on their side or with their heads resting on the ground or on their shoulder more often when on pasture (Krohn & Munksgaard, 1993; Ketelaar-de Lauwere *et al.*, 1999). According to Merrick & Sharp (1971), this lying posture might be analogous to the deepest sleeping stage in humans.

In a behavior study, heifers spent 11 % of their time on stereotypies in the period before pasture and 25 % in the period after the pasture season (Redbo, 1990). However, no stereotypies were seen during the pasture season.

Effects of pasture on the AM system

Milk yield and milking frequency

From a survey performed on 23 Dutch farms with AM, the values of milk production and composition presented in table 1 were reported. There was a striking difference between the farms with some farms having higher net profit during the pasture season (Dooren *et al.*, 2002).

Table 1. Average farm values of milk yield etc. for housing and pasture period. (After Dooren *et al.*, 2002)

Description	Housing	Pasture
BSK[a] (kg)	42,8	42,4
Fat (%)	4,34	4,14
Protein (%)	3,46	3,42
Net profit[b] (kg)	5096	5090

[a] BSK (Farm Standard Cow Index) is a Dutch calculation of standardized milk yield of cows within farm.
[b] Economic return of the 305-days yields of milk, fat and protein.

Figure 1 shows the short-term effects of allowing pasture. Production rose by an average of 0.7 kg milk/cow per day at the beginning of the pasture period and this effect was largest for farms with fewer cows per robot (Dooren *et al.*, 2002). Milking frequency was 2.9 milkings/day during the housing season compared with 2.7 milkings/day during the pasture season. More cows per robot had a negative impact on milking frequency.

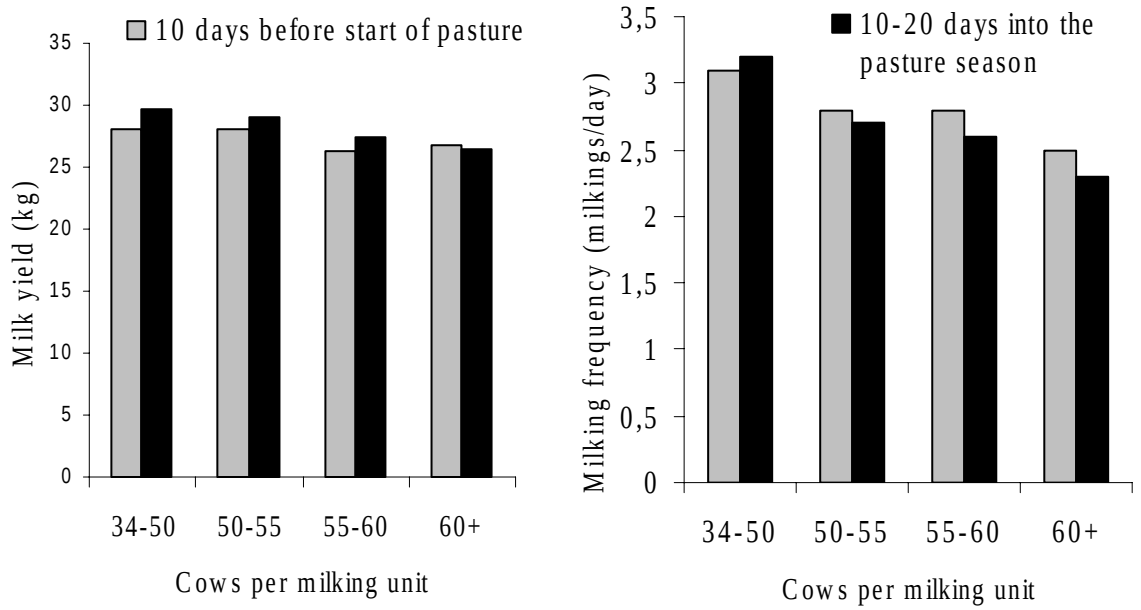

Figure 1. Comparisons of milk yield and milking frequency between the period before start of pasture and beginning of the pasture season depending on number of cows per milking unit. (Adapted from Dooren *et al.*, 2002.)

