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- A case study on nine commercial dairy farms in Sweden

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Free cow traffic in automatic milking systems (AMS) - A case study on nine commercial dairy farms in Sweden

Fri kotrafik i automatiska mjölkningssystem (AMS) – en fallstudie på nio bruksbesättningar

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DEFINITIONS AND ABBREVIATIONS

AF: Automatic feeder for concentrate

AMS: Automatic milking system

Cow traffic *(Kotrafik)*: The cows' activities in an AMS, i.e. the number of milkings and feeding visits per cow and day and their distribution during the day (Pettersson, 2007).

Extra visit *(Avvisning)*: If a cow enters the MU without a milking permission, she will not be milked or fed. Instead, the gates open and the cow is released from the milking box.

Fetching *(Hämtning)*: All impact on the cows, that makes them advance to the MU, even if they are only woken up or forced to stand up. Fetching was used on all farms, but routines varied. Cows were fetched when their minimum milking interval had been exceeded or/and if their last milking had been unsuccessful. To identify cows that fulfilled the criteria for fetching, all farmers used the management programme T4C®. A fetched milking means an involuntary milking.

Fetching frequency *(Hämtningsfrekvens)*: Fetchings per day; Can be expressed as the proportion involuntary milkings of all milkings or the proportion fetched cows of all cows in the herd.

Following milking *(Nästa mjölkning)*: The next milking after an unsuccessful milking.

Free cow traffic *(Fri kotrafik)*: No gates are used, i.e. the cows can move freely between the feeding and resting areas and the MU 24 hours a day.

Milking frequency *(Mjölkningsfrekvens)*: Number of milkings per cow and day

Milking interval *(Mjölkningsintervall)*: Time in hours between two milkings.

MU *(MS)*: Milking unit

PMR: Partly mixed ration

TMR: Totally mixed ration

Unsuccessful milking *(Misslyckad mjölkning)*: When not all teats yield at least 75 % of what is expected (Svensson, 2008). This can be due to a bad milk flow in one or several teats, unsuccessful attachment of the teat cups or kicked off teat cups

SAMMANFATTNING

I automatiska mjölkningssystem (AMS) hålls korna i ett lösdriftsstall, utrustad med en eller flera mjölkstationer (MS). Kornas aktiviteter i systemet kallas kotrafik. Det finns tre system för kotrafik: styrd, styrd med förselektering och fri. I fri kotrafik finns inga grindar och korna kan röra sig helt fritt mellan foder- och liggavdelningen när som helst på dygnet. Syftet med den här studien var att undersöka fri kotrafik med avseende på produktionsresultat, utfodrings- och skötselrutiner, djurhälsa och inhysning. Studien omfattade nio kommersiella mjölkgårdar i Sverige. Den bestod av intervjuer med lantbrukarna, observationer i AMS-stallen, samt nedladdning av data från gårdarnas managementprogram. De insamlade uppgifterna innehöll information om interaktioner för totalt 837 mjölkande kor i 15 MS under en 30-dagars period, behandlades sedan i statistikprogrammet SAS och Microsoft Excel.

Var och en av de undersökta mjölkstationerna delades av mellan 40 och 65 kor och mjölkningsfrekvensen låg på 2,50 till 2,84 mjölkningar per ko och dag, samtidigt som mjölkningsintervallet varierade mellan 8,4 och 9,6 timmar. Det fanns inget samband mellan mjölkningsfrekvens och årsavkastning eller gruppstorlek (antal kor per MS), men den senare hade en gynnsam effekt på mjölkningsintervallet (större grupper hade ett kortare intervall). Även antalet avvisningar (extra besök) per ko och dag, som varierade mellan 0,71 och 1,51, hade en positiv effekt på mjölkningsintervallet. Upp till omkring två avvisningar och fem totala besök till MS per ko och dag blev mjölkningsintervallen kortare och jämnare, men vid fler avvisningar kunde ingen ytterligare positiv förändring i mjölkningsintervallet påvisas. Det fanns en tendens till en signifikant negativ korrelation ($p<0,09$) mellan antalet avvisningar och årsavkastningen per ko. Det fanns en signifikant negativ korrelation ($p<0,001$) mellan antalet avvisningar och dygnsavkastningen per ko. Variationen i andelen misslyckade mjölkningar var stor: 1,94 till 12,19 % av alla mjölkningar (median 3,17). Där specifika tider för hämtning av kor med långa mjölkningsintervall tillämpades hämtades också kor med misslyckade mjölkningar, även om ägaren inte var medveten om detta.

Det fanns stora skillnader i antalet utfodringar mellan de undersökta gårdarna, från 2 till 16 gånger per dygn. Alla nio lantbrukare påstod att de utfodrade grovfoder *ad lib*, men endast två bekräftade att det alltid fanns foder på foderbordet dygnet runt. På fyra av gårdarna var foderbordet tomt varje morgon vilket resulterade i låg mjölkningsaktivitet innan morgonutfodringen och hög aktivitet efteråt. Endast 56 % av lantbrukarna visste hur mycket mjölk de utfodrade för vid foderbordet. Det fanns en signifikant negativ korrelation ($p<0,023$) mellan maxgivan kraftfoder i MS per ko och dag och årsavkastningen per ko. Det fanns en tendens till positiv korrelation ($p<0,093$) mellan maxgivan i MS och antalet avvisningar, men antalet mjölkningar per ko och dag påverkades inte av kraftfodergivan i MS.

Hämtningsfrekvenserna var relativt låga jämförd med vad som visats i försök. Andelen fri tid i MS hade stor effekt på andelen ofrivilliga mjölkningar (hämtningar). Då det fanns över 11 % fri tid i MS var andelen ofrivilliga mjölkningar endast 2,1 %, men då den fria tiden var lägre än 11 % var andelen i stället 5,0 %. Det fanns en signifikant positiv korrelation ($p<0,036$) mellan andelen ofrivilliga mjölkningar och gruppstorleken. Den genomsnittliga hämtningsfrekvensen var 2,3 % (1,0 till 3,8 %) för gårdar med färre än 55 kor och 7,1 % (6,1 till 8,0 %) för gårdar med fler än 60 kor. Det minsta intervallet då kor hämtades till mjölkning

var i genomsnitt 13 timmar, men varierade mellan 10 och 20 timmar. Det fanns en negativ korrelation (ej signifikant) mellan hämtningsfrekvensen och minimum intervallet för hämtning. När det inte fanns några specifika tider för hämtning var mjölkningsintervallet jämnt fördelat över dygnet, men något längre än på gårdar med specifika hämtningsrutiner.

Diskning av MS hade en stark effekt på mjölkningsfrekvensen och antalet mjölkningar per timme minskade redan en stund innan själva diskningen började. Normalt fanns en tydlig topp i antalet mjölkningar efter diskning, men om foderbordet var tomt innan diskning och utfodring skedde kort tid efter, fanns ingen sådan topp. Det fanns stora skillnader i den genomsnittliga mjölkflödeshastigheten på gårdarna, med variationer från 2,01 till 2,56 kg mjölk per minut (medel 2,21). Det fanns en signifikant positiv korrelation ($p<0,013$) mellan antalet kor per MS och det genomsnittliga mjölkflödet i besättningen.

Det fanns stora skillnader mellan de undersökta gårdarna med avseende på det genomsnittliga tankcelltalet. Det varierade mellan 140 000 och 275 000 celler per ml (medel 206 000).. Den främsta motivationen för att investera i AMS var den ökade flexibiliteten i det dagliga arbetet. Andra orsaker var att slippa det tunga mjölkningsarbetet i konventionell mjölkning och att bli mindre beroende av extern arbetskraft. Tekniskt intresse nämndes också som motivation. Larm och jourbehovet uppfattades inte som något problem bland de intervjuade lantbrukarna.

Nyckelord: *Automatisk mjölkning, mjölkstation, fri kotrafik, mjölkningsintervall, mjölkningsfrekvens, mjölkningsfördelning, misslyckade mjölkningar, avvisningar, hämtningar, ofrivilliga mjölkningar*

ABSTRACT

In Automatic Milking Systems (AMS), cows are kept in a free stall barn equipped with one or several milking units (MU). The cows' activities in the system are called cow traffic. There are three types of cow traffic systems: guided, partly-guided and free. Free systems have no gates, allowing the cows access to the feeding and resting areas at any time. This study presents the results of on-farm research on such free systems, especially with a view to production results, feeding and management routines, animal health, and housing. The underlying field work was undertaken on nine commercial dairy farms in Sweden and comprised of manager (farmer) interviews, own observations at the target-barns, and the acquisition of standard data that were collected and stored by the farms' AMS software programmes. The data, covering the system responses and interactions of 837 lactating cows in 15 MUs over a period of 30 days were subsequently processed by aid of the statistical pc-programme SAS and Microsoft Excel.

With each of the 15 investigated MUs shared by 40 to 65 cows, the milking frequency varied from 2.50 to 2.84 milkings per cow and day at intervals between 8.4 and 9.6 hours. While there was no relationship between milking frequency and annual milk yield or herd size, the latter clearly affected milking intervals in a positive fashion. The number of non-milking (extra) visits to the MUs varied between 0.71 and 1.51 per day. When cows paid up to two extra visits and five visits in total to the MUs, milkings took place at shorter intervals and were more evenly distributed over the day. However, no additional positive development in milking interval could be seen for more than two extra visits. There was a tendency for a significant negative correlation ($p<0.09$) between the number of extra visits per cow and her annual milk yield. There also was a significant negative correlation ($p<0.001$) between the number of extra visits per cow and her daily milk yield. The share of unsuccessful milkings varied widely, ranging from 1.94 to 12.19 % of all milkings (median 3.17 %). If there were specific times for fetching cows that were late for milking, cows with unsuccessful milkings were also fetched, even though the farmers were not aware of this.

The feeding patterns applied on the participating farms were distinctly different from each other and ranged from 2 to 16 times per day. Whereas all nine farmers stated that the cows were fed roughage *ad lib*, only two actually had feed on the feeding table at all times. On four of the farms, the feeding table was empty every morning. In consequence milking activities were highest after morning feeding and low prior to feeding. Only 56 % of the farmers had an idea how much milk they were feeding for at the feeding table. There was a significant negative correlation ($p<0.023$) between the maximum allowance of concentrate per cow and day in the MU and the annual milk yield per cow. There was a tendency for a positive correlation ($p<0.093$) between the maximum concentrate allowance in the MU and the number of extra visits, however without affecting the number of daily milkings.

The fetching frequencies were quite low, compared to what has been observed in research studies. Free time in the MU had a large effect on the number of involuntary milkings (fetchings). For free time over 11 %, there were 2.1 % involuntary milkings, but for free time less than 11 % there were 5.0 % involuntary milkings. There was a significant positive correlation ($p<0.036$) between the proportion of involuntary milkings and herd size. The average fetching

frequency for the farms with less than 55 cows per MU was 2.3 % (1.0 – 3.8 %) and for the farms with more than 60 cows it was 7.1 % (6.1 – 8.0 %). The average minimum interval for fetching was 13 hours, with variations from 10 to 20 hours. There was a negative correlation (not significant) between the fetching frequency and the minimum interval for fetching. When there were no specific times for fetching, the milking interval was more regular during the day, but somewhat longer than on farms with specific fetching routines.

Cleaning of the MU had a strong effect on the number of milkings per hour, and there was a drop in milkings already some time before the actual cleaning. Usually there was a peak in milkings after cleaning. However, if the feeding table was empty prior to cleaning and feeding occurred shortly after cleaning, the peak was levelled off. There were considerable differences in the average milk flow rate, varying from 2.01 to 2.56 kg milk/minute (mean = 2.21). It turned out that herd size in terms of cows/MU was significantly positive correlated to the average milk flow rate in the herd ($p<0.013$).

There were great differences regarding the average bulk milk somatic cell count (BMCC). It varied between 140 000 and 275 000 cells/ml (average 206 000). There was no pattern observed, when studying health problems on the investigated farms. Investments in AMS were primarily motivated by the need to provide for more flexibility in daily farm management. Other reasons were the reduction of heavy work related to conventional milking and to be less dependent of extern employees. A technical interest was also mentioned for motivation. Alarms and on-call duty were not a problem for any of the interviewed farmers.

Keywords: *Automatic milking, milking unit, free cow traffic, milking interval, milking frequency, milking distribution, unsuccessful milkings, extra visits, fetchings, involuntary milkings*

INTRODUCTION

In Automatic Milking Systems (AMS) cows are kept in a free stall barn with one or several milking units (MU). The cows can move more or less freely in the system to reach the MU and the feeding or resting areas. The cows' activities in the system are called cow traffic. Pettersson (2007) defined cow traffic as the number of milkings per cow and day, visits in the feeding area per cow and day and the distribution of milking and feeding visits during the day. The total number of milkings per day is a measurement for how efficient the capacity of the MU is used. The variation in number of milkings per cow and day shows how well individual cows adapt to the system, while variations during the day indicate how the barn is managed.

There are three different ways to organize routing of the cows; guided, partly-guided and free cow traffic (Harms, 2004; Melin *et al.*, 2006; van Mourik, 2007; Forsberg *et al.*, 2008). In guided (forced) traffic, cows always have to pass through the MU to get access to the feeding area. In the partly-guided (semi-forced, forced with pre-selection) systems, pre-selection gates give access to the feeding area if the cow does not have permission for milking. If there is a milking permission, the cow has to pass through the MU to get to the feeding area. In free cow traffic, there are no gates at all, and thus, the cows can reach the feeding and resting areas at all times.

Free cow traffic is most natural for the cows and means lower investment costs for the farmer due to the lack of selection gates (Pettersson, 2008). Therefore it is not surprising that farmers all over the world choose this alternative for routing of their cows when installing an AMS. However, there have been rather few investigations on commercial farms concentrating on free cow traffic and specific publications are accordingly scarce. This study was undertaken to contribute to a better understanding of free cow traffic, with a focus on production results, feeding and management routines, animal health and housing.

LITERATURE

Use of AMS and free cow traffic

In 1992, the first AM systems were installed on commercial dairy farms in the Netherlands (Harms, 2004). After a few years of slow development, the new technology became increasingly popular on the dairy sector level until, in 1997, sales rates of AMS virtually exploded. In 2003, 2,200 dairy farms around the world were using a total of 3,800 MUs.

In January 2008, 400 dairy farms under the Swedish Dairy Association's cow registration programme were operating AMS (Larsson, 2008). In March 2007 their number was 356, representing an increase of 12 % in only ten months. In 2007, Lely had sold about 5,000 MUs worldwide, of which more than 90 % were used with free cow traffic (Svensson, 2008). The corresponding share of free cow traffic on Lely farms in Sweden was 75 % in 2006 (Pettersson, 2006) and about 90 % in 2008 (Svensson, 2008). Of all AMS farms in the world, independent of the MU's brand, 85 % use free cow traffic (van Mourik, 2007). In many countries, such as Denmark, Finland, Holland, France and Germany, free traffic is the standard routine on AMS farms. Wendl *et al.* (2000) studied AMS on 22 commercial German dairy farms and found that 80 % were using a MU of the brand Lely and that free cow traffic was clearly preferred (73 %).

Labour need and fetching of cows for milking

According to Meskens & Mathijs (2002), who investigated the motivation of farmers to invest in an AMS, social reasons such as increased labour flexibility, improved social life and health concerns were the primary causes for the investment (two third of all farmers in the study). Van Mourik (2007) claimed that one MU is about equivalent to one half-time employee. When there is only one MU on the farm (smaller farms without extern employees), costs for labour are usually not decreased, because the owner still works on the farm full time. However, the type of work is changed and work related to milking is decreased while working hour flexibility is increased.

Speroni *et al.* (2006) showed that in most occasions AMS farms cannot decrease their need of labour, because cows have to be fetched for milking. If the number of milkings per cow and day is lower than 2.5, there will be much time spent on fetching cows (Van Mourik, 2007). Lely recommends at least 10 % free time in the MU (2.4 h/day) to decrease the need to fetch low ranking cows. Less than 10 % free time results in a large number of fetched cows, which increases labour needs. Forsberg *et al.* (2008) and Ketelaar-de Lauwere *et al.* (1998) showed that the number of fetched cows was considerably higher in free cow traffic than in forced Forsberg *et al.* (2008) observed that the need for fetching cows in AMS decreased when management routines were improved.

Milking frequency, milking interval and milk yield

It has been shown that milk production per hour is negatively correlated to the length of the milking interval, i.e. the time between two milkings (Outweltjes, 1998; Hogeveen *et al.*, 2001). The effect of the milking interval's length on the milk production per hour was greatest

at higher production levels. There were large differences between cows regarding the effect of interval length (Ouweltjes, 1998).

Automatic milking (AM) is expected to increase milking frequency, i.e. the number of milkings per day, and thus the milk yield (Wagner-Storch & Palmer, 2003; Svennersten-Sjaunja *et al.*, 2002). However, Speroni *et al.* (2006) showed that an increase in milking frequency not always leads to a larger milk production. Hopster *et al.* (2002) found no differences regarding milk yield when comparing AMS to traditional milking systems. Melin *et al.* (2006) did not find any significant difference in milk yield when comparing the different cow traffic routines. Forsberg *et al.* (2008) found higher milk yield in free traffic compared to forced traffic, in spite of fewer milking occasions. The milking interval also varied depending on cow traffic and was significantly shorter the more the cow traffic was forced. Wendl *et al.* (2000) found no differences in milking frequency depending on the cow traffic routine, but this was explained by the fact that cows were fetched to the MU if the milking frequency was too low. The number of cows waiting in front of the MU was shorter in free traffic, and instead, cows spent more time eating and resting than in the forced alternative (Forsberg *et al.*, 2008). Even Ketelaar-de Lauwere *et al.* (1998) observed a decreased time for queuing in free cow traffic compared to forced.

Hogeveen *et al.* (2001) showed that there are large variations between individual cows in AMS, regarding the milking interval. This was explained by the fact that cows have to enter the MU voluntarily and therefore are not milked at fixed intervals. Other studies showed that there are great variations in the milking frequencies for individual cows, depending on the traffic system (Ketelaar-de Lauwere *et al.*, 2000; Hermans *et al.*, 2003; Forsberg *et al*., 2008) and the cow's stage of lactation (Svennersten-Sjaunja *et al.*, 2002). Wendl *et al.* (2000) found that a high occupation of an AMS resulted in an increased milking frequency and a more even distribution of milkings over the day.

A reduced number of milkings in the early morning was observed by Hogeveen *et al.* (2001). Ketelaar-de Lauwere *et al.* (1996) and Wendl *et al.* (2000) showed a decrease in milkings during a longer period at night and during early morning. The highest number of milkings occurred in the morning and in the evening (Wendl *et al*., 2000). Stefanowska *et al.* (1999) suggested that an increased number of milkings in the morning could be related to the fact that cows are fetched for milking at that time. Wagner-Storch & Palmer (2003) observed a higher percentage of cows in the MU from 8 a.m. to 1 p.m. and between 3 p.m. to 7 p.m. The number of cows waiting in front of the MU was highest between 8 a.m. and 11 a.m. and between 3 p.m. and 6 p.m. The share of waiting cows was lowest from midnight to 6 a.m. Cows with irregular milking intervals had a lower milk yield than cows that visited the MU at a more regular basis (Bach & Busto, 2005). Optimisation of the milking frequency, and thus the milking interval, is important and should consider effects on milk production, capacity of the AMS and udder health (Hogeveen *et al.*, 2001).

Extra visits

In AM systems without pre-selection, the visits to the MU have to be divided into milking visits and extra visits (non-milking visits) (Wendl *et al.* 2000). Stefanowska *et al.* (1998) showed that the milking efficiency of the AMS is decreased in systems that did not use pre-

selection in front of the MU. This was due to the fact that non-milking visits consumed system time and also slowed down other cows. One extra visit in the Lely Astronaut MU takes about 77 seconds (calculated from Umeland, 2003). Melin *et al*. (2006) observed 2.2 total visits to the MU per cow and day in free cow traffic, of which 0.2 were non-milking passages. In forced cow traffic there were 2.9 milkings and 2.2 extra visits in the MU per cow and day. Wendl *et al.* (2000) found large variations between farms regarding the number of daily milkings (80 to 130 per MU) and extra visits (20 to 180 per MU). These parameters were affected by the cow traffic and housing systems, feeding and management. A higher occupation of the system resulted in less extra visits to the MU. Van Mourik (2007) stated that extra visits are positive, because they show that the cows are motivated to come to the MU. Lely recommends that the number of extra visits should be about 50 % of the number of milkings (Svensson, 2008).

Unsuccessful milkings

Wendl *et al.* (2000) investigated the number of unsuccessful milkings as a parameter for operation safety in AM systems. It was found that the proportion unsuccessful milkings of all milkings varied substantially between individual farms (2.5 – 20 %). The study also showed that, even though almost 60 % of all cows had unsuccessful milkings, a few cows (7.5 %) were responsible for more than 50 % of all failed milkings. This was confirmed by Stefanowska *et al.* (1999), who found that 78 % of all milking failures were related to 12.5 % of the cows. A short term increase in the daily number of failed milkings was often caused by technical failures or dirt on the laser system for teat localization (Wendl *et al.*, 2000). The conclusion was that the daily number of unsuccessful milkings can be kept on low levels with appropriate management, like regular cleaning of the teat localization system or culling of cows with unsuitable udder exterior. In the study, the ratio of unsuccessful milkings was about 6 % of all milkings, which was classified as good to very good. Stefanowska *et al.* (1999) found that the average daily number of milking failures was 0.7 per cow and that approximately 10 % of all visits to the MU resulted in unsuccessful milkings. The study also showed that 34 % of the cows returned to the MU within 30 minutes after a failed milking, in an AMS that was accessible 24 hours per day.

Feeding

In AM, the number of milkings per cow and day varies greatly, depending on feeding (Rodenburg & Wheeler, 2002; Forsberg *et al.*, 2008). Wiedemann & Wendl (2002) showed that it is important to optimise the feed ratio at the feeding table, regarding energy and nutritional contents, in order to maximise the milking frequency. In free cow traffic it is especially important to restrict the energy ratio at the feeding table (van Mourik, 2007; Rodenburg & Wheeler, 2002). Lely recommends that the feed ratio at the feeding table should cover 7 kg milk less than the average milk production of the herd (van Mourik, 2007).

In countries where totally mixed rations (TMR) are common (e.g. Italy), there have been problems with free cow traffic (van Mourik, 2007). Forsberg *et al.* (2008) noted fewer milkings and an increased number of fetched cows when high quality mixed feed was offered on the feeding table *ad lib*. Even Rodenburg and Wheeler (2002) showed that a high proportion

of concentrate in the mixed ration increases the number of cows that have to be fetched for milking.

Wagner-Storch & Palmer (2003) observed low feeding rates at night and during the early mornings, but feeding activity increased after human intervention in the morning. Feeding visits affect cow traffic, and thus milking frequency, and to get an even distribution of milkings over the day (24 h) it is important that there always is enough feed (at least 2 kg DM/cow) on the feeding table (Forsberg *et al*., 2008). The goal should be at least five visits to the feeding table per day, plus one extra visit for each milking (Pettersson, 2007). Forsberg *et al*. (2008) showed that feed shortage during the night results in a lower number of milkings in total and a higher cow activity at the MU, and thus more queuing cows following morning feeding.

A comparative study of the different traffic systems showed that free traffic results in the largest number of feeding visits, but not necessarily in a higher feed consumption (Forsberg *et al*., 2008). However, Melin *et al.* (2006) showed that free traffic resulted in a higher dry matter intake and more time spent ruminating. Hermans *et al.* (2003) reported that the daily feeding time increased in systems where the cows had access to the feeding table 24 hours per day.