Difference between pasture and housing period for three Swedish farms considering milking frequencies can be seen in table 2. Average milking frequencies were 2.6-2.7 during the housed period and 2.5-2.6 during the pasture period (Dooren *et al.*, 2002).

Table 2. Difference in milking frequency over the two first pasture seasons after installation of an AM system on three Swedish farms. (Adapted from Dooren *et al.*, 2002)

	Milking frequency compared with the housed period (milkings/day)	
	Pasture season 1	Pasture season 2
Farm 1	Similar	Similar
Farm 2	-0.3	Similar
Farm 3	Similar	-0.3

According to Spörndly & Wredle (2002), a slightly lower milking frequency (0.2-0.3 milkings/day) seems to be adjoined by letting the cows graze. However, a survey among 14 Dutch dairy farmers did not give evidence of a lower AM system capacity when comparing the pasture period with the housing period (Dooren *et al.*, 2004a). Milk production only decreased with 2.5 % and milking frequency only decreased from 2.68 milkings/day to 2.61 milkings/day. Differences between farms were big indicating that factors unknown to the study affects the outcomes of allowing grazing. Good management skills of the farmer are likely to be important for the outcome of allowing pasture.

Synchronization of cow behavior

The behavior of the cows was found to be more synchronized when on pasture than when housed (Krohn *et al.*, 1992; Dooren *et al.*, 2002; Munksgaard & Søndergaard, 2004) and cows rarely left the pasture unaccompanied (Ketelaar-de Lauwere *et al.*, 1999; Dooren *et al.*, 2004b; Munksgaard & Søndergaard, 2004). Cows tended to enter the barn in close succession

when returning from the pasture, which caused peaks in visits to the milking unit and several hours when it was unvisited (Ketelaar-de Lauwere *et al.*, 2000). A low frequency of visits to the milking unit was seen from 08:30 to 11:30 and from 14:30 to 17:30 when they were allowed pasture between 05:30 and 20:30. Dooren *et al.* (2002) noted that fewer cows waited in front of the milking unit the first hours after midnight when cows were allowed pasture (0.5 on average) than during the housing period (1.6 on average). A time at which Spörndly & Wredle (2004) found that a large proportion of the cows were lying out on the pasture if allowed. A peak in lying down was also found at 17:00. Grazing peaks were reached at 09:00-13:00 and at about 21:00 with 30-60 % of the cows grazing. According to Dooren *et al.* (2002), cows spend more time outdoors and grazing in the afternoons and evenings and they are indoors more in the late night to early morning.

It was claimed that uneven visiting patterns create long waiting hours for the cows and a lower milking frequency (Spörndly & Wredle, 2002) and a suboptimal use of the AM system (Ketelaar-de Lauwere *et al.*, 2000). However, Salomonsson (1999) observed an even visiting pattern day and night for cows allowed pasture 24 h daily.

Combining AM and pasture

Fetching cows to the milking unit

The percentage of cows fetched was generally lower if the fetching took place later in the evening, 38 % at 21:00, rather than afternoon, 63 % at 16:00 (Dooren *et al.*, 2002). Fetching the cows at dusk was also fairly effective, as cows tended to return to the barn voluntarily at this time. There was a big difference between the farms considering the percentage of cows that needed fetching. Farmers who applied 24-hour grazing only needed to fetch a few cows in the mornings. According to farmers, training and habituation are important. Activating the cows and giving them time to return to the barn by own will would reduce labor in the long run by decreasing the need for fetching. The AM system was claimed to be optimally used if the cows got used to a daily pattern with no fetching. Table 3 shows the degree of fetchings during pasture and housing seasons for three Swedish farms and how long their respective AM system had been in use. There were between 34 and 42 cows producing milk on the farms.

Table 3. The percentage of milkings that cows were fetched to for three Swedish farms before, during and after the first pasture period after installation of an AM system. (Adapted from Dooren *et al.*, 2002)

	Weeks in use[a]	Housed period before pasture (%)	Transition to pasture (%)	Pasture period (%)	Housed period after pasture (%)
Farm 1	20	7	9	7	8
Farm 2	7	15	25	14	10
Farm 3	3	32	27	23	33

[a] Time since AM was introduced when pasture period began.

On seven Danish farms, more than half of the cows had to be fetched from the pasture on most observation days and 5 to 55 minutes each day was spent fetching cows (Dooren *et al.*, 2004b). A few troublesome cows increased the time spent fetching.

Influencing cow traffic to pasture

The risk of too long milking intervals can be decreased if cows go out to pasture directly after being milked according to Dooren *et al.* (2002). Then they can spend a long time on the pasture before the milking interval becomes too great. The cows move outdoors faster when not placing forage between the milking unit and the barn exit.

A selection gate makes sure that only cows recently milked are allowed pasture and cows due to be milked within a few hours have to stay indoors (Dooren *et al.*, 2002). Regulating access to the pasture was claimed to be good for achieving smooth cow traffic and more dispersed returns to the barn, resulting in more regular milkings. Thus, milking frequency and milking capacity is positively influenced. Of 25 Dutch farms in a survey, all farms with less than 20 % fetchings used an automatic selection gate at the barn exit or by the milking unit. Dooren *et al.* (2002) and Spörndly & Wredle (2002) claimed that the number of cows needed fetching could be reduced by only permitting recently milked cows to go outdoors. The cows also benefited from the selection gate as there was less restlessness in the barn when cows could not go out every now and then (Dooren *et al.*, 2002).

Daily time allowed pasture

In a study by Ketelaar-de Lauwere *et al.* (1999), cows allowed pasture for 24 h (P24) had a milking frequency of 2.3 milkings/day compared to 2.6-2.8 for cows only allowed pasture for 12 h (P12), between 05:30 and 17:30. The difference was caused by the uneven visiting pattern, few visits at night and many in the afternoon, for the P24 cows. The P24 cows are likely to have spent more time on pasture and visited the milking unit less often if they had had a pasture of better quality and a lower, more moderate, ambient temperature. The AM system was found to be more efficiently used when the cows were allowed pasture only at daytime compared with pasture allowance both day and night (Dooren *et al.* 2004b).

According to Dooren *et al.* (2002), cows become gradually accustomed to a more grass-rich diet and longer distances to the milking unit by only giving the cows access to pasture for a short time during the first days of the pasture season.

Grazing system

Forty-seven Dutch farmers answered questions about grazing system and fetchings and the four farmers who applied strip grazing[2] had the lowest number of fetchings indicating that this system is preferable (Dooren *et al.*, 2002). The highest grazing times were also found for strip grazing. Continuous grazing[3] seemed to give less fetchings than rotational grazing[4] while siesta grazing[5] appeared to give the highest amount of fetching.

Sward Height

An increase in milking frequency from 2.6 to 3.0 milkings/day was observed as the sward height decreased in a rotational grazing system with 4 days in each pasture (Ketelaar-de Lauwere *et al.*, 2000). The distribution in visits to the milking unit changed with different sward heights. The percentage of visits was especially low from 08:30-11:30 and 14:30-17:30 during the first days on a new pasture. The cows spent more time on the pasture during the

[2] Strip grazing; the cows get a new area to graze on each day.
[3] Continuous grazing; grazing takes place in one area during the entire pasture season.
[4] Rotational grazing; the cows graze on each pasture for a number of days.
[5] Siesta grazing; grazing is restricted to a number of hours early in the morning and in the evening.

first days, with high sward heights, compared to the last day in each pasture, when the sward heights were lower. Less of their total time eating forage was spent grazing when sward heights were lower but grazing time did not change. There was an indication that cows spent more time at the feeding gate at low sward heights. Similar results were obtained by Dooren *et al.* (2004b).