Prescott *et al.* (1997) studied the motivation of cows to get milked or eat concentrate in an AMS. The motivation to obtain food was high, while the motivation to be milked was rather low. The conclusion was that some amount of concentrate in the MU is important to motivate cows to visit the MU voluntarily. Halachmi *et al.* (2005) found no differences in milking attendance, when comparing a high and a low concentrate allowance in the MU. Bach *et al.* (2007) carried out a similar study and found that the total number of daily milkings, the milk production, the number of fetched cows, and the number of voluntary milkings were not affected by the concentrate allotment.

Social hierarchy in the herd

It was observed that AM triggers the effects of social dominance, especially concerning the timing of visits to the MU and the feeding table and the waiting of low ranking cows in front of the MU (Ketelaar-de Lauwere *et al.*, 1996). Cows with higher dominance values paid significantly more visits to the MU between noon and 6 p.m. Cows with lower dominance had more milkings between midnight and 6 a.m. Van Mourik (2007) stated that low ranking cows are milked during night and around noon, when the MU is free from high ranking cows. The feeding table was visited significantly less between midnight and 6 a.m. by cows with higher dominance (Ketelaar-de Lauwere *et al.*, 1996). It was suggested that high and middle ranking cows adapt their milking visits, depending on the feeding system used. For low ranking cows there was no such adjustment.

Restrictive feeding increases the effects of social dominance, and thus the risk that primiparous/low ranking cows do not get their daily feed ration (Harms, 2004). In free traffic systems, the cows have free access to the feeding area, which supports low ranking animals. Melin *et al.* (2006) found no difference in feed intake between cows of high and low social rank, but the high ranking cows spent significantly more time chewing.

Alleys in the AMS barn are recommended to be over 2.7 meters to benefit cow traffic (Pettersson, 2007). 2.2 meters works in some cases, but in combination with a dead end there will be problems. Van Mourik (2007) pointed out that narrow passages are unnatural for all cows, but worst for low ranking cows, because they are dominated more often by high ranking cows if space is limited.

Forsberg *et al.* (2008) pointed out the importance of a well suited barn and free access to the feeding and resting areas and the MU 24 hours per day, to promote cow traffic and limit appearance of social dominance between cows. It was also found that forced cow traffic had a negative impact on low ranking cows, in particular regarding time spent in the milking queue.

Animal health

AM manufactures promise better udder health, chiefly due to more milkings per day and thus shorter milking intervals (van Mourik, 2007). Hillerton *et al.* (2003) showed that there were few indications of general health problems in AMS. In the study, individual farms often had their own specific problems that were related to management, expectations and facilities, rather than the milking system. Farms with low bulk milk somatic cell count in general had a higher milk yield. However, there are even studies that show an increase in somatic cell count (SCC), when changing to AM (Jepsen & Rasmussen, 2000; Klungel *et al.*, 2000). Hogeveen *et al.* (2001) suggested that the variation in milking interval could be part of the explanation for an apparent increase of SCC with AM.

MATERIAL AND METHODS

The field work was carried out on nine commercial dairy farms in Sweden. All farms had one or two single milking boxes of the brand Lely Astronaut® (Lely Industries N. V., Maassluis, The Netherlands) and the computer software programme T4C® (Time for Cows) for herd management. Free cow traffic was used on all farms and the cows always had access to the MU, except during cleaning of the system.

All farms fed concentrate both in the MU and in separate automatic concentrate feeders (AF). To determine the maximum concentrate allotment per visit, the daily ration was divided into 24 portions, one for each hour of the day and finally compiled into rations per visit. That means, if there were 10 hours between two visits, the cow had collected 10/24 parts of her maximum daily share. However, there was a possibility for the farmer to report a maximum ration per visit for different cow groups in the table *Feed Access in the MU/AF* in the management programme.

The number of cows per MU on the nine farms varied between 40 and 65. The dominating cow breeds were SRB (Swedish Red Breed) and SLB (Swedish Holstein). Only about one percent of the cows were other breeds, predominantly Jersey. Detailed descriptions of the farms are given in Appendix 3, with a short summary in Table 1. At the time of the investigation, all farms but one had been using AMS for over a year. Farm 7 installed the MU in November 2006, six months prior to the study.

Table 1. Visiting date, installation year for the AMS, organic/conventional production (org./conv.), number of MUs, number of lactating cows at the visiting date and cow breeds for the investigated farms.

Farm no.	1	2	3	4	5	6	7	8	9
Visiting date [a]	May 14th	May 14th	May 14th	May 15th	May 15th	May 15th	May 21st	May 21st	March 16th
Inst. year	2001	2005	2004	2003	2004	2005	2006	2006	2003
Org./conv.	Conv.	Conv.	Conv.	Conv.	Conv.	Org.	Conv.	Org.	Conv.
No. of MUs	2	2	1	2	2	1	2	1	2
No. of cows	127	113	62	106	93	60	102	40	90
SRB (% of herd)	80	30	44	80	42	60	82	84	20
SLB (% of herd)	20	70	56	20	54	40	18	7	80
Other (% of herd)	0	0	0	0	4	0	0	9	0

[a] *all in 2007*

Each farm was visited once during spring 2007. The study contained interviews (Appendix 1) with the farmers, observations in the AMS-barns and downloading of data from the software programme. The interviews provided information about milk production, feeding routines, labour, management, fetching routines and animal health. Data collecting was finished before the grazing period started, and thus the effects of grazing did not have to be considered in this study.

The software lists in T4C®, that were used to get raw data for the study, are:

- Robot performance *(Robotprestanda)*
- Lely all milkings *(Lely alla mjölkningar)*
- Own report (containing extra visits) *(Egen rapport med avvisningar)*

- Milking permission *(Mjölkningstillstånd)*
- Feed access in the MU/AF *(Gruppens foderautomatik i mjölkstationerna respektive kraftfoderautomaterna)*

Data was downloaded and analysed for a period of 30 days prior to the visiting date on seven of the farms. Farm 1 had a stop in operation May 11th (three days prior to the visit) and therefore data was analysed for 30 days prior to the stop. Farm 9 was visited in February 2007, but data was not downloaded before March 2008. Data was edited in the statistical software programme SAS (SAS Institute, 2006) and in Microsoft Excel. Parameters studied were the milking interval, milking distribution, number of milkings, unsuccessful milkings, total number of visits to the MUs and extra (non-milking) visits. Data was collected for a total of 837 lactating cows in 15 MUs during 30 days.

RESULTS AND DISCUSSION

Visits to the milking unit

Milking visits

According to Pettersson (2007) the daily number of milkings per MU is a measurement for how efficient the capacity of the system is used. The total number of milkings per MU and day varied between 102 and 167 (Table 2), which was higher than observed in Wendl *et al.* (2000), where the number of milkings per MU and day varied from 80 to 130.

There were differences between the investigated farms regarding the number of milkings per cow and day (average for seven days) (Table 2). Melin *et al.* (2006) observed only 2.0 milkings per cow and day when studying free cow traffic. However, in the present study the number of milkings varied from 2.5 to 2.8 per cow and day, which fulfilled Lely's recommendation of at least 2.5 milkings per cow and day (van Mourik, 2007). Different studies have concluded that the annual milk yield would increase with a higher number of milkings per cow and day (Wagner-Storch and Palmer, 2003; Svennersten-Sjaunja *et al.*, 2002). However, in the present study there was no significant correlation between the milking frequency and the annual milk yield (Figure 1), which confirmed Hopster *et al.* (2002) and Speroni *et al.* (2006), who found that an increased milking frequency not necessarily resulted in a greater milk yield. There were large differences in the average annual milk yield (kg ECM) per cow between the investigated farms (Table 2).

In the present study, there was no significant correlation ($p<0.78$) between the number of cows per MU and the milking frequency. This contradicts Wendl *et al.* (2000), who found a significant positive correlation between the number of cows per MU and the milking frequency.

Table 2. The average annual and daily milk yield, milking frequency, milking interval, number of extra and total visits and the overall proportion of unsuccessful milkings on the investigated farms.

Farm no.	1	2	3	4	5	6	7	8	9
Annual milk yield, kg ECM/cow	9 700	9 200	9 519	9 600	10 297	9 450	9 800	8 000	8 800
Daily milk yield, kg milk/MU	1341	1590	1657	1598	1656	1098	2034	1757	1987
Daily milk yield, kg milk/cow	27.6	29.5	31.4	29.0	32.5	27.5	31.0	32.4	30.8
Milkings/MS/day	167	149	161	144	129	145	139	102	132
Milkings/cow/day	2.6	2.8	2.6	2.7	2.5	2.8	2.7	2.6	2.7
Milking intervals, hours	9.3	8.7	9.2	8.8	9.6	8.4	8.9	9.4	8.9
Extra visits/MS/day	56	86	82	58	21	42	46	58	47
Extra visits/cow/day	0.9	1.5	1.3	1.1	0.8	0.7	0.9	1.4	1.0
Total visits/cow/day	3.5	4.3	3.9	3.8	3.3	3.6	3.6	4.0	3.6
Unsuccessful milkings, %	2.4	2.7	3.6	1.9	3.2	6.2	2.6	12.2	3.8

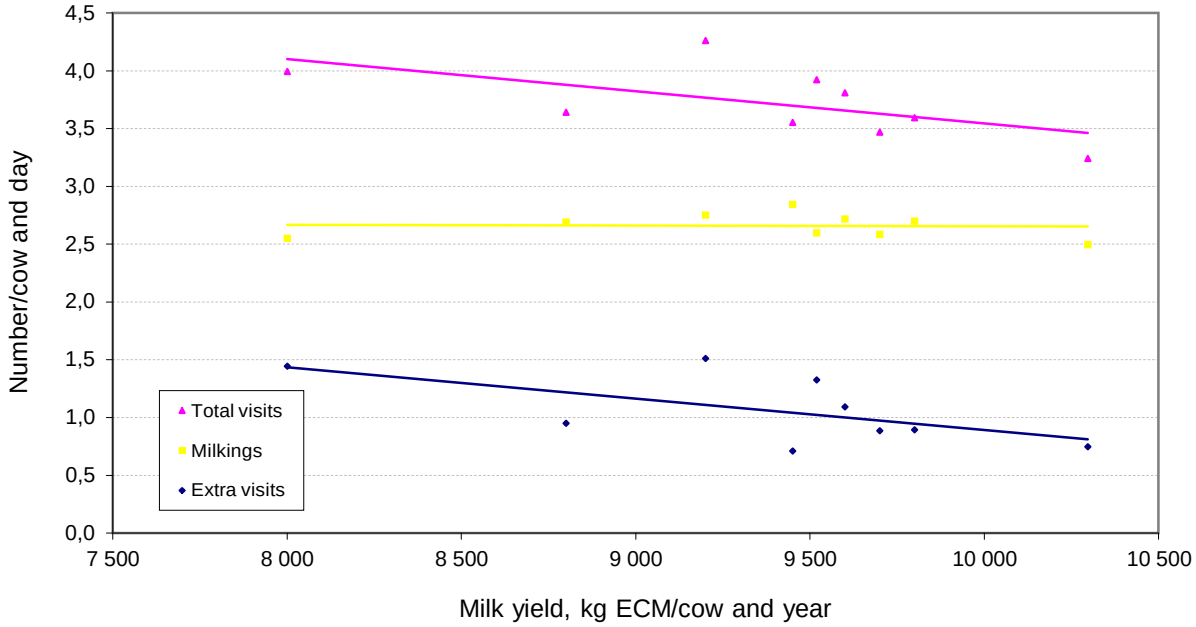

Figure 1. Total visits, milkings and extra visits versus milk yield (all farms).

The average milking interval on the investigated farms varied between 8.4 and 9.6 hours (Table 2), among others depending on the occupation level of the AMS (number of cows per MU). With an increasing number of cows per MU, the average milking interval became shorter and its standard deviation lower (Figure 2 and 3), which is in line with Wendl *et al.* (2000) who found that a higher occupied AMS resulted in an increased milking frequency and a more even distribution of milkings during the day.

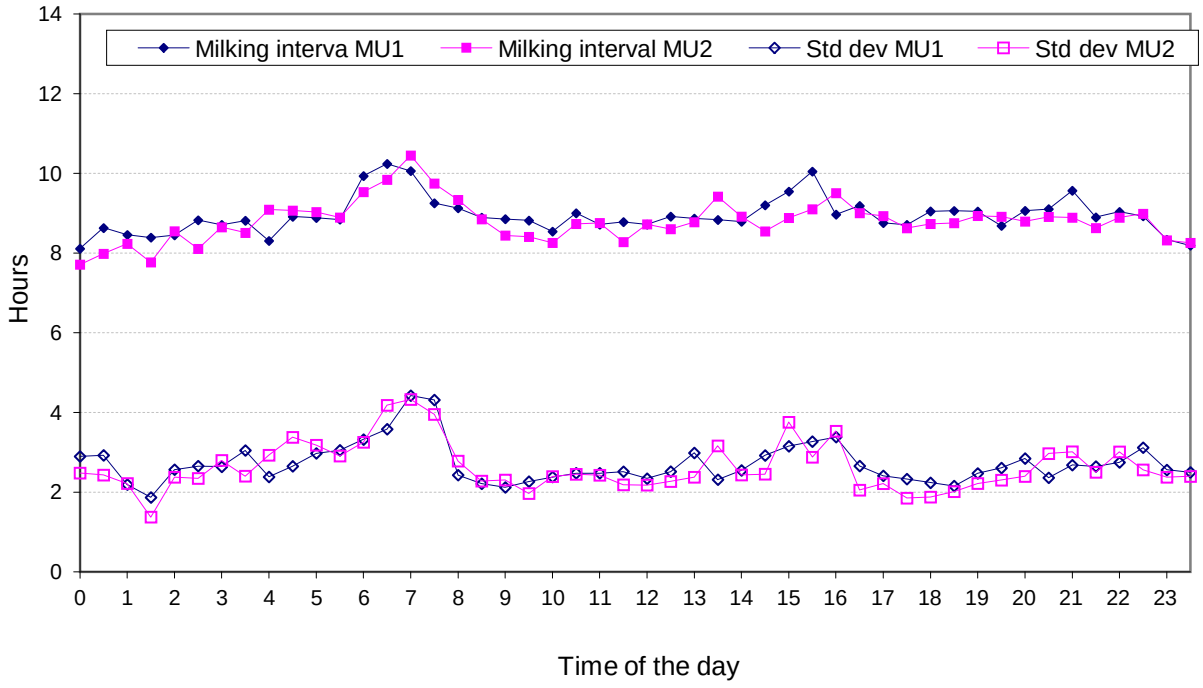

Figure 2. The distribution of the milking interval and its standard deviation during the day, when the occupation of the system was high (Two MUs, farm 1).

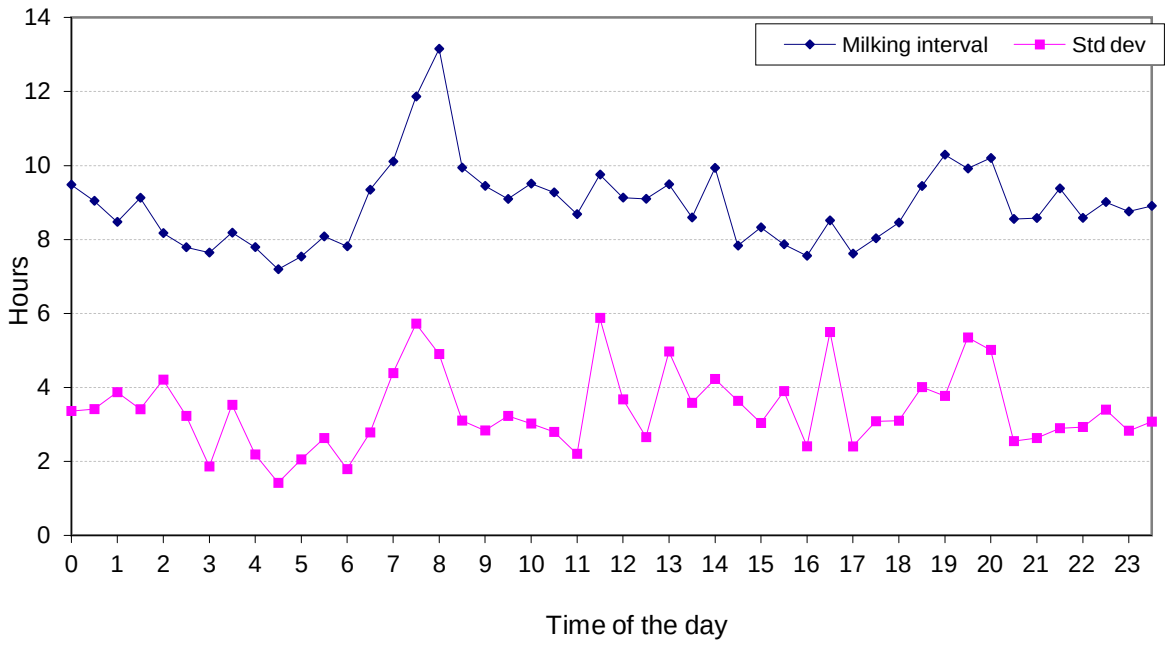

Figure 3. The distribution of the milking interval and its standard deviation during the day, when the occupation of the system was low (Farm 8).

Extra visits

According to Van Mourik (2007) extra visits (non-milking visits, denials) are indicative for the cows' motivation to visit the MU. Lely suggests to aim at about 50 % extra visits in proportion to milkings (Svensson, 2008). In the present study extra visits per cow and day varied between 0.7 and 1.5 (Table 2). The recommended 50 % were maintained on one farm only (farm 3), of the remainders six had less and two had more than 50 % extra visits. Wendl *et al.* (2000) observed between 20 and 180 extra visits per MU, which is higher than in the current study (21 to 86) (Table 2). Another study showed 0.2 extra visits, i.e. only 10 % of the number of milkings (Melin *et al.*, 2006).

Although this study confirmed, that more extra visits contribute to shorter and more regular milking intervals, this effect was only observed within a certain range of visits. Figure 4 illustrates this for farm 3: Here the milking interval and its standard deviation decreased, when the number of visits remained below two extra and four to five total visits per cow and day. Short and regular milking intervals favour not only milk production but also udder health (Hogeveen *et al.*, 2001), and extra visits in this order should therefore be encouraged.

There was a tendency for a significant negative correlation ($p<0.09$) between the number of total/extra visits and the annual milk yield on the investigated farms (Figure 1). The farms with the largest annual milk yield had less extra and total visits, but the same milking frequency as lower yielding farms. The average number of total visits per cow and day varied between 3.3 and 4.3 for the nine farms (Table 2), which was lower than observed by Wendl *et al.* (2000) (about five total visits per cow and day).

In this study the number of cows per MU and the number of extra visits were not correlated with any significance, which was different from the findings of Wendl *et al.* (2000) that showed a significant negative correlation between those parameters.

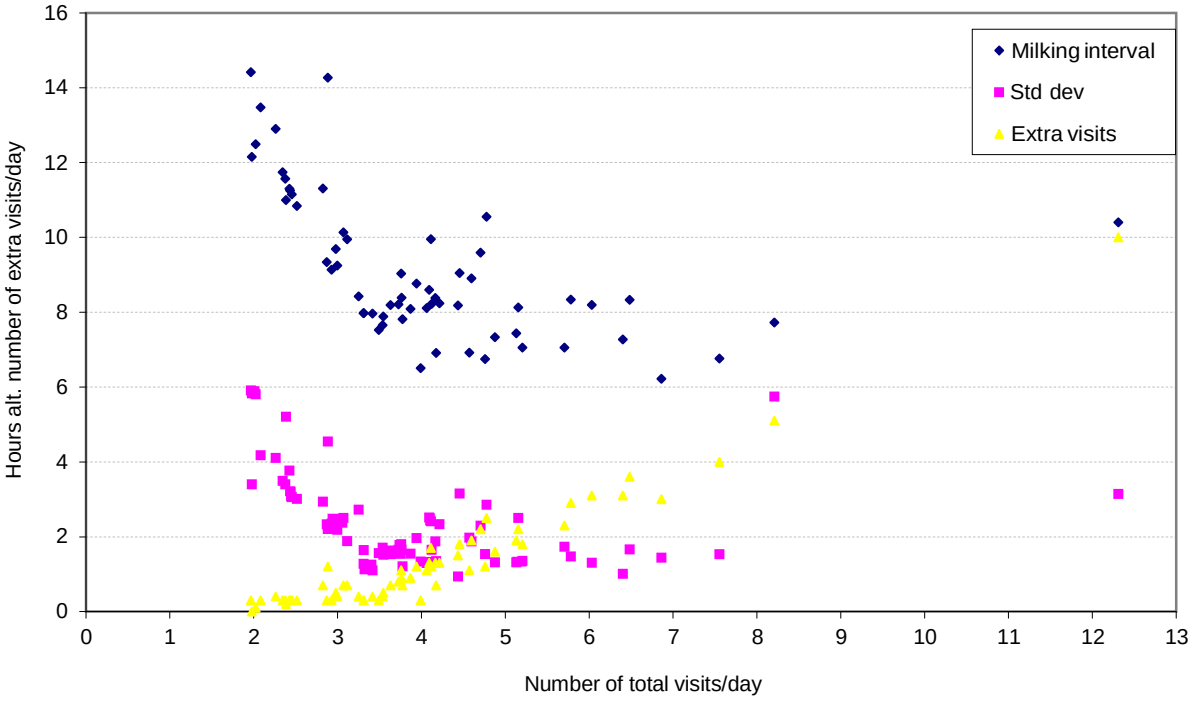

Figure 4. The number of extra visits, the milking interval and its standard deviation versus the total number of visits (farm 3).

Unsuccessful milkings

There were great variations in the proportion of unsuccessful milkings (% of all milkings), ranging from 1.9 to 12.2 (Table 2), with the median being 3.2. That was much lower than observed in Wendl *et al.* (2000), where the range was 2.5 to 20 % and the median 6 %. In the same study, a proportion of unsuccessful milkings of 6 % of all milkings was defined as good to very good. According to that definition, only farm 8 seemed to have problems with unsuccessful milkings (12.2 %). The resulting values in the present study were much lower than in Stefanowska *et al.* (1999), who found that the average daily number of milking failures was 0.7 per cow and that approximately 10 % of all visits to the MU resulted in unsuccessful milkings.

The farms had different routines, regarding cows with unsuccessful milkings (Table 5 further down). Farm 1 and 2 reported that they fetched cows with unsuccessful milkings twice a day, in the morning and in the afternoon. This was confirmed when studying the distribution of unsuccessful milkings and the next milking afterwards. In Figure 5, farm 1 is given as an example (for all farms see Appendix 3). There were two obvious peaks in the number of next milkings during the day (morning and afternoon). There also seemed to be less unsuccessful milkings during daytime, when people were working in the barn. One explanation for this could be that the laser camera lens in the MU usually is cleaned during the day, but could become dirty

during night. Also, cubicles, alleys and the floor in the MU are cleaned during the day, which results in cleaner cows and a cleaner laser lens.