Falk (2007) found no difference in milk yield when comparing cows on a pasture of low sward height, meant primarily to give the cows exercise rather than feed, (exercise group) with cows on pastures of higher sward heights, where the cows could graze more over the pasture season (pasture group). The cows were given access to pasture 8.5 hours daily. During the first of two periods, when the difference in sward heights was greatest between the treatments, the exercise group had the highest milking frequency. They also ate more silage indoors in the first period compared with the pasture group. Throughout the entire experiment, the exercise group spent more time lying down and ruminating but less time on the pasture and less time grazing.

Salomonsson (1999) saw that the milk yield of cows with pasture as only feed (P) became lower as the sward height decreased compared with cows also allowed feed indoors (P+S). The P cows did not decrease their grazing time and spent 32-33 % of their time grazing during all the eight observation days. During the first four observation days, the P+S cows spent 22 % of the time grazing. However, they spent less time outdoors and only 10 % of the time was spent grazing during the last four observation days. The P+S cows ate more roughage indoors and increased their time spent eating as the sward height decreased. No change in lying down time was seen for either treatment but a tendency for less time ruminating was observed for the P group compared to the P+S group as the sward height decreased.

Dooren *et al.* (2002) reported that if the cows were on the same pasture for a lot more than one day, the percentage of cows needed to be fetched to the robot was higher on the first day than on the following days.

Indoor feeding

Cows without access to feed indoors (P) were found to spend more time outdoors and more time grazing than cows also allowed feed indoors (P+S) (Salomonsson, 1999). Milk yield was higher for the P+S group than the P group. However, there was no difference in milking frequency, lying down time or time ruminating between the two treatments. When the sward height decreased, the P+S cows spent less time grazing, more time indoors, and ate more roughage indoors. Grazing time for the P cows did not change as the sward height decreased.

No difference in milk yield was observed when an indoor ad libitum supplementation of silage was compared with one of 3 kg dry matter silage (Spörndly & Wredle, 2004). The milking frequency was equal for the two treatments in the early season (2.3 milkings/day) but lower for the ad libitum treatment (2.1 versus 2.5) during the latter part. Thus, giving silage ad libitum indoors when a good quality pasture is available seems unfavorable, as neither milk yield nor milking frequency was positively affected.

Dooren *et al.* (2004b) saw no difference in milk yield, milking interval or number of fetched cows between offering 6 kg dry matter silage or 10 kg dry matter silage as supplementary feed in the barn. In one of the two pasture seasons studied, cows with the higher supplementation level spent more time on the pasture. This is thought to be due to the cows

eating most silage in the morning. They then started ruminating earlier in the pasture and did not return to the barn to look for more silage.

Dutch farmers reduced the amount of grass grazed and stimulated their cows to return to the barn by supplying sufficient amounts of good feed in the barn (Dooren *et al.*, 2002). Furthermore, the cows where stimulated to return indoors when they noticed that fresh feed was supplied in the barn. If the feed was supplied at the same time every day the cows learnt to expect it, which can decrease number of cows needed to be fetched due to too long milking intervals. This effect was also noted by Ketelaar-de Lauwere *et al.* (1999), as cows began to walk from the pasture to the barn's feeding area an hour before forage was supplied in the mornings.

Distance to pasture

Ketelaar-de Lauwere *et al.* (2000) discovered no difference in milking frequency when comparing distances between the barn and the pasture ranging from 146 m to 360 m. The number of milkings per day was 2.8 for all studied distances. No difference in milk yield or milking interval was found by Dooren *et al.* (2004b) when a pasture less than 150 m from the barn was compared with one over 500 m away.

Spörndly & Wredle (2004) found that cows with a short distance, 50 m, from the barn to the pasture increased their milk yield during the first week on pasture while cows on a pasture 260 m away (LD) had a slight decrease in their milk yield. The difference in milk yield created during the first week was then kept at a similar level for the rest of the pasture season. Higher energy requirement for walking might partly explain the lower milk yield for the cows in the LD group and one part of the divergence might be due to differences in pasture intake at the start of the grazing season. Milking frequency was lower for cows in the LD group (2.3 milkings/day versus 2.5 milkings/day) during the early part of the pasture season. In the later part of the season, milking frequency was 2.5 milkings/day for both treatments.

No effect on milk yield for different distances to the pasture was found by Dooren *et al.* (2002). Frequency of milkings, however, decreased by 0.18 milkings/day per km for farms with free cow traffic to pasture and no fetching of cows. Cows needed to be fetched increased with 14 % per km. An effect of distance on milking frequency or number of fetchings was not found on all farms. Distances looked at ranged from several meters up to 1300 m. Distant pastures were often combined with closer pastures to limit the daily walking distance, thus cows only walked to the distant pasture once per day. Furthermore, cows were encouraged to return from the distant pastures to the barn by use of strip grazing.

Cows spent more time and more of their lying down time on the pasture when it was located closer to the barn according to Spörndly & Wredle (2004). Ketelaar-de Lauwere *et al.* (2000) however, found that cows spent the most time on the pasture when on a more distant pasture for the first time. This was thought to have with habituation to do, making it difficult to combine the first time on a further away pasture with AM. It was noted in study that if cows could choose between a closer (50 m) and a more distant pasture (about 300 m) they preferred the closer one, even though there was much more grass on the more distant (Falk, 2007).

Water in pasture

Supplying water in the pasture when it is located 340 m from the barn was found to result in a lower milking frequency and a lower milk yield compared to only supplying water in the barn

(Karlsson, 2002). Only milk yield was lower when the cows were on the pasture 340 m away during a period of hot weather. A tendency for lower milk yield was found for the cows with access to water in the pasture when the cows were in a pasture 50 m from the barn. The cows able to drink at pasture drank 32 % of their total water intake there.

Spörndly & Wredle (2005) studied the difference between giving cows access to water only in the barn (B) or both in the barn and out on the pasture (B+P). No difference in milk yield, milk composition, milking frequency or water intake was found. Cows in the B+P group drank 55-67 % of their total water intake in the pasture indicating that cows were often thirsty and liked to drink while grazing, even though herbage contains a lot of water. The B cows compensated a few hours' lack of water by drinking more when it was available. Of the B cows' total water intake, 21.7 L (40 % of their total water intake) was drunk within 30 minutes after returning to the barn while the B+P cows drank 4.8 L in the same period. Thus, thirst might have been a factor for the B cows to leave the pasture but the B+P cows also returned to the barn regularly. The cows' behavior only differed between the two treatments in one of the two years of the study. When the cows were on a distant pasture, located 340 m from the barn, the B+P group spent 40 % of their time on the pasture and grazed 21 % of the time. However, the B group cows spent 34 % of their time on the pasture and grazed 17 % of the time in the same period.

When comparing the number of fetched animals between 29 Dutch farms that supplied water in the pasture with 22 Dutch farms that only supplying water in the barn, it seemed like supplying water in the pasture increased the number of cows needed to be fetched (Dooren *et al.*, 2002). The difference in fetched cows between the two treatments was greatest during hot weather. However, it was claimed that cows need water ad libitum to maintain their level of milk production during hot weather

Discussion

Pasture seems to benefit the health of cows (Thomsen *et al.*, 2006). Softer surface and more exercise are probably the most important reasons for the positive effects of pasture (Haskell *et al.*, 2006). Improvements in housing conditions can probably lessen the difference (Hernandez-Mendo *et al.*, 2007) and are thus imperative, as many cows have to spend large parts of the year in the barn only. It is also important to keep the pasture in good shape over the pasture season, so that the cows can benefit optimally from it each year. For example, a poor cow track can cause a higher prevalence of lameness (Hemsworth *et al.*, 1995).

Cows resting behavior appears to be positively influenced by pasture and they prefer spending their time on different behaviors outdoors if possible (Ketelaar-de Lauwere *et al.*, 1999). More time is spent eating when at pasture (Ketelaar-de Lauwere *et al.*, 1999), which could be due to that the feed is not as easily accessible as that in the barn and this might explain the decrease in stereotypic behavior during the pasture season (Redbo, 1990). The fact that cows spend time outdoors even if no grass is available (Krohn *et al.*, 1992) clearly indicates that the welfare of cows increases by giving access to pasture.