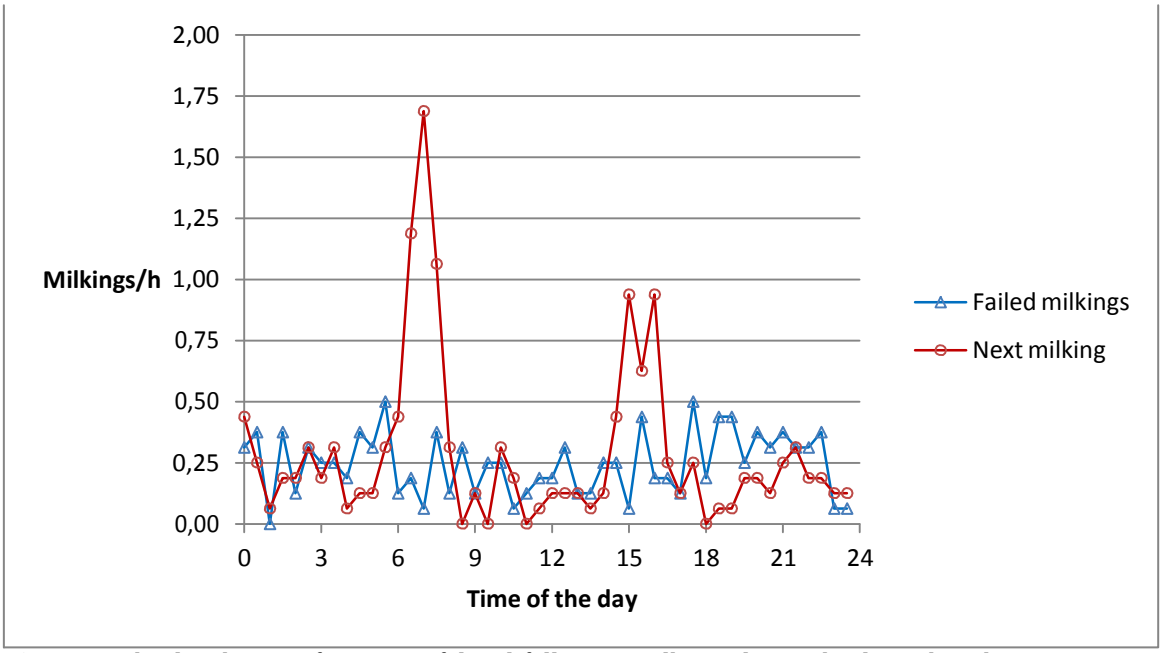

Figure 5. The distribution of unsuccessful and following milkings during the day, when there was a routine to fetch cows with unsuccessful milkings twice a day (farm 1).

Although the remaining farms did not report any routines for fetching cows with unsuccessful milkings, some of them did but were apparently unaware of it (Figure 6). This was the same for all farms which routinely fetched late cows to the MU at certain times of the day. However, on farm 6 and 7, which did not have any such time-fixed routines, unsuccessful and following milkings were evenly distributed over the day, without any peaks (Figure 7). It could be concluded that if there are specific times for fetching cows that are late for milking, cows with unsuccessful milkings are also fetched for milking, even though the farmer is not aware of this.

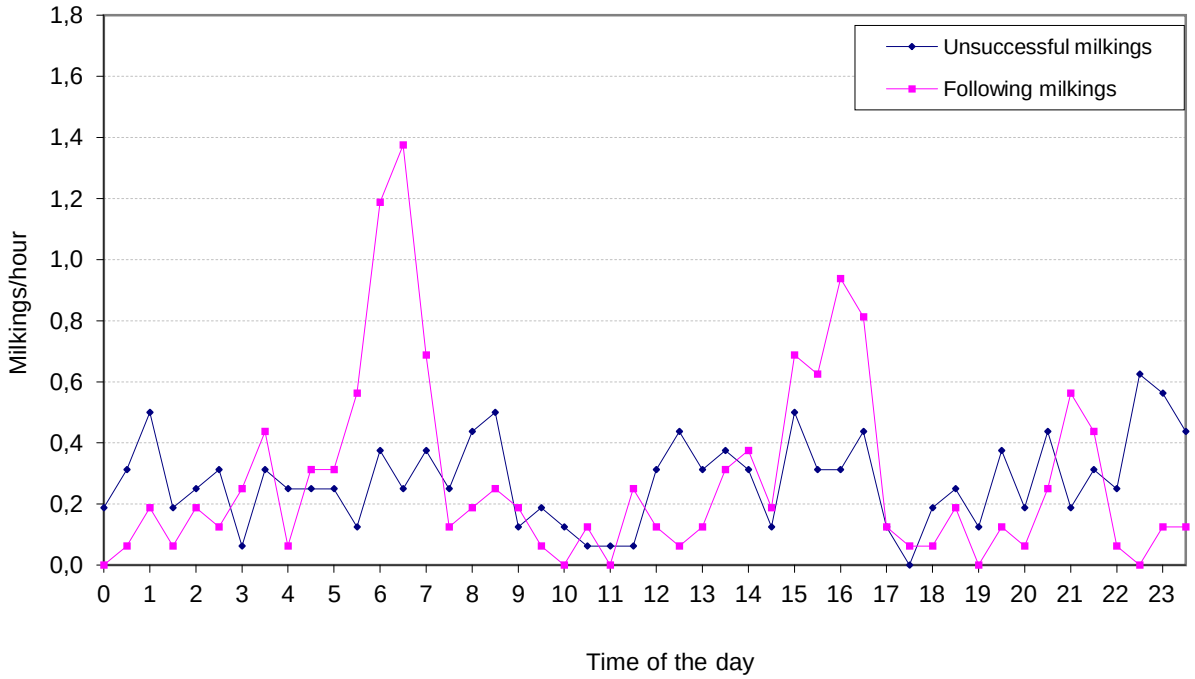

Figure 6. The distribution of unsuccessful and following milkings during the day, when there was no routine to fetch cows with unsuccessful milkings, but cows with long milking intervals were fetched twice a day (farm 4).

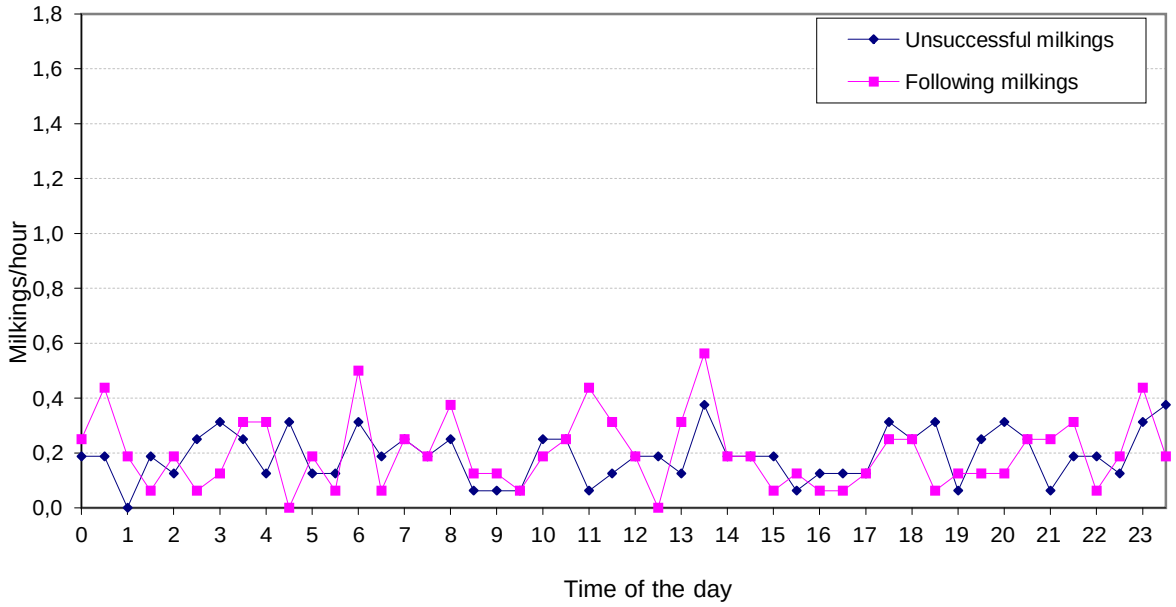

Figure 7. The distribution of unsuccessful and following milkings during the day, when there was no routine at all to fetch cows at specific times (farm 7).

Feeding

Roughage

Silage or a partly mixed ration (PMR) was fed on the feeding table manually or automatically. There were great differences between the investigated farms in the number of feeding occa-

sions, ranging from 2 to 16 times per day (Table 3). When studying AM systems, Rodenburg & Wheeler (2002) and Forsberg *et al.* (2008) found large variations in the number of milkings per cow and day, depending on the feeding routines and feed availability. In the present study, the number of milkings per cow and day varied between 2.5 and 2.8 (Table 2). There was a positive, but not significant ($p<0.18$), relation between the number of feedings per day and the annual milk yield (Figure 8).

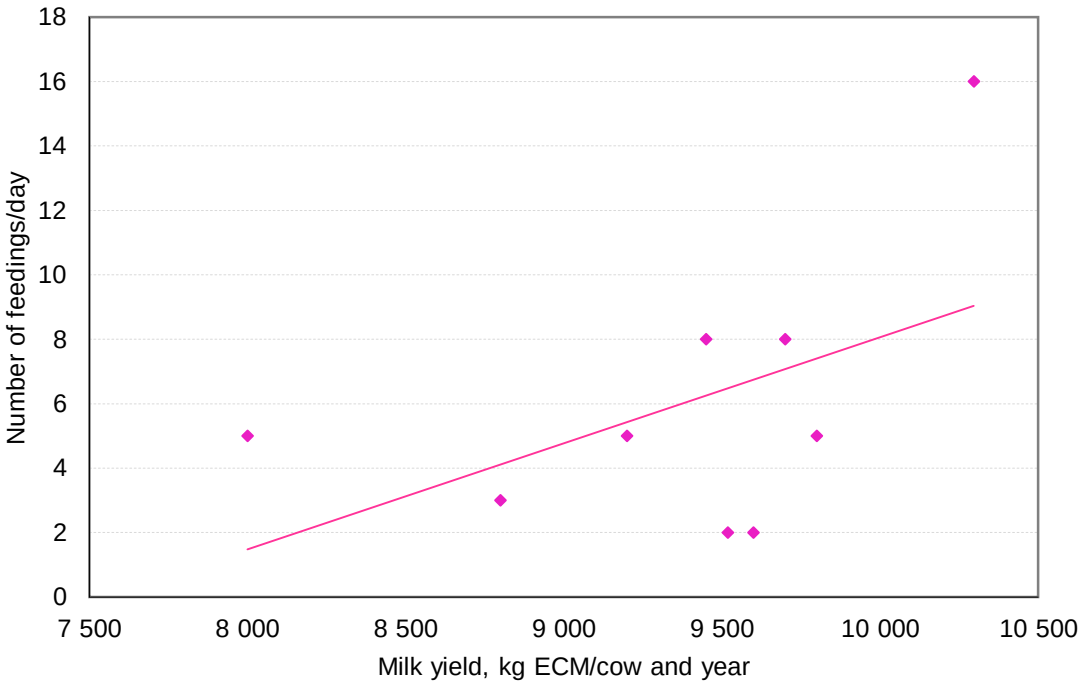

Figure 8. The number of roughage feedings per day versus the annual milk yield (all farms).

Wiedemann & Wendl (2002), van Mourik (2007) and Rodenburg & Wheeler (2002) discusses of an optimised feed ratio on the feeding table, regarding energy and nutritional contents. To keep free cow traffic going, it is important that the cows cannot satisfy their need of nutrients at the feeding table, so that they are motivated to advance to the MU for concentrate. Therefore, it is important for the farmer to know how much energy he/she is offering at the feeding table, which, in this study, applied to slightly more than half of the farmers (56 %; see table 3). When feeding silage only, it is difficult to adjust the energy level, so this question was primarily important for the two farms in this study that were using PMR. Here, the cows were fed for a daily milk production of 26 and 25 kg, respectively (Table 3). Lely's recommendation is to provide energy, covering 7 kg milk less than the herd's average milk yield per cow and day at the feeding table, when PMR is used (van Mourik, 2007; Svensson, 2008).

Forsberg *et al.* (2008) found that access to roughage affected cow traffic, and thus the milking frequency. To get an even distribution of milkings over 24 hours a day, it was recommended to always provide enough feed on the feeding table (at least 2 kg DM/cow). In the present study, all farmers stated that the cows were fed roughage *ad lib.*, but only two of the nine farmers confirmed that there was feed on the feeding table at all times (Table 3). At four of the farms, the feeding table was empty every morning and there were peaks in the number of milkings after morning feeding and a decreased number of milkings prior to feeding (Figure

8). These observations agree with Forsberg *et al*. (2008), who found an increased cow activity following morning feeding when the feeding table was empty, resulting in more queuing cows at the MU. According to the same study, feed shortage at night results in a decreased number of milkings in total.

Even Hogeveen *et al.* (2001), Wendl *et al.* (2000), Stefanowska *et al.* (1998) and Ketelaar-de Lauwere *et al.* (1996) found a decreased number of milkings during night and early morning, but they did not study the relation between feed access and the number of milkings. Stefanowska *et al.* (1999) suggested that the increased number of milkings in the morning could be related to the fact that cows were fetched for milking at that time. This could also partly explain the increase in milkings on farm 8, because cows were fetched in the morning (Figure 8; Table 5).

Table 3. Type of feed at the feeding table, feeding level and number of feedings per day on the investigated farms.

Farm no.	1	2	3	4	5	6	7	8	9
Type of feed	Silage	Silage	Silage	Silage	Silage	Silage	PMR	Silage	PMR
Feedings/day	8	5	2	2	16	8	5	5	3
Ad. Lib.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Empty[a]	< 2 h/day	M	M	M	S	nn	N	M + S	N
Covered milk yield[c, d]	x	x	> 22	x	x	> 20	> 26	> 24	< 25

[a] *M = Mornings, S = Sometimes, N = Never, nn = not known*
[b] *Average for the herd*
[c] *x = No idea*
[d] *kg/cow/day*

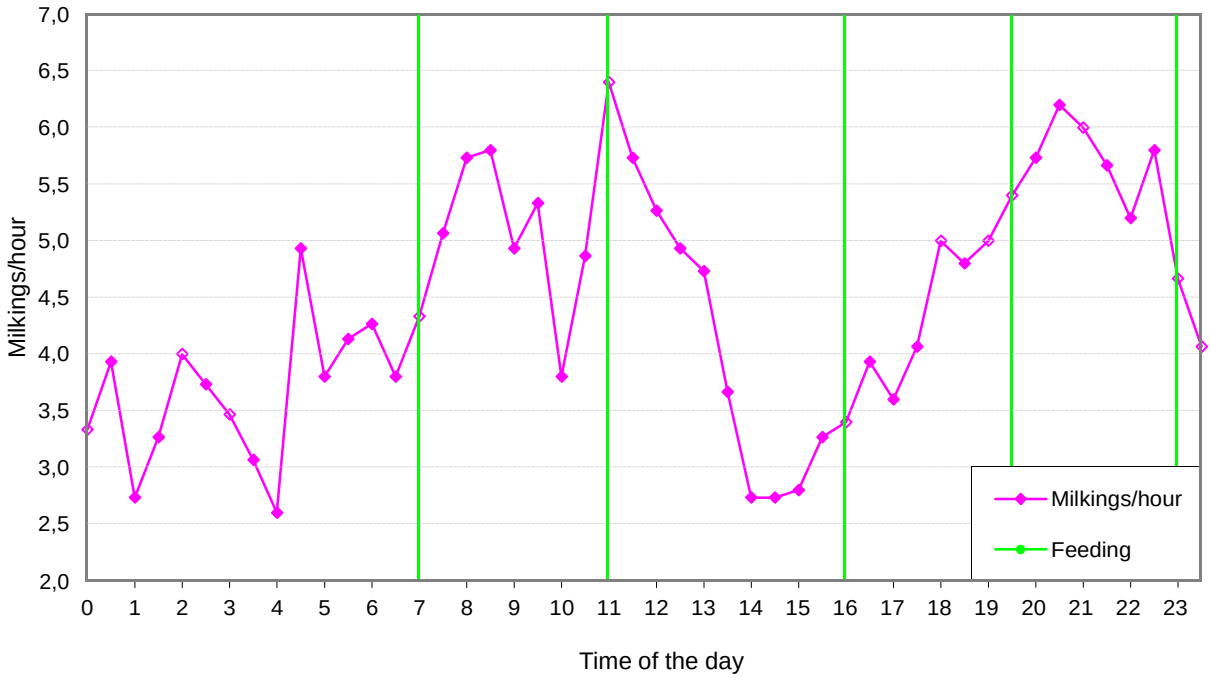

Figure 8. The distribution of milkings and feedings during the day, when the feeding table was empty in the mornings (farm 8).

Concentrate

There were some differences between the farms regarding the amounts of concentrate that were offered to the cows in the MU and the AF, respectively (Table 4). Bach *et al.* (2007) defined 3 kg of concentrate per cow and day in the MU as a low concentrate allotment, and 8 kg per cow and day as a high allotment. In the present study, the maximum amount of concentrate per cow and day varied between 4 and 8 kg in the MUs and 5 to 15 kg in the AFs. There was a significant negative correlation ($p<0.023$) between the maximum concentrate allowance in the MU per cow and day and the average annual milk yield per cow (kg ECM) (Figure 9). This contradicts Bach *et al.* (2007), who did not find any difference in milk yield when comparing groups of cows with a low and a high concentrate allotment, respectively.

Table 4. Maximum allowance of concentrate per cow and day in the concentrate stations (AF) and the milking units (MU) on the investigated farms.

Farm no.	1	2	3	4	5	6	7	8	9
AF	9.5 – 10.5	nn	9.5 – 11.45	9.0 – 14.0	15.0	5.0	4.5 – 7.5	8.0 – 12.0	8.0 – 11.
MU	6.0	8.0	6.5	4.0 – 5.0	5.0	5.0	4.0 – 5.0	5.2 – 6.0	7.5 – 8.0

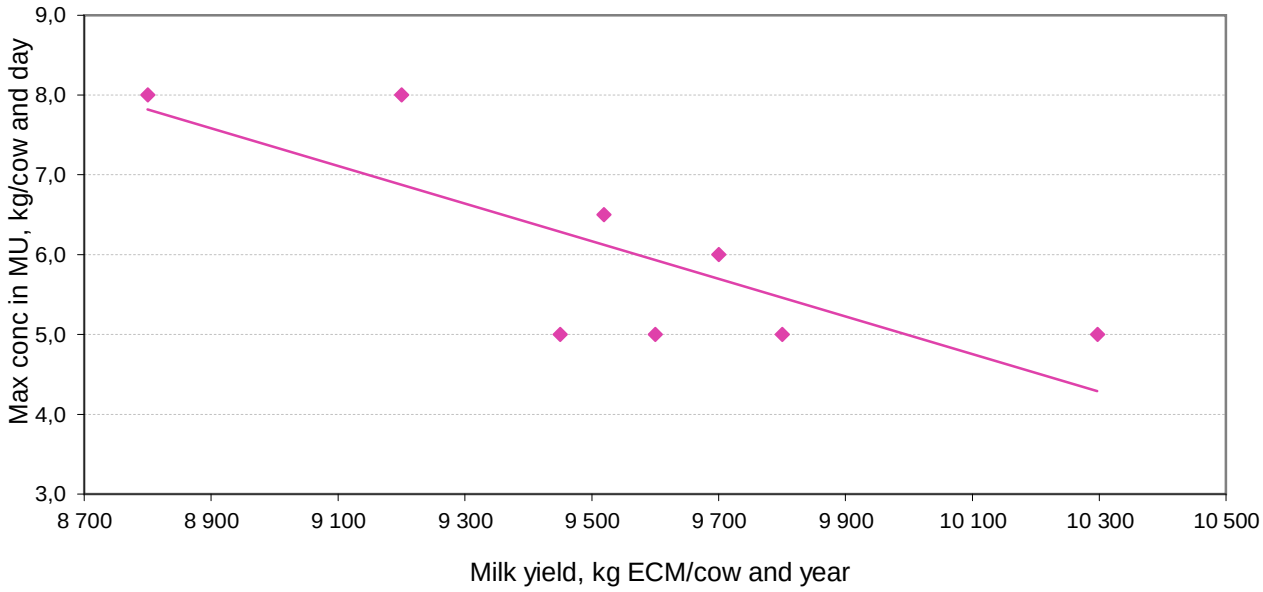

Figure 9. The maximum concentrate allowance versus the total annual milk yield (8 farms).

There was no significant correlation between the number of milkings per cow and day and the maximum concentrate allowance (Figure 10). This confirmed Halachmi *et al.* (2005) and Bach *et al.* (2007), who did not find any positive effect on the daily milking attendance when offering large amounts of concentrate in the MU. In the present study, there was a tendency of a positive correlation ($p<0.093$) between the number of extra visits and the maximum concentrate allowance per cow and day (Figure 10). Weisbjerg (2008) found that the number of total visits increased and the number of milkings remained the same, when there were large amounts of concentrate fed in the MU. In the same study, it was also observed that cows with high concentrate allotments had left-overs, which then could be eaten by other cows.

For high yielding cows, the number of extra visits was relatively low, compared to low yielding cows (Figure 11). More extra visits could result in an increased number of milkings and thus a shorter milking interval.

The increased risk for feed left-overs in the trough could explain why, in the present study, the number of extra visits increased, when the concentrate allowance was high. Cows probably learned that they sometimes could get a "treat", even when entering the MU without permission for milking, and thus came to the MU occasionally to check for feed. This was confirmed when studying the relationship between the number of total visits, milkings and extra visits to the MU and the milk production level (kg) per cow and day (Figure 11). There was a significant negative correlation ($p<0.001$) between the number of extra visits and the daily milk production per cow, meaning that low yielding cows came to the MU more often without a milking permission. This could be explained by the fact that cows continue to visit the MU to the same extend as earlier, even though their milk production, and thus the number of milking permissions, is decreasing, which results in more extra visits. However, low yielding cows actually visited the MU more often in total, than high yielding cows. This supports the theory that low yielding cows, that had a lower concentrate allowance, came to the MU to look for feed left-overs to a larger extent than high yielding cows. There was no difference between primiparous and multiparous cows, regarding this observation.

The average number of milkings per cow and day was significantly higher for high yielding cows, than for lower yielding cows (Figure 11). This confirmed Svennersten-Sjaunja *et al.* (2002), who found a positive relation between the number of milkings per cow and day and the cow's stage of lactation.

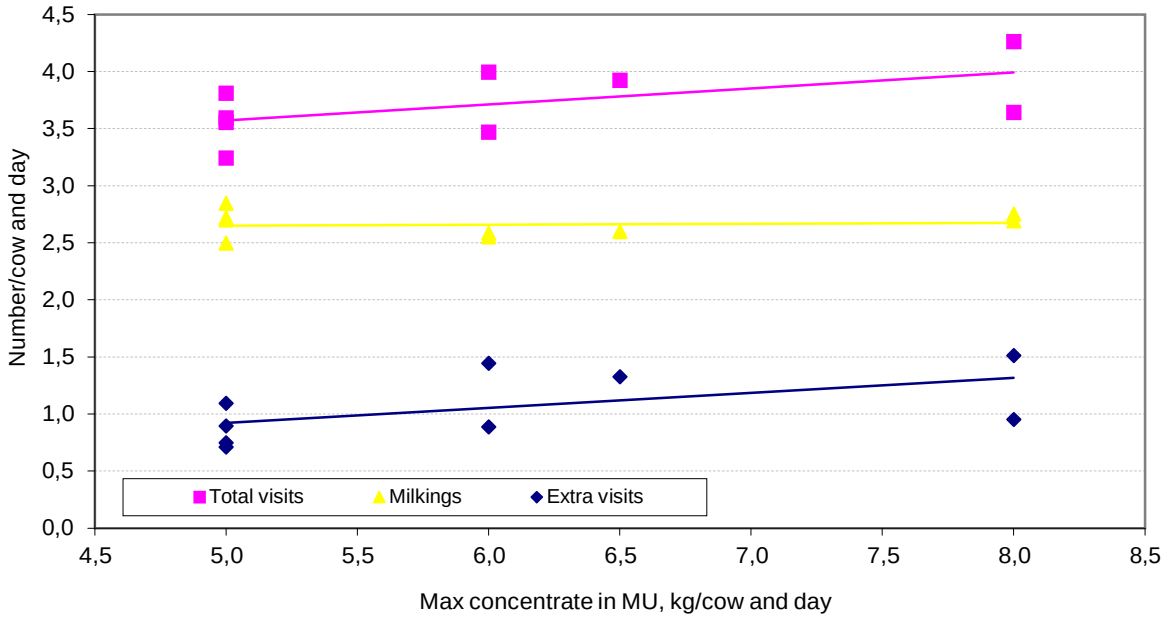

Figure 10. The number of total visits, milkings and extra visits to the MU, versus the maximum concentrate allowance in the MU per cow and day (All farms).

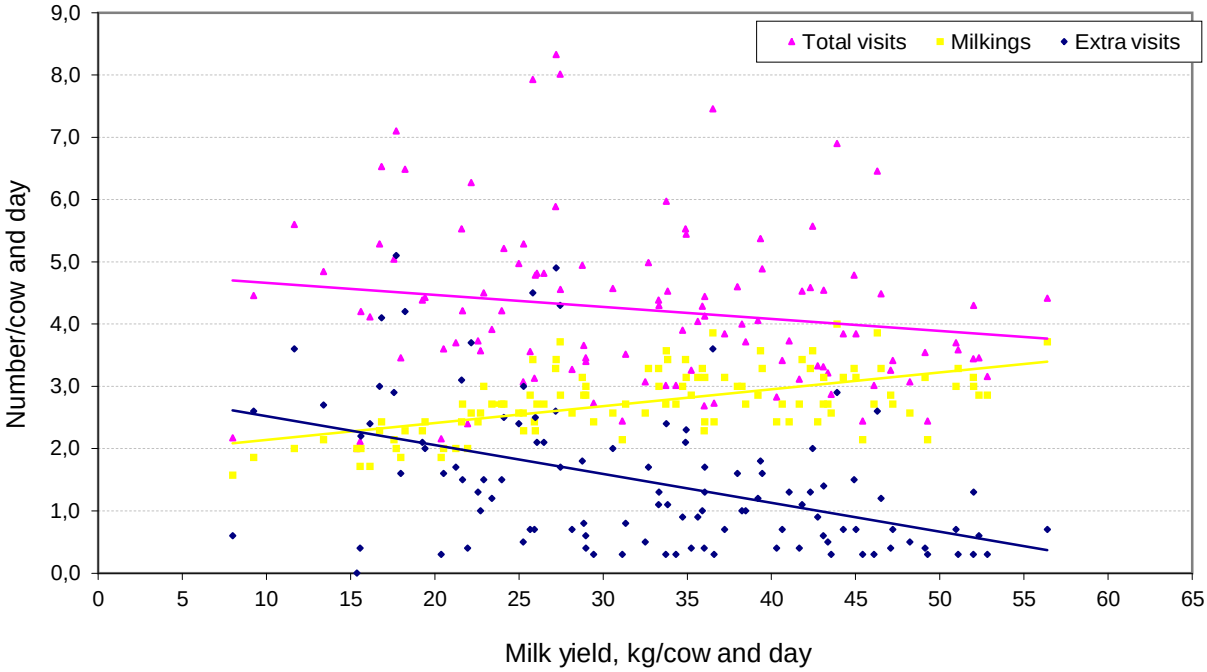

Figure 11. The number of total visits, milkings and extra visits to the MU, versus the daily milk yield per cow (individual cows, farm 2).

Fetching cows

Fetching was necessary to some extent on all investigated farms, but there were large differences in fetching routines. On all farms, cows were fetched if they were late for milking, e.g. had exceeded a certain pre-set minimum milking interval. On farm 1 and 2, cows were also fetched if their last milking had been unsuccessful. The fetched cows were either locked up in front of the MU and/or milked before other waiting cows. All farms were using the management software program to find late or unsuccessful cows. Most of the farms fetched cows twice a day at certain times. Table 5 gives a summary on fetching routines on the nine investigated farms.

Table 5. Fetching routines on the investigated farms.

Farm no.	1	2	3	4	5	6	7	8	9
Min. interval , hours	10	12	12	14	10	20	15	12	11
Unsuccessful	x	x							
Locked up	x		X	x	x			X	x
Milked first		x	X			x		X	x
Time of the day[a]	M + A	M + A	M + A	M + E	M + A	none	none	M + E	M + E

[a] *M = morning, A = afternoon, E = evening, none = no specific time*

The need for fetching cows varied a lot between the nine farms (Table 6) and seemed to depend on management routines. This was also seen in Forsberg *et al.* (2008), where the fetching frequency decreased when management was improved from experiment 1 to experiment 2. In the present study, fetching frequencies were quite low, compared to what is reported in literature (Bach *et al.*, 2005; Forsberg *et al.*, 2008).

Table 6. The number of cows per MU and the fetching frequencies on the investigated farms.

Farm no.	1	2	3	4	5	6	7	8	9
Cows/MU	63	54	62	53	51	51	51	40	49
Fetched cows , % of herd	13.6-19.7	5.3-7.1	16.1-25.8	1.9-18.9	9.7	1.7-3.4	3.9	7.5	6.1
Fetched milkings, % of all milkings	4.8-7.5	2.0-2.7	6.2-9.9	0.7-6.9	3.5	0.7-1.4	1.4	2.9	2.3

Free time in the MU had a strong impact on the number of involuntary milkings (fetchings) (Figure 12). The fetching frequency (fetched milkings per all milkings) averaged 2.1 % (1.0 – 2.9 %) on the six farms with more than 11 % free time and 5.0 % (3.8 – 6.1 %) on the two farms with less than 11 % free time. An exception was farm 3, where the fetching frequency was 8.0 % (highest for all farms!), even though there was 14.5 % free time in the MU. However, on farm 3 there were comparatively many cows per MU (62) in combination with narrow alleys in the AMS barn (1.2/2.0 meters), and the farmer had been experiencing some space-related problems with cow traffic, especially for primiparous cows. Pettersson (2007) recommended that alleys in an AMS free stall should be over 2.7 meters to benefit cow traffic. Even van Mourik (2007) pointed out the importance of space for well-working cow traffic, especially for low ranked cows.

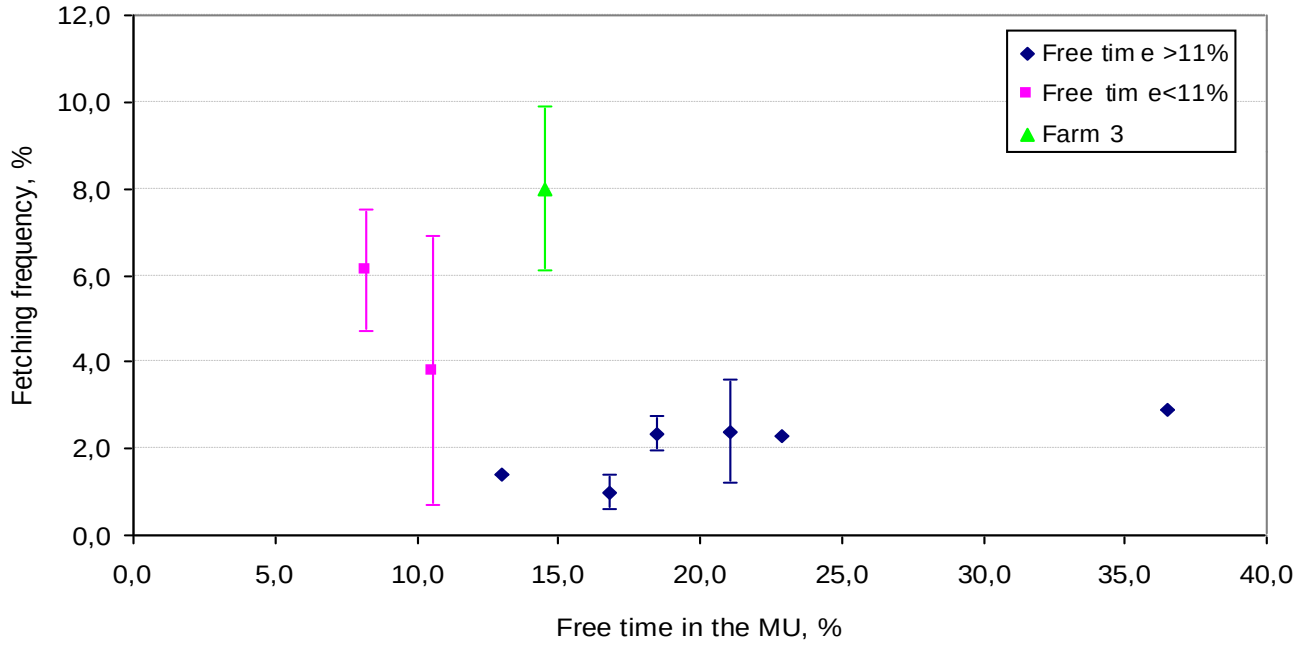

Figure 12. The fetching frequency in relation to free time in the MU (All farms).

There was a significant positive correlation ($p<0.036$) between the proportion of involuntary milkings (% of all milkings) and the number of cows per MU (Figure 13). The herd size on the nine investigated farms varied between 40 and 63 cows per MU (mean = 53). There were seven farms with a herd size of less than 55 cows and two farms with more than 60 cows. The average fetching frequency for the farms with less than 55 cows per MU was 2.3 % (1.0 – 3.8 %) and for the farms with more than 60 cows it was 7.1 % (6.1 – 8.0 %). Rousing *et al.* (2006) reported a fetching frequency (number of fetched cows over total number of cows) of

approximately 10 to 30 % on three commercial dairy farms with free cow traffic and 60, 67 and 70 cows per MU, respectively. In the present study, the fetching frequency varied between 13.6 and 25.8 % (fetched cows/total cows) for the two farms with more than 60 cows per MU (63 and 62, respectively), and was thus comparable with Rousing *et al.* (2006).

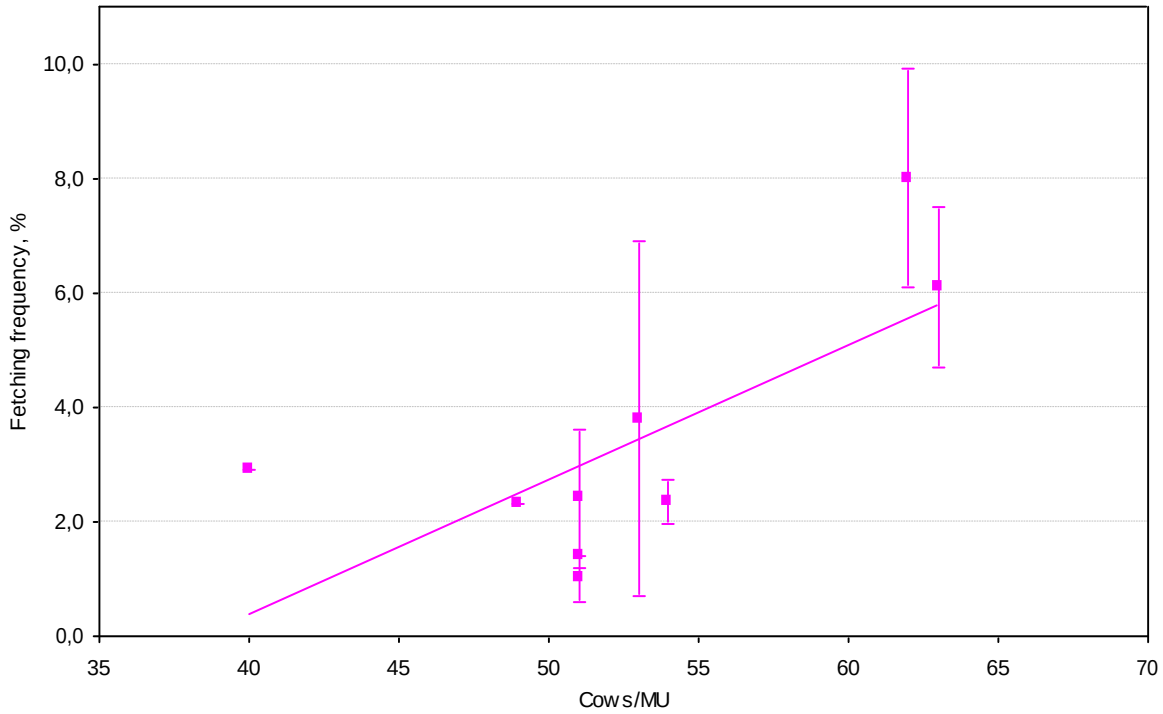

Figure 13. The fetching frequency in relation to herd size (All farms).

Forsberg *et al.* (2008) found that the fetching frequency depended on the cow traffic system and was higher for free traffic than for the forced alternatives (14.5 % of total milking occasions for free traffic and only 2.6 % for forced traffic with pre-selection). The study was performed on groups of 54 cows, which makes it comparable in size to farms 2, 4, 5, 6 and 7 in the present study (51 to 54 cows). The average fetching frequency on these farms was 2.2 % (1.0 to 3.8 %), which was much lower than observed for free cow traffic in Forsberg *et al.* (2008), but was comparable to what was observed for forced traffic with pre-selection in the same study. In the present study, the number of fetchings was based on statements from the farmers, and thus should be treated with some criticism.

As described earlier, all the investigated farms were fetching cows that were late for milking. However, there were great variations between the farms regarding the minimum milking interval for fetching (Table 5). The average minimum interval for fetching was 13 hours, with variations from 10 to 20 hours. There was a negative relationship (not significant, $p<0.22$) between the proportion of involuntary milkings (% of all milkings) and the average minimum milking interval (hours) (Figure 14). Farm 6 had the highest toleration limit for fetching (20 hours) and the lowest frequency of involuntary milkings (1.0 %). This agrees with Pettersson (2007) who observed that cows adapt to management routines by waiting for fetching if the minimum fetching interval is low.

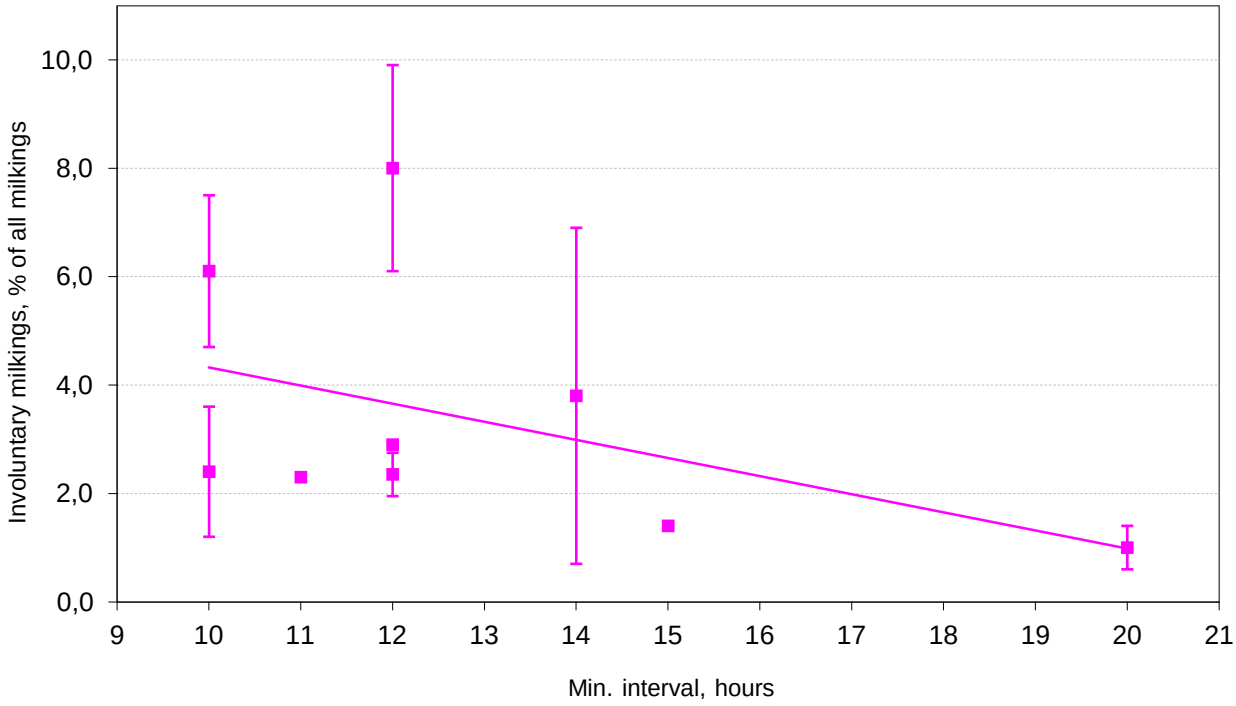

Figure 14. The fetching frequency in relation to the minimum milking interval (All farms).

The milking interval and its standard deviation increased in connection with the fetching occasions (Figure 15). The peaks in milking interval are probably due to the fact that fetched cows had exceeded their minimum interval. If fetched cows were milked before other waiting (queuing) cows, the waiting cows' milking intervals were of course increased, too. Ketelaar de Lauwere *et al.* (1998) observed that queues themselves actually may keep cows that were not queuing from coming to the area closest to the MU. This could explain why the milking interval remained at a somewhat higher level even some time after the fetching occasions (Figure 15). The standard deviation for the milking interval also increased, which suggests that there was an increased difference between the milked cows, regarding their milking interval. On farm 6 and 7 there were no specific times for fetching and thus, the milking interval was evenly distributed over the day (Figure 16). However, the milking interval increased slightly between 6 am and 7 pm, presumably because cows were fetched occasionally during daytime, when there were people active in the barn. The standard deviation for the milking interval was higher for farm 7 (around 3), compared to farm 3 (around 2) (Figure 15 and 16).

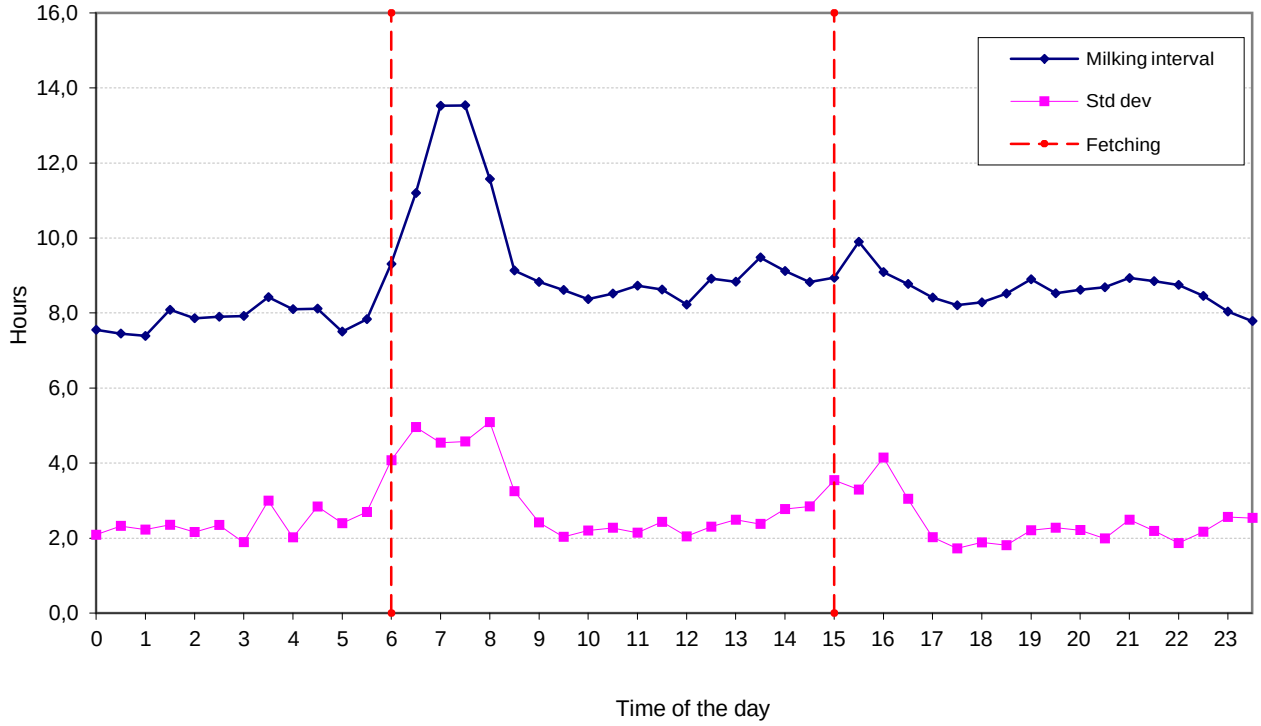

Figure 15. The milking interval and its standard deviation during the day, when fetching was performed twice a day at specific times (farm 3).

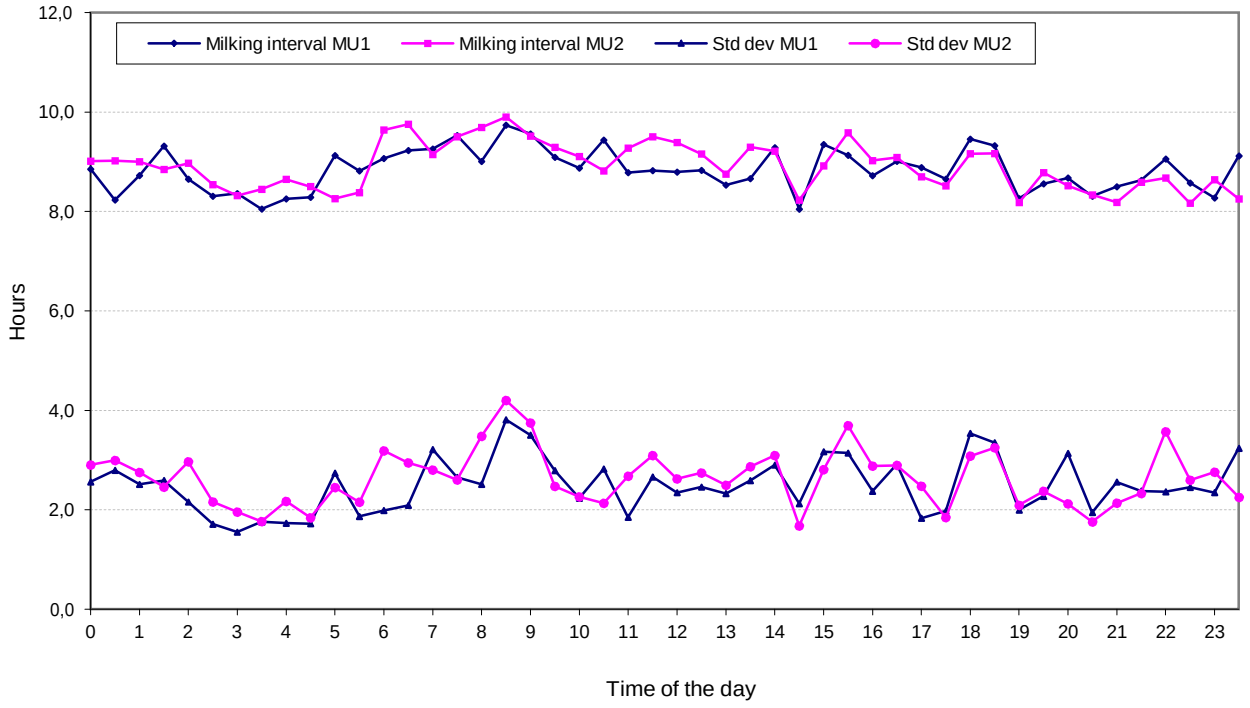

Figure 16. The milking interval and its standard deviation during the day, when there were no specific times for fetching (two MUs, farm 7).