It might be realistic to expect a slightly lower milking frequency and a more uneven distribution of milkings (Spörndly & Wredle, 2002) but there is a large variation in how farmers succeed in combining pasture with AM and pasture does not necessarily cause a lower capacity (Dooren *et al.*, 2004a). This indicates that differences between farmers and

farming conditions exist and that there probably is a scope for improvements on farms having problems to combine AM and pasture.

Fetching the cows can be time consuming (Dooren *et al.*, 2004b) and the need for it can probably be decreased in the long run by trying to keep the number of fetchings down (Dooren *et al.*, 2002), avoiding habituating the cows to being fetched and allowing somewhat longer milking intervals. Production might suffer at first but if done right, it could be an investment for the future.

Restricting pasture time, keeping the cows indoors at night, (Ketelaar-de Lauwere *et al.*, 1999) and using a selection gate to control cow traffic to pasture (Dooren *et al.*, 2002) can be ways for farmers to keep problems with synchronization low. If all cows are taken into the barn for the night, this should be done late in the evening, as it is likely that fewer cows will need to be fetched and they tend to go indoors more willingly then (Dooren *et al.*, 2002). A selection gate can also help to keep milking intervals short (Dooren *et al.*, 2002) and is probably the most advantageous when opening to pasture in the morning, making sure that cows get milked before going outdoors.

Having pasture of good quality can reduce the cows' will to return indoors (Ketelaar-de Lauwere *et al.*, 2000). If the indoor feed is not attractive enough to compete with the pasture, it is probably a good idea to limit the amount of grass for grazing each day so that the cows have to return to the barn for more feed. This might be why strip grazing has a positive effect on the need for fetching cows (Dooren *et al.*, 2002) as cows leaving pasture for indoor feed comes closer to the milking unit and its concentrates (or some other attractive feed). Supplying high quantities of indoor feed as a way to attract cows to go back to the barn does not seem to be effective (Dooren *et al.*, 2004b; Spörndly & Wredle, 2004). However, indoor feed of good quality supplied at regular times is likely to be good at drawing the cows to the barn (Dooren *et al.*, 2002). Another way to stimulate the cows' to return to the barn is to use a grazing system where the cows are guided to one pasture in the morning and a new one, with fresh grass, when they go out later in the day after having visited the robot (Lely, 2008). Once cows learn that they are guided to a better pasture this way, they should be motivated to get milked.

Long distances to pasture can have a negative influence on the performance of the AM system (Dooren *et al.*, 2002; Spörndly & Wredle, 2004) but does not have an effect in all cases (Ketelaar-de Lauwere *et al.*, 2000; Dooren *et al.*, 2002). Its impact on the AM system is probably related to other management factors. Thus, the effect of distance can be affected by the farmer, implying the importance of making it attractive for the cows to return to the barn. However, distance to pasture should be kept short if possible since negative effects have been seen with long distances (Dooren *et al.*, 2004b).

Supplying water in the pasture does not have a clear affect on production according to Spörndly & Wredle (2005) but Karlsson (2002) found that it could cause a decrease in production. More cows might need to be fetched (Dooren *et al.*, 2002) since having water in the barn only might attract cows to go indoors, making it a more interesting option for farmers. Cows' welfare probably benefits with access to water in the pasture, as they seem to like to drink when at pasture (Spörndly & Wredle, 2005).

Conclusions

Pasture seems to be good for cow health and welfare. Allowing pasture in combination with an AM system might result in lower production and extra work to fetch cows. Avoiding letting the cows get used to being fetched, restricting pasture to daytime only, using a selection gate to control cow traffic to pasture, supplying good quality feed indoors at regular times and applying strip grazing are some good ways to make the most of pasture in AM. Supplying water only in the barn might be a way to make cows go indoors but this could reduce cow welfare. Many farmers and experimental results have shown that it is possible to combine pasture and AM successfully.

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