Cleaning of the milking unit

The MUs were cleaned automatically twice or thrice a day on all farms. There were differences between farms, regarding time of the day for cleanings (table 7) and their relation in time to feeding.

Table 7. Times of the day for cleaning of the MUs on each farm.

Farm no.	1	2	3	4	5	6	7	8	9
Cleaning time	01.00 13.00	01.00 05.00 13.00	00.30 12.30	02.30 10.00 18.30	05.00 13.30 21.30	05.30 12.30 23.30	05.30 14.30 22.00	04.00 14.00	02.30 14.30

There was a strong effect of cleaning on the number of milkings per hour on all farms which was expected, because the MU was shut down during cleaning (approx. 15 minutes per cleaning). The cows seemed to learn when cleaning usually took place, and thus adapted their milking behaviour by not visiting the MU when it was time for cleaning. However, there was a drop in the numbers of milkings already some time before the actual cleaning was started (Figure 17), which has also been observed at the Kungsängen Research Centre (Pettersson; 2007).

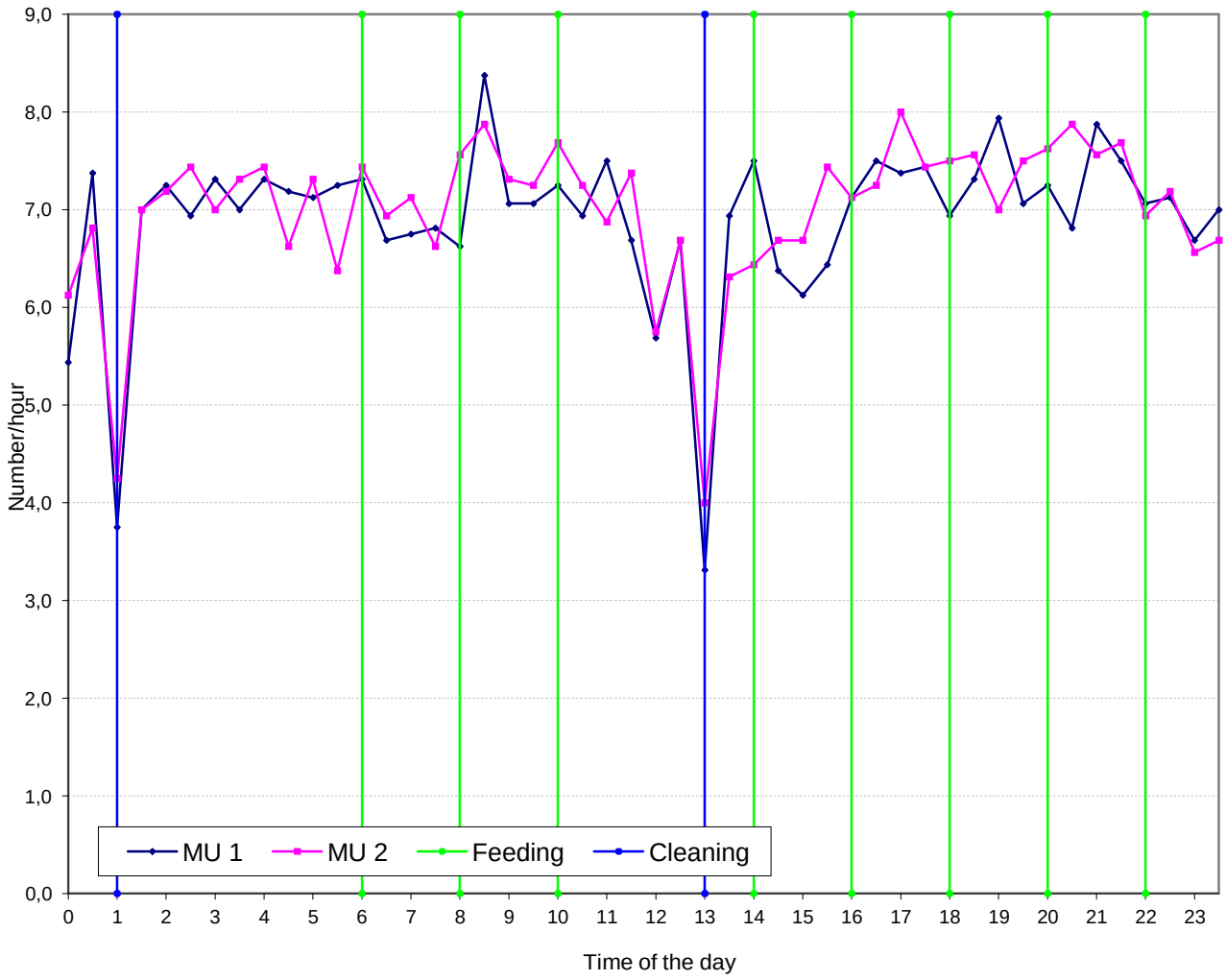

Figure 17. Distribution of milkings, cleanings and feedings during the day, when the feeding table was empty less than 2 h/day (two MUs, farm 1).

On some of the farms, feeding occurred shortly after cleaning, this seemed to disturb cow traffic. Usually there was a peak in milkings after cleaning, probably because the cows had been waiting for the MU to open. However, if feeding followed upon cleaning, the cows seemed to prioritize feeding over milking and the peak was flattened out. This observation agrees with Prescott *et al.* (1997) who found that cows' motivation to feed is larger than their motivation for being milked. The phenomenon was seen to some extent on farm 1 (Figure 17), but even more on farm 8 (Figure 18). After cleaning of the MU at 2 pm, there should have been a peak in the number of milkings, but instead, the level for milkings continued to be low.

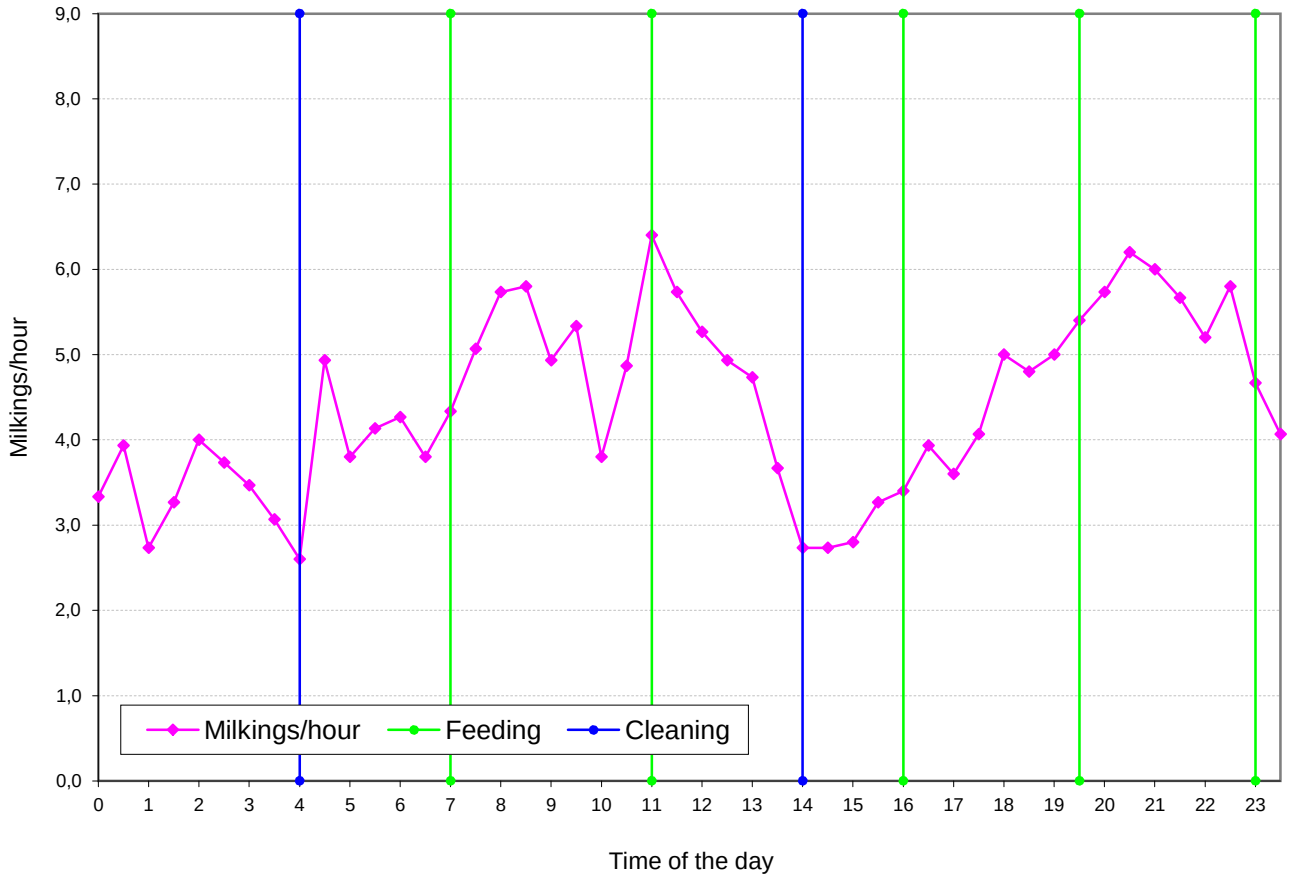

Figure 18. Distribution of milkings, cleanings and feedings during the day, if the feeding table was empty every morning and feeding occurred shortly after cleaning of the MU (farm 8).

Milk flow rate

There were large differences in the milk flow rate (kg milk/minute, average for seven days) between the investigated farms, varying from 2.01 to 2.56 (mean = 2.21) (Table 8). These were quite high, according to Wendl *et al.* (2000), who defined a low milk flow rate as 1.3 kg per minute. However, taking an average milk yield of 12 kg per milking as an example, the time for one milking would vary between 4.7 and 6.0 minutes per cow on the investigated farms (Table 8). For the average herd in this study, with 53 cows per MU and 2.6 milkings per cow and day, this would mean a total effective milking time of 10.8 and 13.8 hours, respectively. This means that by increasing the milk flow from 2.01 to 2.56 kg per minute, there is a potential to increase the number of cows per MU with up to 22 %. Farmer 1, who had been

breeding for a better milk flow rate, had the second best result of the investigated farms (2.49 kg milk/minute). Farm 4 kept all young cattle at a neighbour's farm and the farmer suspected that he was not getting back the best heifers. This could be the reason why farm 4 had a low milk flow rate (2.01 kg milk/minute).

Table 8. The milk flow rate and the time to milk 12 kg on the investigated farms.

Farm no.	1	2	3	4	5	6	7	8	9
Milk flow rate	2.49	2.21	2.56	2.01	2.07	2.30	2.15	2.08	2.05
Milking time (12 kg)	4.8	5.4	4.7	6.0	5.8	5.2	5.6	5.8	5.9

According to Lely (Svensson, 2008), one MU can serve about 70 cows if the milk flow rate is good. If "slow" cows are kept in the system, the capacity might only be about 65 cows per MU. None of the investigated farms was even close to those numbers. Farm 1 had most cows per MU (63), but the average for the nine farms was only 53 cows per MU. There was a significant positive correlation ($p<0.013$) between the number of cows per MU and the milk flow rate (Figure 19). Farm 1 and 3, which had the largest number of cows per MU (63 and 62, respectively) also had the highest milk flow rate (2.49 and 2.56 kg/minute, respectively). It was concluded that a high milk flow rate is necessary in order to maximise the capacity of the MU. This confirmed Wendl *et al.* (2000), who found that the influence of the milk flow rate on the AM system's capacity was great. Farm 3 had a high average milk flow rate (2.6 kg milk per minute), combined with a low milk yield (kg per milking), which explains why there was so much free time (14.5 %), even though there were many cows in the system (62 cows per MU). The faster milk flow and the smaller milk yield made farm 3 0.1 minutes faster per milking than farm 1.

On farm 4, there were only 10.6 % free time in the system, and thus the capacity of the MU was already maximised. An increased number of cows would result in a low level of free time, and would probably cause an increased number of fetchings. Thus, farm 4 has to increase the milk flow rate in the herd to be able to reach the goal 60 cows per MU. This could be done by culling "slow" cows in a short term perspective, but in a long term perspective it is important to breed "faster" cows.

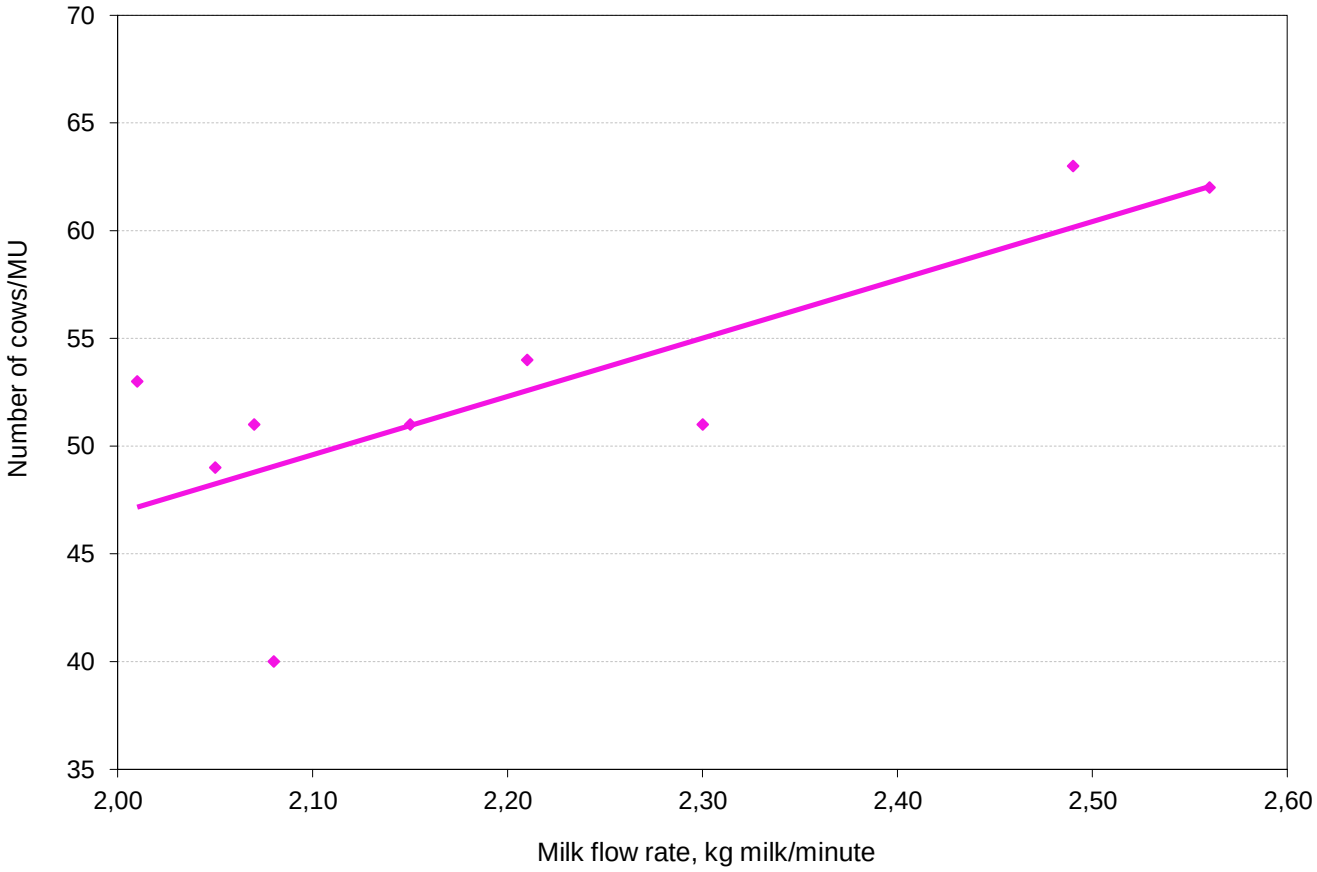

Figure 19. The milk flow rate versus the number of cows per MU (All farms).

Udder Health

The bulk milk somatic cell count (BSCC) varied greatly between the investigated farms (Table 9). The lowest BSCC was 145,000 cells/ml and the highest 275,000 cells/ml (206,000 in average). One of the farmers reported that the udder health in his herd had improved since the introduction of the AMS.

There were large variations between farms regarding mastitis, leg/hoof problems and feeding related diseases, but no pattern could be seen in this study. In the individual farm descriptions in Appendix 2, the occurrence of different health problems is described. To investigate the consequences of animal health on production results, there should be further studies.

Table 9. Bulk milk somatic cell count (BSCC) on the investigated farms during 2006.

Farm no.	1	2	3	4	5	6	7	8	9
BSCC (10^3 cells/ml)	180	225	194	150	210	275	145	200	275

Alarms

On call-duty was not considered as a problem on any of the investigated farms. There were on average 1.3 stop alarms per month, of which about 50 % at night. The frequency of stop alarms varied between farms from once a week to once in two months. These great variations

could be explained by differences in management routines on the farms, but this needs further investigation.

Why AMS?

All of the interviewed farmers reported that the main motivation for investment in AMS was a better social life, due to a greater flexibility. The second reason stated was a decreased need for extern employees and less heavy work related to milking. This agrees with Meskens & Mathijs (2002) who found that social reasons such as increased labour flexibility, improved social life and health concerns were the primary motivations for investing in AMS. One of the farmers in the present study also mentioned a technical interest as a reason for investment.

None of the interviewed farmers mentioned a higher milk yield as a motivation, which was somewhat surprising. This indicates that farmers do not really believe in the possibility to increase milk yield when introducing an AMS. In literature there are different observations regarding milk yield in an AMS compared to a conventional system. Wagner-Storch & Palmer (2003) and Svennersten-Sjaunja *et al*. (2002) both found a positive impact of AMS on the milk yield. However, Speroni *et al*. (2006) and Hopster *et al*. (2002) could not find any proof for a higher milk yield, when comparing AMS and traditional systems.

CONCLUSIONS AND RECOMMENDATIONS

Extra visits

The present study shows that extra visits are positive up to a certain limit, approximately two extra visits and four to five total visits per cow and day. More than two extra visits do not have any positive impact on the milking interval or its standard deviation. Low yielding cows are standing for the greatest part of extra visits, which is negative because it takes valuable time from the system and does not result in more milk. To decrease the number of extra visits for low yielding cows, it is important to minimise the risk for feed left-overs in the MU by restricting the concentrate allotments. High yielding cows, on the other hand, should pay more visits to the MU to decrease their milking intervals. It therefore is a challenge to manage feeding so that the number of extra visits is optimised.

Feeding strategies

There could be a positive effect of the number of roughage feedings per day on the annual milk yield. It is important to always provide feed on the feeding table at least 23 hours per day. If the feeding table is empty in the mornings there will be a disturbance in cow traffic, resulting in fewer milkings in the morning and queuing in front of the MU after morning feeding. The farmers should be aware of the meaning of *ad lib.* feeding and also follow the recommendations, and thus never allow the feeding table to be empty. Farmers often plan for the feeding table to be empty once a day to make cleaning easier. Unfortunately it is common to put this empty period in the morning, which means that the farmer usually has no idea about for how long the feeding table has been empty. To ensure good cow traffic, the empty period should be at daytime, so that the feeding table can be cleaned at once and then filled again.

Roughage feeding should not be done shortly after cleaning of the MU, because cows prioritise feeding over milking and thus visit the feeding table instead of the MU. This means that the "dead" period in the MU gets unnecessarily long if food is offered to the cows after cleaning of the MU. The negative effect is of course greatest if the feeding table is empty prior to cleaning. Instead, it could be an idea to synchronise feeding and washing, so that the dead time in the MU is used effectively for feeding.

Cows learn when the system is cleaned and stop visiting the MU already some time before. Therefore, cleaning should always be undertaken at the same time of the day, so that the disturbance in cow traffic is minimised. This is of course extra important if there is no buffer tank used, so that the MU is shut down during emptying and washing of the milk tank. The milk truck usually comes somewhat different times every day and thus there might be a loss in milkings. Therefore, there should always be a buffer tank in order to minimise disturbance.

Large amounts of concentrate do not increase the number of milkings, but instead the number of extra visits. The farms with the highest annual milk yield did not feed high amounts of concentrate in the MU. The conclusion could thus be that there is no point in feeding large amounts of concentrate in the MU.

Fetching
A high need for fetching is often used as an argument against free cow traffic, but the present study shows that free traffic does not necessarily mean many fetchings. The fetching frequency depends instead on herd size, free time in the MU, space in the AMS-barn and fetching routines. The impact of herd size seems to be great, with the average fetching frequency on farms with more than 60 cows per MU being thrice as high as on farms with less than 56 cows. This phenomenon is very interesting and should be further investigated. It seems like the manufacturers might have to adjust their recommendations regarding herd size.

There should be at least 11 % free time in the system to minimise the need for fetching. It is also important to be patient and not fetch late cows too early. The farms with the highest minimum interval for fetching also had the lowest number of fetched cows. The fetching frequencies on the commercial farms in this study are generally lower than observed earlier on research farms. Part of the explanation for this could be that the results in the current study are based on interviews. Therefore there should be further investigations of the need for fetching on commercial dairy farms with free cow traffic, using more scientific methods for the determination of the fetching frequency.

Milk flow
A high milk flow rate is necessary to maximise the capacity of the system. In order to expand the herd, and at the same time keep the optimum free time of 11 %, the milk flow rate usually has to be increased. If the herd size is expanded but the milk flow is not increased, there is a risk that the need for fetching cows increases considerably. When breading for a higher milk flow it is important to remember that this is an optimum parameter, meaning that it should neither be too low, nor too high, in order to keep good animal health in the herd (Tufvesson, 2008).

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APPENDICES

Appendix 1 – Questionnaire

Gård…….. **Datum……**
Installation av AMS år ……..

Brukare……

AMS-stallet:

Antal liggbås, mjölkkor: ……sinkor: ……kvigor: ……ungdjur …….

Mjölkning kan ske utanför AMS-stallet ( ) system: …….

Mjölkning möjlig i behandlingsbox: ( ) kalvningsbox: ( )

Djurmaterial:

Antal kor i AMS idag: …… Planerat i AMS: ……

Antal kor utanför AMS: ……..

Antal: SLB ……..SRB ……..Övriga ……

Bröstomfång: …….. (besättningsmedeltal)

Inkalvningsålder ……. Kalvningsintervall …….

Medelavkastning, kg ECM/år:

2006 i AMS: …….. Målsättning: ……..

Rekryteringsprocent med AMS: …….

Antal mjölkningar per ko och dygn:

2006: ……. Idag:……Målsättning: ……

Kalvningsfördelning:

Senaste året: ……

Målsättning: ……..

Djurhantering:

Kvigor som ska kalva……

Nykalvade kor: ……..

Nya kor i AMS-gruppen: ……..

Kor som skall sinläggas: ……

Sinkor:…….

Mastitkor: ……

Kor med höga celltal (ej mastit)……..

Övriga sjuka djur: …….

Djurhälsa:

Klövvård, antal gånger per år……

Tankcelltal, AMS:……

Förekommande behandlade mastiter:

Typ:	Antal 2006
……	…….
……	…….
……	…….

Problem med klövar/ben:

Typ:	Antal 2006
…..……	…….
…..……	…….

Foderrelaterade sjukdomar

Typ:	Antal 2006
…..……	…….
…..……	…….

Hur hittas sjuka kor:

……

……

Mjölkkvalitet i AMS

Frånsorterad mjölk i AMS:

Anledning	Frekvens	Kg mjölk
Råmjölk	……..	…….
Blod i mjölk	……..	…….
Mastitmjölk	……..	…….
Höga celltal	……..	…….
Totalt……	……..	…….

Stallet:

Gångar i lösdrift, typ……..……mått…… spaltgolv ( )

Gång vid utfodring typ……..……mått…… spaltgolv ( )

Foderbord, antal ätplatser, längd……

Foderbord med nackbom ( ) bogstöd ( ) ätbås ( ) övrigt ……

Antal kraftfoderstationer…….

Foderstationer placering, ( ) foderavdelning

( ) liggavdelning

( ) nära mjölkstation ( ) efter mjölkstation

Belysning i liggavdelning

Dagtid:…….Nattetid:…….

Foder:

Fodermedel som används

Mjölkstation ……..

Kraftfoderstationer …….

Utfodringssystem, grovfoder

Ensilage, separat ( ) Blandfoder ( ) Fullfoder ( )

Foderblandningens sammansättning

Fodermedel	kg	ts	MJ/kg	smb rp/kg
……	……	…….	……	……
……	……	…….	……	……
……	……	…….	……	……
……	……	…….	……	……
……	……	…….	……	……

Foder på foderbordet skall täcka……. kg mjölk

Antal utfodringar per dygn……man/aut?……

Tider för utfodring …… ……. ……. …… ……. ……

…… ……. ……. …… ……. ……

Önskat antal besök vid foderbordet per ko och dygn …….

Inställningar i kraftfoderstationen:

Kategori	Maxgiva per dygn:	per besök, kg
…….	……..	…….
…….	……..	…….
…….	……..	…….
…….	……..	…….

Inställningar i mjölkstationen:

Kategori	Maxgiva per dygn:	per besök, kg
…….	……..	…….
…….	……..	…….
…….	……..	…….
…….	……..	…….

Önskad fördelning mjölkstation/kraftfoderstationer:……

Mjölkning:

Behov av hämtning (även väckning och uppmotning):

Principer för hämtning:…….

När hämtas kor: ……

Hantering av hämtade kor

( ) stängs in före MS

( ) mjölkas före andra väntande kor

…….

Läckande kor ( ) Vanligt för vissa kor

( ) Sporadiskt vid långa mjölkningsintervall

( ) Sällan eller aldrig

Djurgrupper som hålls separerade och mjölkas separat i AMS:

Höga celltal ( ) Behandlingsbox ( ) Förstakalvare ( )

Annan grupp:……..

……..…

Arbetsrutiner

Rengörning båspallar
……
……

Rengörning väntytor, ev. ätbås
……
……

Strö-
ning……
……

Utfod-
ring……
……

Mjölkning, diskning, tanktömning
……
……
……

Varför AMS?

……..……..……

Arbetskraft:

Vilken erfarenhet har de som arbetar i stallet?
……..

……..

Vilka uppgifter har de?……..

……Normala arbetstider i stallet

Morgon…… Dag: ……..… kväll……

lörd/sönd ……

Totalt mjölkningsrelaterat arbete, tim/dag: …….

Totalt foderrelaterat arbete, tim/dag: …….

AMS-larm:

Frekvens: …….. stopplarm per …….., varav stopplarm nattetid: ……

Övrigt……
……
……

Appendix 2– Farm descriptions

Farm 1
Visiting date: May 14th 2007
Installation of AMS: December 2001
AMS barn:

- Two robots, one group
- Cubicles: lactating cows: 118, dry cows: 10, heifers: 35, young stock: 16
- No milking possible outside the AMS
- Hold-up in operation: approx. 1 h May 11th

Livestock:

- In AMS: 127 lactating cows + 8 heifers and dry cows
- Outside AMS: 15 dry cows
- Breeds: 20% SLB and 80% SRB
- Age at first calving: 26.6 months
- Calving interval: 12.6 months
- Milk yield: average for 2006: 9 700 kg ECM, goal: 9 500 – 10 500 kg ECM/year
- Replacement with AMS: 36%
- Number of milkings per cow and day: average 2006: 2.8 – 3.0; today: 2.6; goal: 2.8
- Calving distribution: last year: 10 – 15 calvings/month; goal: 10 – 15 = even distribution over the year

Livestock management:

- Heifers: AMS one month prior to calving, feed in the milking unit
- Older cows: AMS 14 days prior to calving
- After calving: 24 h in a separate calving box, milked once in the AMS (colostrums)
- Drying cows: less concentrate in the milking box (0.5 kg), if milk production is still high they get only water and straw for some days
- Dry cows: kept in a separate cold loose house system
- Mastitis cows: part of the group, are milked often
- Cows with high cell count (not mastitis): part of the group
- Other sick cows: treatment boxes but milked in the AMS

Animal health:

- Hoof care: 2 times/year
- Bulk milk somatic cell count: 180 000 cells/ml
- Sick cows are found by animal eye, computer programme and lists
- Treated cases of mastitis during 2006: nn
- Hoof/leg problems during 2006: nn
- Diseases related to feeding during 2006: nn

Stable:

- Three row system with slatted floor
- Alley in the free stall: 2.20 m
- Alley in the feeding area: 2.80 m
- Feeding table: 55 m with shoulder support (“bogstöd”)
- Automatic feeders for concentrate: four in the feeding area, two in the resting area
- Illumination in the resting area: full lights day and night

Feeding:

- Feed in the milking unit: Solid (commercial concentrate mixture)
- Feed in the automatic feeders for concentrate: Solid and soy meal
- Silage is fed separately *ad lib.* (empty < 2 h/day)
- Silage quality during the test period:
    1. From May 11th: Second cut, DM = 31%, ME = 10.3 MJ/kg DM, CP = 149 g/kg DM
    2. Before May 11th: First cut, DM = 30%, ME = 10.8 MJ/kg DM, CP = 150 g/kg DM
- Feeding is handled manually six to eight times a day at 06.00, 08.00, 10.00, 14.00, 16.00, 18.00, 20.00 and 22.00

Settings in the automatic concentrate feeder:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	9.5	4.5
Older cows	10.5	4.5

Settings for concentrate in the milking unit:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	6	5.5
Older cows	6	5.5

Fetching cows:

- 10 – 15 cows in the morning and 6 – 10 cows in the afternoon
- Milking interval > 10 h (> 8 h for high yielders) and unsuccessful milkings
- Fetched cows are locked up in front of the AMS
- Milk leakage: common for some cows, sporadic at long milking intervals for all cows

Groups of cows kept separately and milked separately in the AMS:

- First time calvers
- All cows 24 h after calving (milked once in the AMS)

Work routines:

- Rinsing of cubicles: morning, afternoon and evening, very exactly! Scraping on the slatted floor
- Cleaning of waiting area and feeding area: washing with a water hose in front and behind and in the robots
- Litter: Mondays, Wednesdays and Fridays, plenty of litter even though there is a rubber carpet in the cubicles (minilastare och ströskopa)
- Silage: belt feeder (PLC-controlled) (tower silo)
- Concentrate: automatic feeders to all animals
- Automatic cleaning of the robots twice a day (both robots at the same time)
- Buffer tank cleaning: every second day when emptying the tank

Why AMS:

- Saving labour
- Flexible working hours

Labour:

- Owners and one full-time employee

- Large experience
- "Animal eye" is very important!
- Working hours: weekdays: 06.00 – 09.00, 14.00 – 17.00, 21.00 – 21.30, weekends: 06.00 – 09.00, 17.00 – 20.00
- Total work related to milking: 5 h/day
- Total work related to feeding: 0.5 h/day

AMS alarm:

- Maximum of one stop alarm per month
- Half of the alarms at night
- Do not have problems with the alarm on-call duty

Other:

- Breeding deliberately for high milk flow with good results
- Operation stop approx. 1 h May 11th

Farm 2

Visiting date: May 14th 2007
Installation of AMS: 2000 and April 2005 (after a big fire 2004)
AMS barn:

- Two robots
- Cubicles: lactating cows: 118, heifers and young stock: 110
- No milking possible outside the AMS

Livestock:

- In AMS: 113 cows (108 lactating); goal: 118
- Outside AMS: 0
- Breeds: 70% SLB and 30% SRB
- Age at first calving: 28 months
- Calving interval: 11.8 months (13.3 after the fire)
- Milk yield: average for 2006: 9 200 kg ECM, goal for 2007: 10 300 kg ECM
- Replacement with AMS: 42%
- Number of milkings per cow and day: average 2006: 2.8; today: 2.8; goal: 3.0
- Calving distribution: even distribution over the year

Livestock management:

- Heifers: AMS about two months prior to calving
- Older cows: always in the AMS, calving normally in the free range ("lösdrift")
- After calving: part of the AMS group
- Drying cows: part of the AMS group
- Dry cows: part of the AMS group
- Mastitis cows: part of the AMS group or treatment boxes, milked in the AMS
- Cows with high cell count (not mastitis): part of the AMS group
- Other sick cows: part of the AMS group or treatment boxes, milked in the AMS

Animal health:

- Hoof care: 2 times/year
- Bulk milk somatic cell count: 200 000 – 250 000 cells/ml
- Sick cows are found by MQC warning (not visiting the robot) and when "mota upp" all cows for straying in the morning

- Treated cases of mastitis during 2006:

Type	No.
E. coli	7

- Hoof/leg problems during 2006:

"Klövspalt"	6 - 7
Lameness	2 - 3

- Diseases related to feeding during 2006:

Type	No.
"Löpmage"	1

Discarded milk in the AMS:

- Colostrums: average two cows
- Blood: 1 -2 cows/year
- Mastitis/high cell count: average 2 – 3 cows
- Total: 159 kg milk/day (average over 7 days)

Stable:

- xxx row system with slatted floor
- Alley in the free stall: 2.20 m
- Alley in the feeding area: 2.80 m
- Feeding table: 40 m with shoulder support ("bogstöd")
- Automatic feeders for concentrate: four in the feeding area
- Illumination in the resting area: same at day and night

Feeding:

- Feed in the milking unit: crushed cereals and Unik 52 (commercial concentrate mixture)
- Feed in the automatic feeders for concentrate: crushed cereals and Unik 52
- Silage is fed separately *ad lib.* (empty in the mornings)
- Feeding is handled manually five times a day at 07.00, 09.00, 13.30, 16.00 and 18.00
- Do not adapt silage portion after feed analysis, but choose type of concentrate after silage quality; if problems – closer analysis
- Silage quality during the test period: First cut, DM = 38%, ME = 10.4 MJ/kg DM, CP = 150 g/kg DM

Settings for concentrate in the milking unit:

- Maximum per day: 4 kg crushed cereals and 4 kg Unik 52
- Maximum per visit: 1.2 kg crushed cereals and 1.2 kg Unik 52
- Same for all categories of cows

Fetching cows:

- Mornings and afternoons, 3 – 4 cows per occasion
- Milking interval > 12 h and cows with unsuccessful milkings
- Fetched cows are milked before waiting cows if there are many cows waiting
- Milk leakage: sporadic at long milking intervals for all cows

Groups of cows kept separately and milked separately in the AMS:

- All in one

group Work routines:

- Rinsing of cubicles: scraping morning and evening

- Cleaning of the feeding table: Every morning
- Litter: Manually every morning
- Cleaning: Automatic cleaning of the robot twice a day, scavenging around the robot and the robotic arm twice a day

Why AMS:

- Avoid the heavy milking work
- More convenient working hours

Labour:

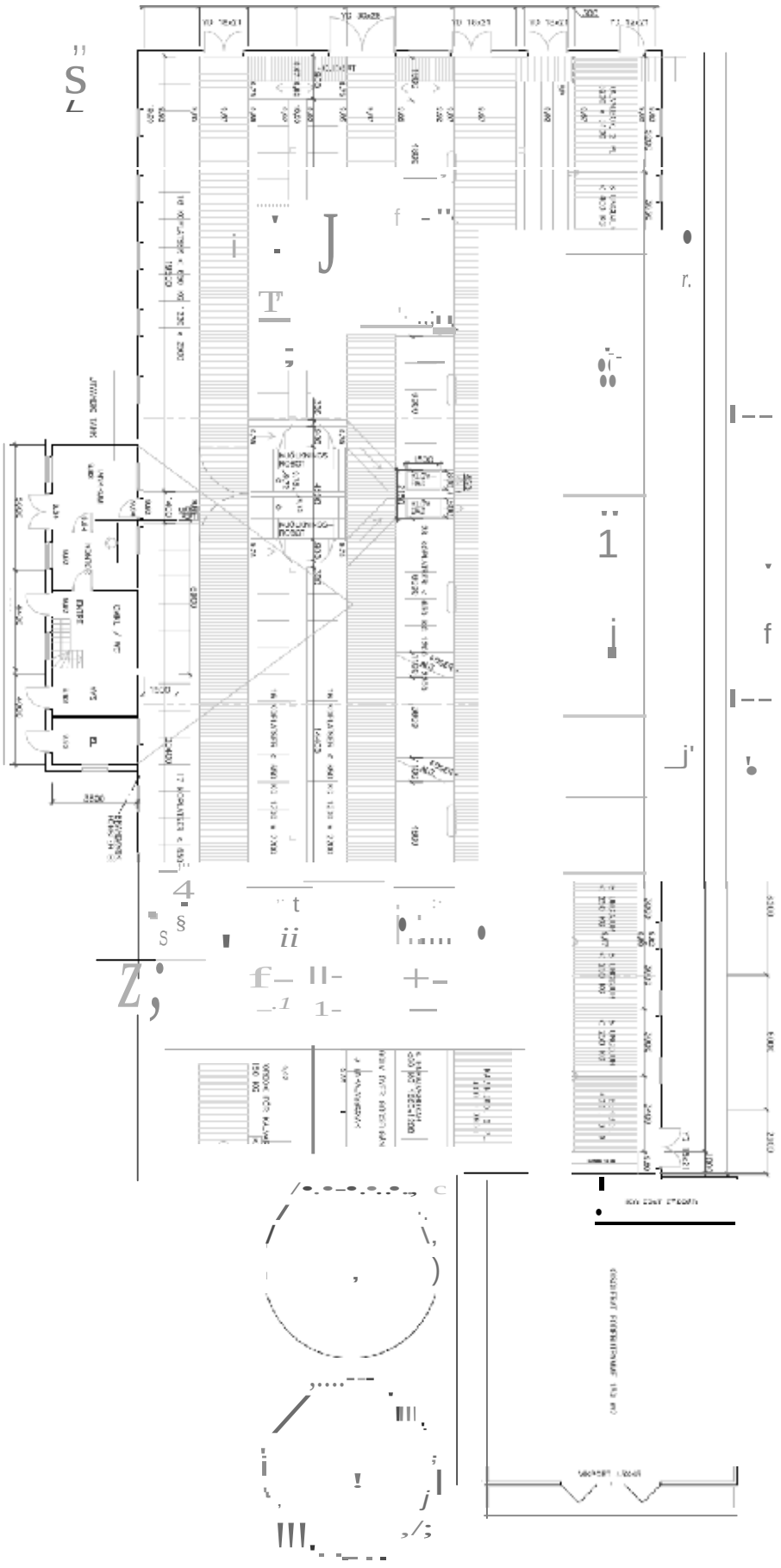
- Owners and a hired substitute 4 days/month
- Good experience
- Working hours: weekdays: 07.00 – 09.00, 13.30 – 13.45, 16.00 – 18.00, weekends: same
- Total work related to milking: 35 min/day (of which fetching 15 + 15 min/day)
- Total work related to feeding: approx. 25 min/day

AMS alarm:

- One stop alarm per month
- Half of the alarms at night
- Do not have problems with the alarm on-call duty

Other:

- Do not treat mastitis other than during the dry period, lactating period: cut off the infected teat or cull the cow



Farm 3
Visiting date: May 14th 2007
Installation of AMS: 2004 (used system)
AMS barn:

- One robot
- Cubicles: lactating cows: 71
- Milking possible in the parlour "grop" (seldom used)

Livestock:

- In AMS: 62 lactating cows, goal: 60 - 65
- Outside AMS: 70 young stock in a separate barn
- Breeds: 56% SLB and 44% SRB
- Chest size: 192 cm on average for the herd
- Age at first calving: 27 months
- Calving interval: 13.6 months
- Milk yield: average for 2006: 9 519 kg ECM, goal: 10 000 kg ECM/year
- Replacement with AMS: 40%
- Number of milkings per cow and day: average 2006: 2.7 today: 2.7; goal: 2.8 – 2.9
- Calving distribution: last year: less calvings in April – June; goal: even distribution

Livestock management:

- Heifers: AMS approx. Four weeks prior to calving
- Fresh cows: separate calving box during calving, separated immediately from the calve and put back in the AMS
- Drying cows: dried off "when it is time", sometimes depending on milk yield
- Dry cows: kept in a separate barn
- Mastitis cows: part of the AMS-group
- Cows with high cell count (not mastitis): part of the group
- Other sick cows: treatment boxes but milked in the AMS

Animal health:

- Hoof care: 2 times/year
- Bulk milk somatic cell count: 194 000 cells/ml
- Sick cows are found by studying the animals, computer lists are used for help
- Treated cases of mastitis during 2006:

Type	No.
Sr. dysgalactiae	5
E. coli	2
S. aureus	2
Klebsiella spp.	1

- Hoof/leg problems during 2006:

Type	No.
"Klövspalt"	2

- Diseases related to feeding during 2006:

Type	No.
"Acetonemier"	2

Discarded milk in the AMS:

- Total: 28 kg milk/day (average over 7 days) (“ringorm” treatment), average/month: 500 kg

Stable:

- xxx row system with slatted floor
- Alley in the free stall: 1.20 m
- Alley in the feeding area: 2.00 m
- Feeding table: 20 eating stands and 62 eating cubicles
- Automatic feeders for concentrate: three in the resting area
- Illumination in the resting area: full lights day and night

Feeding:

- Feed in the milking unit: cereals and concentrate
- Feed in the automatic feeders for concentrate: cereals and concentrate
- Distribution milking unit/automatic feeders: > 40% in the robot
- Silage is fed separately, *ad lib.* but empty almost every morning (approx. 3 – 4 h)
- Silage portion should cover milk yield > 22 – 23 kg ECM
- Silage quality during the test period: First cut, DM = 30%, ME = 11.5 MJ/kg DM, CP = 175 g/kg DM, NDF = 553 g/kg DM
- Feeding is handled manually two times a day at 07.00 and 16.30
- Visits at the feeding table: goal: at least five/day, more silage at the eating stands to get rotation, eating cubicles result in bad rotation

Settings in the automatic concentrate feeder:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	11.4	3
Older cows	9.5	3
High yielders	9.5	3
Heifers < 60 days	11.4	4

Settings for concentrate in the milking unit:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	6.5	4
Older cows	6.5	4
High yielders	6.5	4
Heifers < 60 days	6.5	4.5

Fetching cows:

- Twice a day, 06.00 and < 15.00, 5 – 8 cows/occasion
- Milking interval > 12 h
- 3 – 4 fetched cows are milked before other waiting cows, “resterande” are locked up in front of the AMS
- Milk leakage: sporadic at long milking intervals for all

cows Work routines:

- Rinsing of cubicles: 2 times/day
- Litter: 1 time/day
- Feeding: manually 2 times/day
- Cleaning: Automatic cleaning, the buffer tank is cleaned when emptied

Why AMS:

- Hard to find labour for milking 3 times/day
- Better social life

Labour:

- One part-time employee when needed (no agricultural education)
- Working hours: weekdays: 06.00 – 08.00, 15.00 – 17.00, at night: check for cows in heat, weekends: same
- Total work related to milking: 3.5 h/day (max. 1 – 1.5 h/day for milking)
- Total work related to feeding: approx. 0.5 h/day

AMS alarm:

- Total 10 stop alarm per year
- Half of the alarms at night
- Very few alarms
- Common alarm reason: hose that has been ripped apart

Other:

- First-time calvers produce badly – environmental cause? Too little space?
- Too much silage on the feeding table gives problems with cow traffic

Farm 4

Visiting date: May 15th 2007

Installation of AMS: October 2003

AMS barn:

- Two robots
- Cubicles: 118 for lactating cows, dry cows and heifers
- Young stock are kept at a neighbour's barn
- Milking possible outside the AMS: "dubbel-8", treatment boxes and calving boxes

Livestock:

- In AMS: 106 lactating cows (total 138 cows), goal: 120 lactating cows
- Outside AMS: 8 cows
- Breeds: 20% SLB and 80% SRB, medium seized cows
- Age at first calving: 26 months
- Calving interval: approx. 11.9 months
- Milk yield: average for 2006: 9 600 kg ECM, goal: approx. 10 000 kg ECM/year
- Replacement with AMS: 32%
- Number of milkings per cow and day: 2.6 in average for 7 days; goal: 2.7 – 3.2
- Calving distribution: last year: even over the year; goal: same

Livestock management:

- Heifers: AMS 14 days prior to calving
- Fresh cows: calving in separate calving box, immediately back to the AMS-group
- Drying cows: removed from the AMS when milking < 12 – 14 kg
- Dry cows: part of the group, outside during grazing period
- Mastitis cows: part of the AMS-group, really bad individuals are milked in the parlour
- Cows with high cell count (not mastitis): part of the AMS-group
- Other sick cows: treatment boxes and milked in the parlour

Animal health:

- Hoof care: 2 times/year and when necessary
- Bulk milk somatic cell count: 115 000 - 180 000 cells/ml
- Best paid for < 150 000 cells/ml, but chose category 2 (< 200 000 cells)
- Sick cows are found by animal eye and computer programme
- Treated cases of mastitis during 2006:

Type	No.
S. aureus	20

- Hoof/leg problems during 2006:

Type	No.
	2

- Diseases related to feeding during 2006:

Type	No.
Milk fever	3 - 5

Discarded milk in the AMS:

- Total: 34 kg milk/day (average for 7 days)

Stable:

- xxx row system with slatted floor
- Alley in the free stall: 3.50 m
- Alley in the feeding area: 3.50 m
- Feeding table: 35 m with shoulder support ("bogstöd"), under reconstruction
- Automatic feeders for concentrate: five in the feeding area/resting area (same)
- Illumination in the resting area: little less at night

Feeding:

- Feed in the milking unit: Solid Profet (commercial concentrate mixture)
- Feed in the automatic feeders for concentrate: Solid Profet and Suverän
- Silage is fed separately *ad lib.* (empty once/day, normally in the morning)
- Silage quality during the test period: Xx cut, DM = x %, ME = x MJ/kg DM, CP = x g/kg DM, NDF = x g/kg DM
- Feeding is handled automatically twice a day at 06.00 and

16.00 Settings in the automatic concentrate feeder:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	9	2
Older cows	14	2

Settings for concentrate in the milking unit:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	4	5
Older cows	5	5

Fetching cows:

- As few as possible, do not want the cows to get used to being fetched
- 1 – 10 cows morning and evening
- Milking interval > 14 h

- Fetched cows are locked up in front of the AMS
- Milk leakage: sporadic at long milking intervals for all cows

Groups of cows kept separately and milked separately in the AMS:

- None – are milked in the

parlour Work routines:

- Rinsing of cubicles: big cleaning once/year
- Cleaning of waiting area and feeding area: close to the robot 2 – 3 times/year
- Litter: 2 times/day
- Feeding: belt feeder and silo emptier
- Cleaning: automatic cleaning of the robots 3 times/day, automatic cleaning of the buffer tank

Why AMS:

- "Slippa" milking work
- Better working environment

Labour:

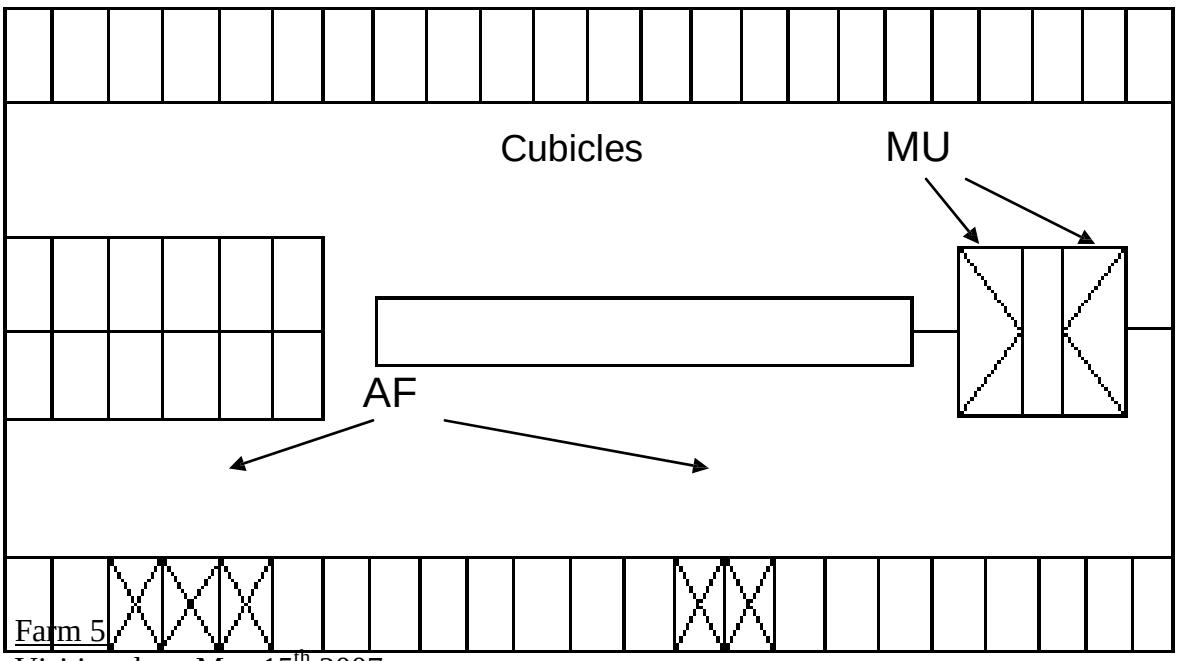
- Family and one full-time employee
- Working hours: weekdays: 06.00 – 09.00 and 15.00 – 18.00, weekends: same
- Total work related to milking: 6 h/day
- Total work related to feeding: 0.5 h/day (young stock)

AMS alarm:

- One stop alarm per week
- Most of the alarms at night
- Day-time you can fix before there is a stop alarm

Other:

- Highest milk yield is not the same as best total economy
- Bad contract with the neighbour – do not get the best heifers
- Low no. of milkings/day (2.6), some cows only 1 milking/day



Farm 5

Visiting date: May 15th 2007

Installation of AMS: 2004
AMS barn:

- Two robots
- Cubicles: 126
- Milking possible in "rör" system, treatment boxes and calving boxes
- Two robots, two groups of cows

Livestock:

- In AMS: total 105 cows; approx. 93 lactating cows and 12 dry cows and heifers; goal: around 115 cows
- Outside AMS: 0
- Breeds: 54% SLB, 42% SRB and other
- No young stock on the farm, heifers are bought in from the owners brother
- Age at first calving: 28.7 months
- Calving interval: 13 months
- Milk yield: average for 2006: 10 297 kg ECM, goal: increase
- Replacement with AMS: 41% (trying to increase the quality of the herd)
- Number of milkings per cow and day: average 2006: approx. 2.6; today: approx. 2.6; goal: 3
- Calving distribution: last year: inseminations in autumn and spring; goal: even distribution over the year

Livestock management:

- Heifers: bought in 1.5 months (at least 1 month) prior to calving; tied up in a stanchion barn for about 2 weeks, in the AMS-group one month prior to calving
- Fresh cows: calving in the loose herd, the calf is taken away and the cow continues in the AMS
- Bought in older cows: always during the dry period, join the dry cow group, introduced to the AMS the same way as heifers
- Drying cows: time is the important parameter for drying off cows, milk production has some impact, in the AMS-group but are not milked
- Dry cows: separate part of the barn, if there are few dry cows they are kept in the AMS
- Mastitis cows: part of the AMS-group
- Cows with high cell count (not mastitis): part of the group
- Other sick cows: treatment boxes or tied up, milked in the AMS or with "spann" depending on how bad they are, sometimes sucked by a calf

Animal health:

- Hoof care: 2 times/year
- Bulk milk somatic cell count: little over 200 000 cells/ml
- Sick cows are found by animal eye
- Treated cases of mastitis during 2006:

Type	No.
Sr. dysgalactiae	1
*KNS**	2
S. aureus	1
Bl. fl. (?)	3

*Koagulas Negative Stafylococcus

- Hoof/leg problems during 2006: none
- Diseases related to feeding during 2006:

Type	No.
"Acetonemier"	2
"Löpmage"	2

Discarded/separated milk in the AMS:

- Total: 32 kg milk/day (average for 7 days)

Stable:

- xxx row system with slatted floor
- Alley in the free stall: 2.20 m
- Alley in the feeding area: 2.80 m (+ 0.50 m "klövpall")
- Feeding table: 26 m with shoulder support ("bogstöd")
- Automatic feeders for concentrate: four in the resting area
- Illumination in the resting area: daytime: full lights if necessary, night illumination

Feeding:

- Feed in the milking unit: Solid 270 (commercial concentrate mixture)
- Feed in the automatic feeders for concentrate: Solid 270
- Silage is fed separately *ad lib.* (sometimes empty on the feeding table, no specific time of the day)
- Silage quality during the test period: DM = 44%, ME = 10.2 MJ/kg DM, CP = 145 g/kg DM, NDF = 579 g/kg DM
- Feeding is handled automatically16 times a day at 00.10, 03.00, 04.30, 06.00, 07.30, 08.30, 09.30, 11.00, 12.30, 14.00, 15.30, 16.30, 18.00, 19.30, 21.00 and 22.00

Settings in the automatic concentrate feeder:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	15	2.5
Older cows	15	2.5

Settings for concentrate in the milking unit:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	5	
Older cows	5	

Fetching cows:

- Two times/day about 9 cows in total (often less, some variation occurs)
- Milking interval > 10 h and the ones that always are fetched (right now 5 heifers)
- Fetched cows are locked up in front of the AMS, waiting area for 1 – 2 cows, in special cases the fetched cows are milked before other waiting cows
- Milk leakage: common for some cows, sporadic at long milking intervals for all cows

Groups of cows kept separately and milked separately in the AMS:

- First time calvers
- Two random groups, one for each robot

Work routines:

- Rinsing of cubicles: scraping twice/day
- Litter: twice/day

- Silage: filling the mixer once a day
- Automatic cleaning of the robots 3 times/day
- Automatic buffer tank cleaning

Why AMS:

- Wanted to

change Labour:

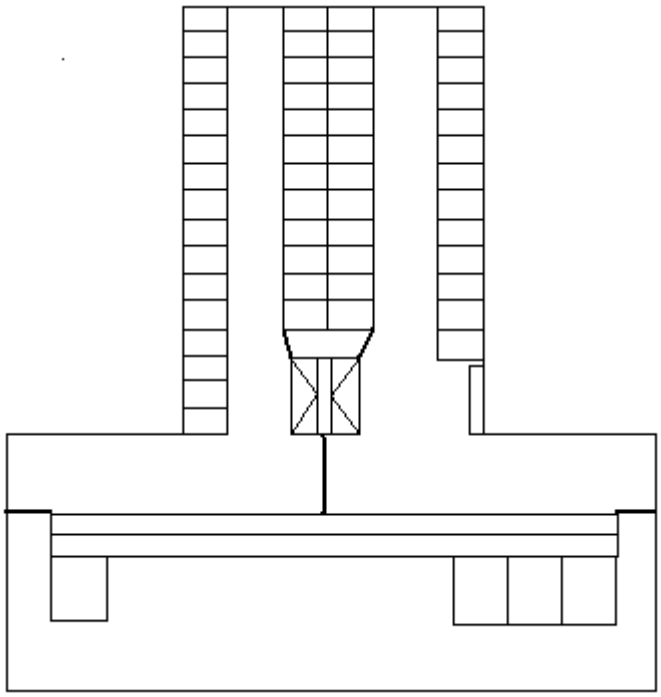
- Owner, one part-time employee (1.5 days/week) and a hired substitute (2 times/month)
- Working hours: weekdays: 06.45 – 09.15 and 15.30 – 18.15 (very flexible!), week-ends: same
- Total work related to milking: 4.5 h/day
- Total work related to feeding: 0.75 h/day (feeding calves)

AMS alarm:

- Maximum of one stop alarm per month
- Half of the alarms at night
- Do not have problems with the alarm on-call duty

Other:

- Increased flexibility, but also increased number of cows which results in an unchanged work demand in total



Farm 6
Visiting date: May 15th 2007
Installation of AMS: 2005
Organic farm
AMS barn:

- One robot
- Cubicles: 60 for lactating cows, 10 for dry cows and 14 for heifers
- Milking possible in a few "långbåsplatser", treatment boxes and calving boxes

Livestock:

- In AMS: 60 cows; goal: 65 cows
- Outside AMS: 5
- Breeds: 40% SLB, 60% SRB
- "Bröstomfång" in average for the herd: 192 cm
- Age at first calving: 25.1 months
- Calving interval: 12.8 months
- Milk yield: average for 2006: 9 450 kg ECM, goal: 10 000
- Replacement with AMS: 40%
- Number of milkings per cow and day: 2006: nn; today: approx. 2.5; goal: 2.8 – 3.0
- Calving distribution: last year: hardly any in May to July, many in August, September, December and January; goal: increased number of calvings in April to July

Livestock management:

- Heifers: in the AMS three to two weeks prior to calving
- Fresh cows: calving box four to five days, then AMS
- Drying cows: old barn, only fed straw
- Dry cows: own group, fed straw and some silage
- Mastitis cows: old barn, treated
- Cows with high cell count (not mastitis): part of IndividJuver (Swedish Dairy Association's control program for udder health), try to slaughter chronicles and cows that have or have had *S. aureus*, seldom treated
- Other sick cows: treatment boxes or tied up in the old

barn Animal health:

- Hoof care: 3 times/year
- Bulk milk somatic cell count: 250 000 – 300 000 cells/ml
- Sick cows are usually found because they do not come to the MU
- Treated cases of mastitis during 2006:

Type	No.
E. coli	3
Streptococcus	2
S. aureus	2

- Hoof/leg problems during 2006:

Type	No.
Hooves	2

- Diseases related to feeding during 2006:

"Acetonemi"	1 – 2
"Trumsjuka"	2

Discarded/separated milk in the AMS:

- Total: hardly any, no colostrums because fresh cows are milked in the calving boxes, blood in the milk the most common reason for discard (2 to 3 cows/year)

Stable:

- xxx row system
- Alley in the free stall: rubber mat
- Alley in the feeding area: rubber mat
- Feeding table: 29 eating cubicles
- Automatic feeders for concentrate: two in the feeding area, close to the MU, after the MU
- Illumination in the resting area: daytime: "lysrör"; night time: some lights (night illumination)

Feeding:

- Feed in the MU: crushed cereals and commercial concentrate (Akleja 100 (80))
- Feed in the AF for concentrate: crushed cereals
- Silage is fed separately
- Silage portion should cover milk yield about 20 kg milk
- Feeding is handled automatically 8 times a day at 03.00, 06.00, 09.00, 12.00, 15.00, 18.00, 21.00 and 24.00

Settings in the automatic concentrate feeder:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers		
Older cows		

Settings for concentrate in the milking unit:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers		
Older cows		

Fetching cows:

- 1 – 2 cows per day
- Milking interval > 20 h
- Fetched cows are milked before other waiting cows
- Milk leakage: common for some cows, sporadic at long milking intervals

Groups of cows kept separately and milked separately in the AMS:

- None

Work routines:

- Rinsing of cubicles: scraping twice/day
- Litter: once/day
- Cleaning of the robot and changing filters twice/day
- Buffer tank is used while cleaning the robot

Why AMS:

- Barn too old, had to quit or invest in a new barn
- Parlour did not feel right
- Interested in techniques

Labour:

- Owner and extern employees (earlier experience of working with cows and basic agricultural education are always required)
- Working hours: weekdays: 06.30 –15.30, weekends: 06.30 – 08.30 and 14.00 – 15.30 (flexible)
- Total work related to milking: nn
- Total work related to feeding: 2 h/day (including young stock)

AMS alarm:

- 1 - 2 stop alarms per month

Farm 7

Visiting date: May 21st 2007
Installation of AMS: November 2006
AMS barn:

- Two robots, one group
- Cubicles: lactating cows: 136, dry cows: 16, heifers: 29
- Milking possible outside the AMS: stanchion barn, treatment boxes and calving boxes
- Two robots, one group of cows

Livestock:

- In AMS: 102 lactating cows, goal: 130
- Outside AMS: 14
- Breeds: 18% SLB and 82% SRB, 1 SKB cow
- Age at first calving: 25 months
- Calving interval: 12 months for cows, 14 months for heifers
- Milk yield: average until today: 32.5 kg ECM/cow and day, but lower after a change in feeding
- New herd! 70 – 75% heifers
- Replacement with AMS: nn
- Number of milkings per cow and day: today: 2.6; goal: 2.7 - 2.8
- Calving distribution: last year: varying a lot (bought in cows); goal: even distribution over the year

Livestock management:

- Heifers: in the old barn or in a calving box
- Fresh cows: calving box
- New cows: fetched 2 weeks – 2.5 months (all were tied up earlier)
- Drying cows: old barn, milked every second day, penicillin treatment during dry period if necessary
- Dry cows: 16 in the AMS, "resten" in the old barn
- Mastitis cows: none, marked for mastitis in the computer, but disappeared again after one day
- Cows with high cell count (not mastitis): old barn
- Other sick cows: old barn

Animal health:

- Hoof care: 3 times/year
- Bulk milk somatic cell count: 145 000 cells/ml

- Sick cows are found by the computer: late for milking – studying the cow, conductivity ...
- Treated cases of mastitis during 2006: none
- Hoof/leg problems during 2006: in the beginning, cows not used to free stall
- Diseases related to feeding during 2006: none

Discarded/separated milk in the AMS:

- Colostrums: five first days after calving
- Blood: some in the beginning
- High cell count: some
- Total: nn (very little)
- All spirited milk is fed to the calves

Stable:

- xxx row system
- Alley in the free stall: 2.80 m, scraped floor with rubber carpet
- Alley in the feeding area: 3 m + 40 cm "klövpall"
- Alley close to the robot: 3 x 15 m
- Feeding table: 50 m with shoulder support ("bogstöd")
- Automatic feeders for concentrate: four in the resting area, far from the robots
- Illumination in the resting area: full lights day, darker at night (depending on the season)

Feeding:

- Feed in the milking unit: Solid 120 (commercial concentrate mixture) and Acetona (first month after calving)
- Feed in the automatic feeders: Solid 120 and Perfekt
- PMR (partly mixed ration):

Feed	Silage	Straw	Minerals	Crushed cereals*	Salt	Lime
Ration	2.5 tons/100 cows	0.8 kg/cow	8 kg/all cows	450 kg/all cows	8 kg/all cows	8 kg/all cows

* 80% barley and 20% wheat

- Feeding is handled automatically five times a day at 09.00, 11.30, 16.00, 18.00 and 24.00/01.00 and 22.00 (goal: 6 – 7 times/day)
- PMR portion should cover milk yield about 26 kg ECM, never empty on the feeding table

Settings in the automatic concentrate feeder:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Older cows (55 kg*)	7.5	
Older cows (40 kg*)	4.5	
Heifers (50 kg*)	7	
Heifers (40 kg*)	5	

* milk production

Settings for concentrate in the milking unit:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Older cows (55 kg*)	5	
Older cows (40 kg*)	4	
Heifers (50 kg*)	4.5	

Heifers (40 kg*)	4

* milk production

Wanted distribution automatic feeder/milking unit: mostly milking unit

Fetching cows:

- 3 old cows and 1 new heifer per day (in average)
- No specific time of the day!
- Milking interval > 15 - 16 h
- Fetched cows cannot be locked up in front of the AMS, but are put directly in the robot
- Do not want to disturb working cows -> if there are cows waiting fetching is delayed
- Milk leakage: sporadic at long milking intervals

Groups of cows kept separately and milked separately in the AMS:

- None

Work routines:

- Rinsing of cubicles: scraping 3 times/day on the slatted floor
- Cleaning of waiting area: slatted floor and "self-fall" at the robots are enough when the faeces are loose
- Litter: 1 time/week or 1 time/two weeks
- Automatic cleaning of the robots 3 times/day
- Buffer tank cleaning

Why AMS:

- Wanted to increase the herd
- Hard to find employees

Labour:

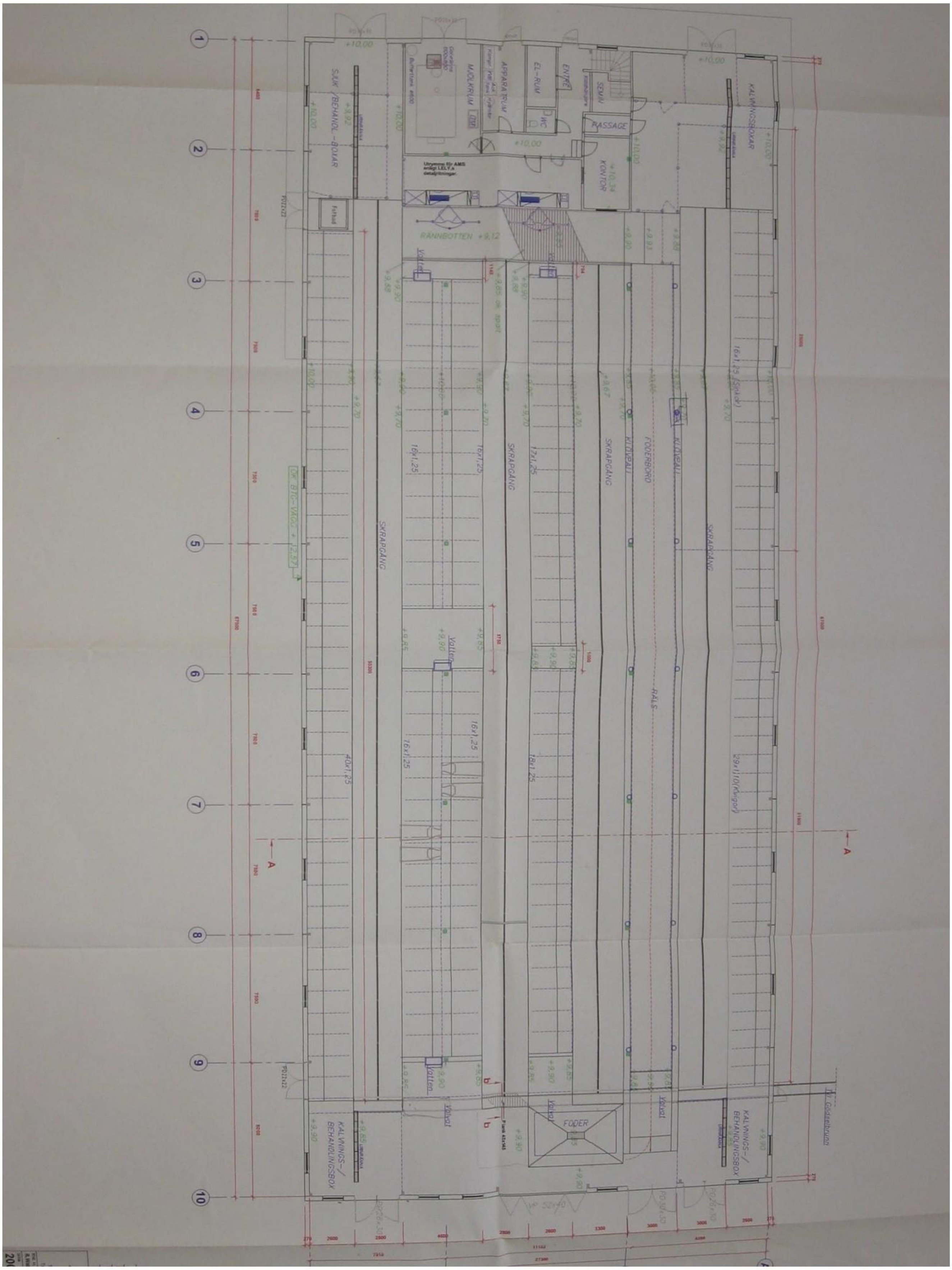
- Owners (father and son), one whole-time employee and two extras when needed (working hours)
- Always the same people working
- Working hours: weekdays: 08.00 – 09.00, 11.00 – 12.00, 17.30 – 18.00 and 24.00 – 01.00; weekends: same
- Total work related to milking: 3 h/day
- Total work related to feeding: 2 h/day

AMS alarm:

- Maximum of one stop alarm per month
- None of the alarms at night

Other:

- Extra wide alleys and "passager"
- Lots of space
- Water tubs outside the alleys to spare space inside
- Automatic feeders far from the robots to minimise disturbance
- Cow traffic is working very well
- Many cows eating/resting
- Few cows waiting at the robots


SJUK-/BEHANDL.-BOXAR
MJÖLKRUM
APPARATRUM
EL-RUM
ENTRÉ
SEMIN
WC
PASSAGE
KONTOR
KALVNINGSBOXAR
RÅNNBOTTEN +9,12
SKRAPGÅNG
FODERBORD
RALS
FODER
KALVNINGS-/BEHANDLINGSBOX

Farm 8
Visiting date: May 20th 2007
Installation of AMS: May 2006
Organic farm
AMS barn:

- One robot
- Cubicles: 70
- Milking possible in "rör" system (separate old stanchion barn), treatment boxes and calving boxes

Livestock:

- In AMS: 40 cows; goal: 70 cows
- Outside AMS: 0
- Breeds: 7% SLB, 84% SRB, 3% Jersey and 6% Jersey mixes
- Age at first calving: 28 months
- Calving interval: 15 months
- Milk yield: average for 2006: nn (8 000 kg ECM/year in the old system, but production has increased with the robot), goal: 10 000 kg ECM/cow and year
- Replacement with AMS: nn
- Number of milkings per cow and day: average 2006: nn; today: 2.4; goal: 3
- Calving distribution: last year: even distribution over the year; goal: even distribution over the year

Livestock management:

- Heifers: loose on deep stray in the old barn, in the AMS-barn if there is space
- Fresh cows: in the old barn 3 – 4 days
- Bought in older cows: none
- Drying cows: dried off at 8 – 10 kg milk production, no concentrate
- Dry cows: in the AMS-barn or on deep stray in the old barn
- Mastitis cows: old barn, but have not had any yet
- Cows with high cell count (not mastitis): part of the group
- Other sick cows: old barn

Animal health:

- Hoof care: 2 times/year
- Bulk milk somatic cell count: 270 000 cells/ml last time, normally < 190 000 cells/ml
- Sick cows are found by observation, computer as help
- Treated cases of mastitis during 2006: none
- Hoof/leg problems during 2006: none
- Diseases related to feeding during 2006:

Type	No.
"Kalvningsförlamning"	2

Discarded/separated milk in the AMS:

- Total: 1 000 kg milk/month
- Jersey cows are separated as colostrums
- Blood: few occasions only
- Mastitis: robot is very sensitive (too sensitive?)

Stable:

- xxx row system with rubber carpet
- Alleys in the free stall: 2.70 m
- Alleys in the feeding area: 3.20 m
- Feeding table: 25.5 m with shoulder support ("bogstöd")
- Automatic feeders for concentrate: 3 in the resting area
- Illumination in the resting area: daytime: full lights (28 lights), night: less (2 lights)

Feeding:

- Feed in the milking unit: Akleja 80 (commercial concentrate mixture) and crushed cereals (50% oats and 50% autumn wheat)
- Feed in the automatic feeders for concentrate: Akleja 80, crushed cereals and minerals
- Silage is fed separately (feeding table empty a few times each day, always empty in the mornings)
- Silage quality during the test period: DM = x%, ME = x MJ/kg DM, CP = x g/kg DM, NDF = x g/kg DM
- Feeding is handled manually 5 times a day at 07.00, 11.00, 16.00, 19.30 and 23.00
- Silage portion should cover milk yield about 24 kg

Settings in the automatic concentrate feeder:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	6 + 6	
Older cows	4 + 4	

Settings for concentrate in the milking unit:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Heifers	2.6 + 2.6	
Older cows	3 + 3	

Wanted distribution automatic feeders/milking unit: more in the feeders, do not have time to eat too much in the milking unit

Fetching cows:

- Two times/day at 07.00 and 18.00
- Milking interval > 12 h
- Total 3 cows/day, always the same, normally no other cows
- Fetched cows are locked up in front of the AMS and milked before other waiting cows
- Milk leakage: sporadic at long milking intervals

Groups of cows kept separately and milked separately in the AMS: none

Work routines:

- Rinsing of cubicles: scraping 3 times/day at 07.00, 11.00 and 18.00
- Waiting area: scraping 3 times/day at 07.00, 11.00 and 18.00
- Litter: distributed 3 times/day at 07.00, 11.00 and 18.00, one wheelbarrow with new litter every night
- Silage: "sopa" the feeding table 5 times/day and then use the silage barrow to feed
- Automatic cleaning of the robot 3 times/day
- Automatic buffer tank cleaning

Why AMS:

- Easier work

- Less wear for the

body Labour:

- Owner and two employees
- Owner has large experience, dairy cows since 1986
- Employee 1: basic agricultural education, substitute in the barn
- Employee 2: no education, cleaning and feeding
- Working hours: weekdays: 07.00 – 09.00, 11.00 – 11.30 and 18.00 – 20.00, weekends: same
- Total work related to milking: 1 h/day (+ cleaning 1.5 h)
- Total work related to feeding: 2 h/day

AMS alarm:

- Maximum of one stop alarm per two months
- None of the alarms at night
- Very few alarms!

Other:

- Increased production with AMS (showing now, second calvings)
- New building for the AMS
- Many bad cows are kept to increase the herd faster

Farm 9
Visiting date: March 16th 2007
Installation of AMS: December 2003 and January 2006
AMS barn:

- Two robots, two groups
- Cubicles: lactating cows and heifers: 132 (66 + 66), dry cows: 8
- Milking possible outside the AMS: stanchion barn with 28 "långbåsplatser"

Livestock:

- In AMS: 90 lactating cows, goal: 120
- Just bought 30 pregnant heifers
- Outside AMS: 0
- Breeds: 80% SLB and 20% SRB, 1 Jersey cow
- Age at first calving: about 28 months
- Calving interval: about 13 months for cows, 14 months for heifers
- Milk yield: average 2006: 8 800 kg ECM/cow; goal: 10 000 kg ECM/cow/year
- Replacement with AMS: Expanding the herd -> earlier only 8%; goal about 30%
- Number of milkings per cow and day: 2006: about 2.8; today: 2.9; goal: about 3
- Calving distribution: last year: even distribution over the year; goal: same

Livestock management:

- Heifers: one month to two weeks prior to calving they are moved to a calving box
- Fresh cows: 24 hours calving box, 24 hours calving box but milked in the AMS, after two days -> AMS
- New cows: fetched once and if necessary
- Drying cows: decrease number of milkings (max 2/day), much less concentrate (-10 kg/day) in the MU
- Dry cows: 8 in the AMS barn, "resten" in the old barn
- Mastitis cows: treatment/calves/slaughter, milked in the AMS but kept in a treatment box
- Cows with high cell count (not mastitis): test for *S. Aureus*, if positive -> bull calves
- High cell count/mastitis cows are kept/milked in one group in the AMS
- Other sick cows: treatment boxes but milked in the AMS

Animal health:

- Hoof care: 1 time/year
- Bulk milk somatic cell count: 250 000 - 300 000 cells/ml
- Sick cows are found by "animal eye" ("common" illnesses) and with the computer (udder and milk)
- Treated cases of mastitis during 2006:

Type	No.
Strept./Staf.	8
S. aureus	4

- Hoof/leg problems during 2006:

Type	No.
"Klövspalt"	2
Always stiff legs	3
Extra hoof care	4

- Diseases related to feeding during 2006:

Type	No.
"Acetonemi" (maybe)	1

Discarded/separated milk in the AMS:

- Colostrums: four days after calving (8 – 10 calvings/month)
- Total: about 36 kg/day (average for 7 days), big variations

Stable:

- xxx row system
- Alley in the free stall: 2.50 m, patterned concrete floor with scraper
- Alley in the feeding area: 3 m, patterned concrete floor with scraper
- Feeding table: about 35 m with shoulder support ("bogstöd")
- Automatic feeders for concentrate: four in total (two in each group) in the resting areas
- Illumination in the resting area: no lights at daytime (shining from the robot), at night time: summer = no lights, winter = half of the lights

Feeding:

- Feed in the MUs: Rosa fett and Pektin top (commercial concentrate mixtures)
- Feed in the AFs: Rosa fett
- PMR (partly mixed ration):

Feed	Silage	Straw	Minerals	Crushed triticale and rape cake	Salt
Ration				1 kg/cow/day	

- Silage quality: DM = 40%, ME = 10.8 MJ/kg, CP = 480 g/kg DM
- Feeding is handled manually ("rivarvagn") three times a day at 06.00, 11.00 and 17.00
- PMR portion should cover max milk yield 25 kg ECM, never empty on the feeding table

Settings in the automatic concentrate feeder:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Older cows	11	2
Heifers	8	2

Settings for concentrate in the milking unit:

Animal category	Max portion/day (kg)	Max portion/visit (kg)
Older cows	8	
Heifers	7.5	

Wanted distribution automatic feeder/milking unit: nn

Fetching cows:

- On average 3 cows/occasion (0 – 7 cows); total 0 – 14 cows/day
- Twice a day
- Milking interval never > 11 h
- Checking the robot before scraping, force cows to stand up
- Fetched cows are locked up in front of the AMS and milked before other waiting cows
- Milk leakage: rarely in the herd, but common for some cows (high yielders)

Groups of cows kept separately and milked separately in the AMS:

- Cows with high cell count (own group)
- Sick cows (under treatment) and all cows 2nd day after calving

Work routines:

- Cubicles: scraping and littering 2 times/day, morning and evening
- Waiting area: scraping 2 times/day, morning and evening
- Feeding: same time every day morning and evening, some variation at noon
- Automatic cleaning of the robots 3 times/day (12 minutes/cleaning)
- Buffer tank cleaning when big tank cleaning

Why AMS:

- Believed in AMS from the beginning
- Interested in technique
- Work situation – did not want to get more employees
- Wanted to get "credit" for the investment

Labour:

- Owners (father and son), occasional extra help when needed
- Working hours: weekdays: 06.00 – 07.30, about 11.00 – 12.00 (0.5 h) and 16.30 – 18.30; weekends: same
- Total work related to milking: 0.75 h/day (milking and fetching cows)
- Total work related to feeding: 1.5 h/day (0.5 h mixer and 1 h filling and feeding)

AMS alarm:

- One stop alarm per three weeks
- One alarm per three months at night
- Varies a lot!

Other:

- Very happy with AMS
- Results even better than expected!
- Less mastitis with AMS

Appendix 3

Farm 1.

118 cows in 1 group. 2 MS. Production level 9 700 kg ECM. Silage and concentrate fed separately. Silage distributed eight times a day at 06:00, 08:00, 10:00, 14:00, 16:00, 18:00, 20:00 and 22:00.

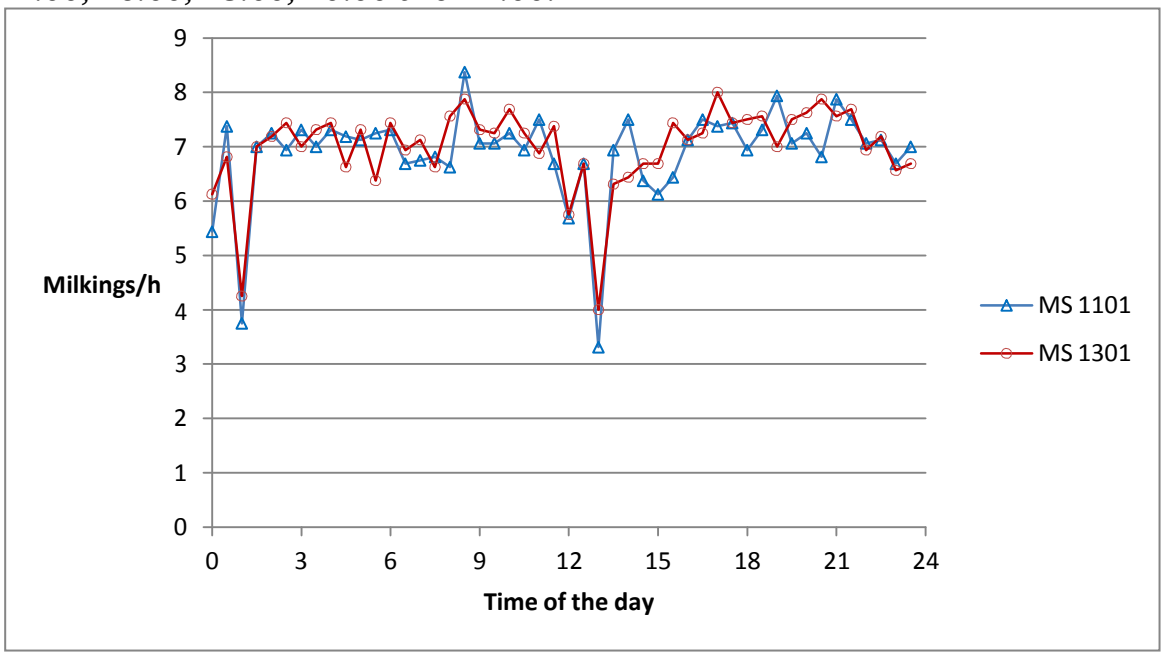


Figure 1. Distribution of milking visits over the day in visits per hour and MS

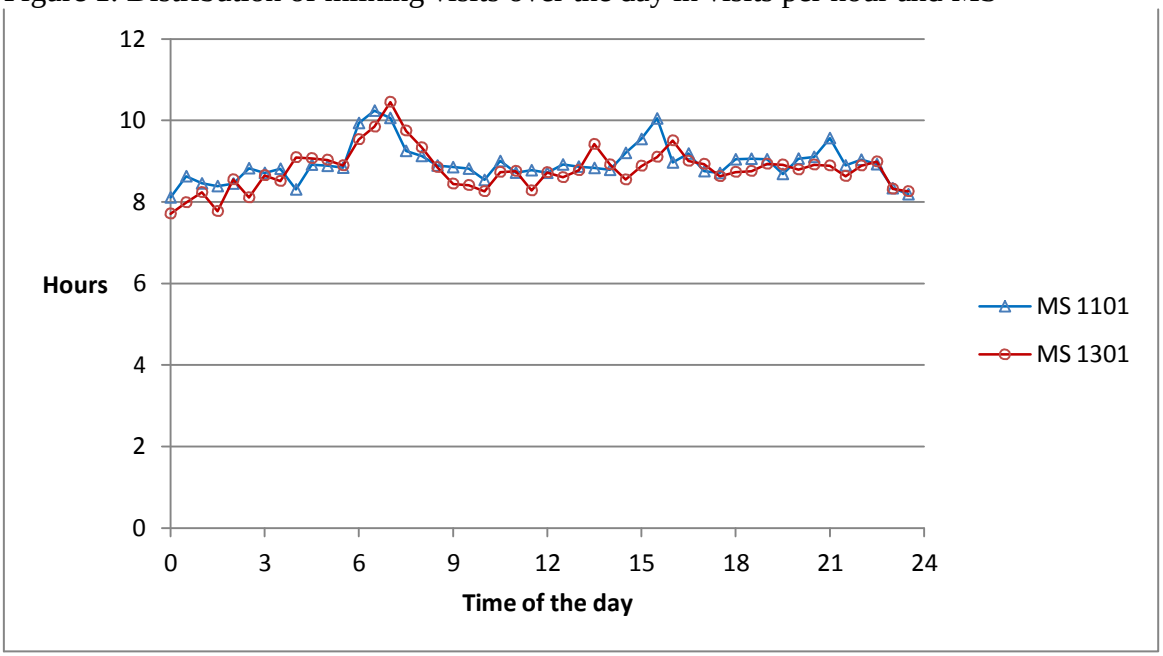


Figure 2. Average milking interval for milking visits over the day

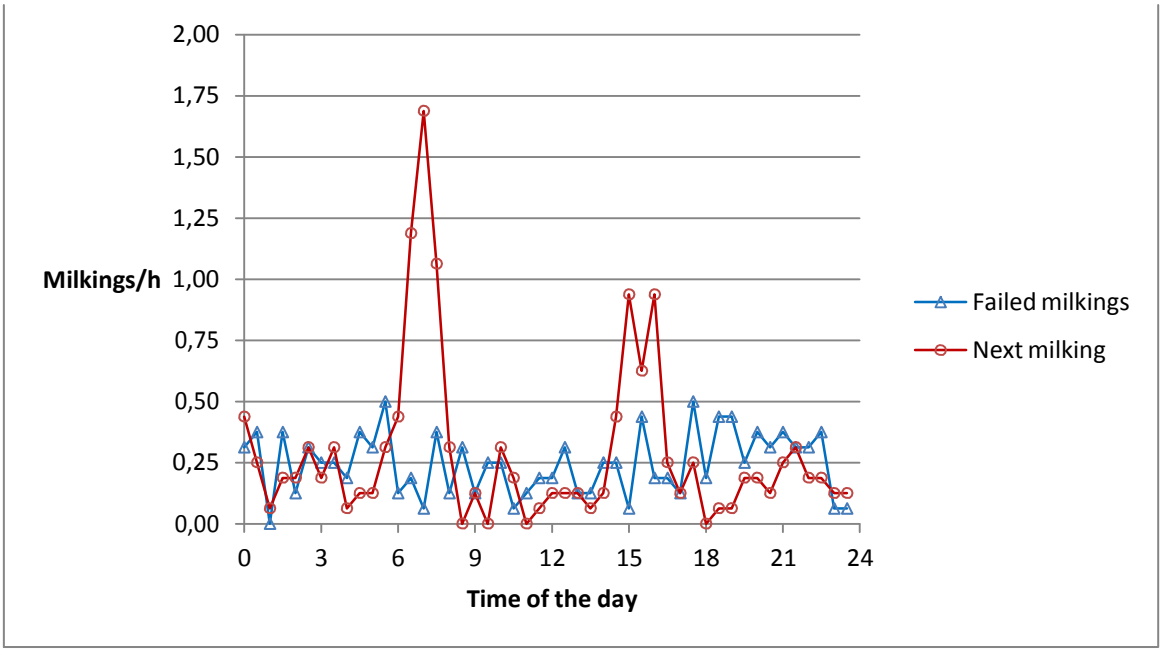


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

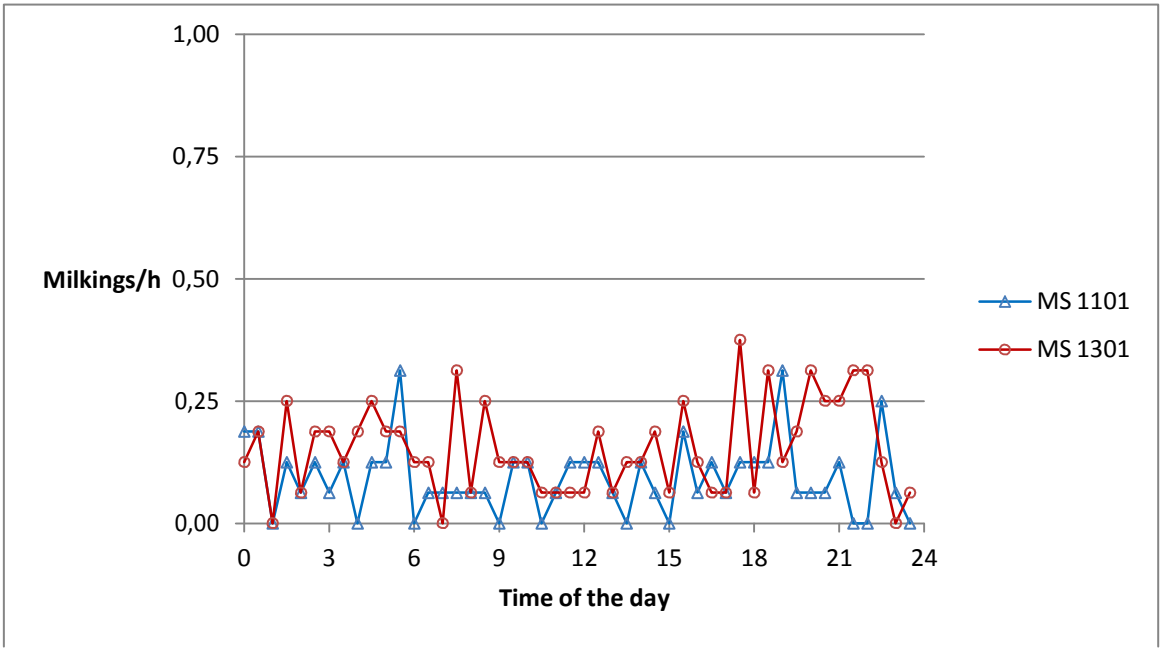


Figure 4. Distribution of failed milkings over the day

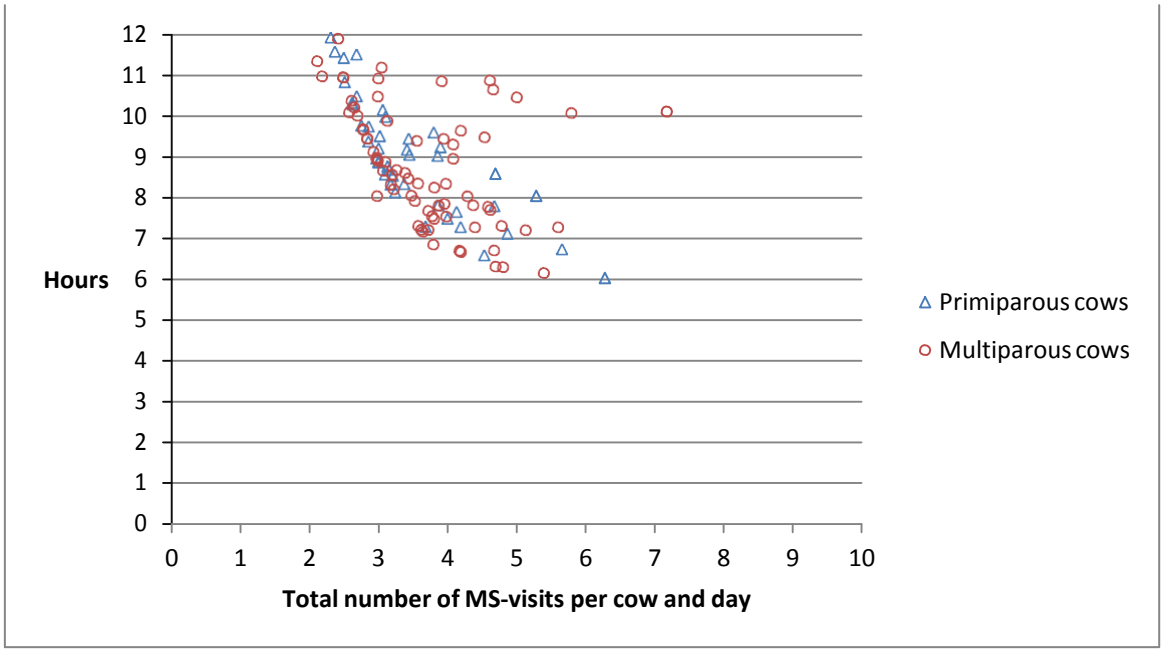


Figure 5. The relation between total number of visits to MS and the milking interval for individual cows

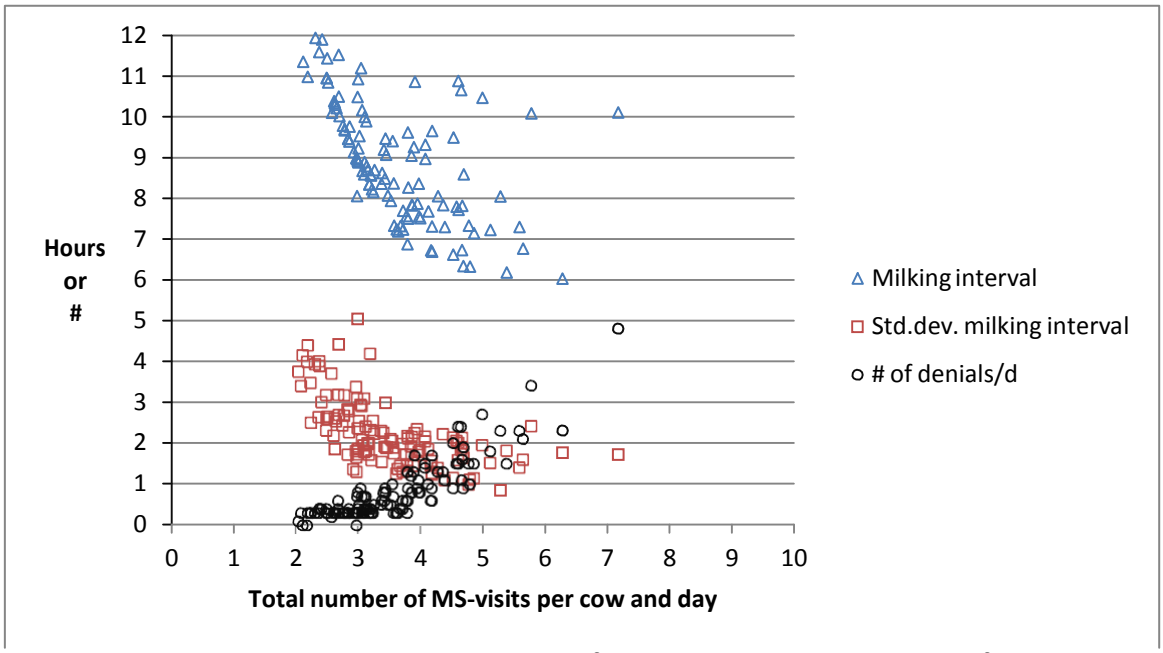


Figure 6. The relation between total number of visits to MS on the number of denied milkings and the effect on average and variation in milking interval for individual cows.

Farm 2.

113 cows in 1 group. 2 MS. Production level 10 500 kg ECM. Silage and concentrate fed separately. Silage distributed five times a day at 07:00, 09:00, 13:30, 16:00 and 18:00

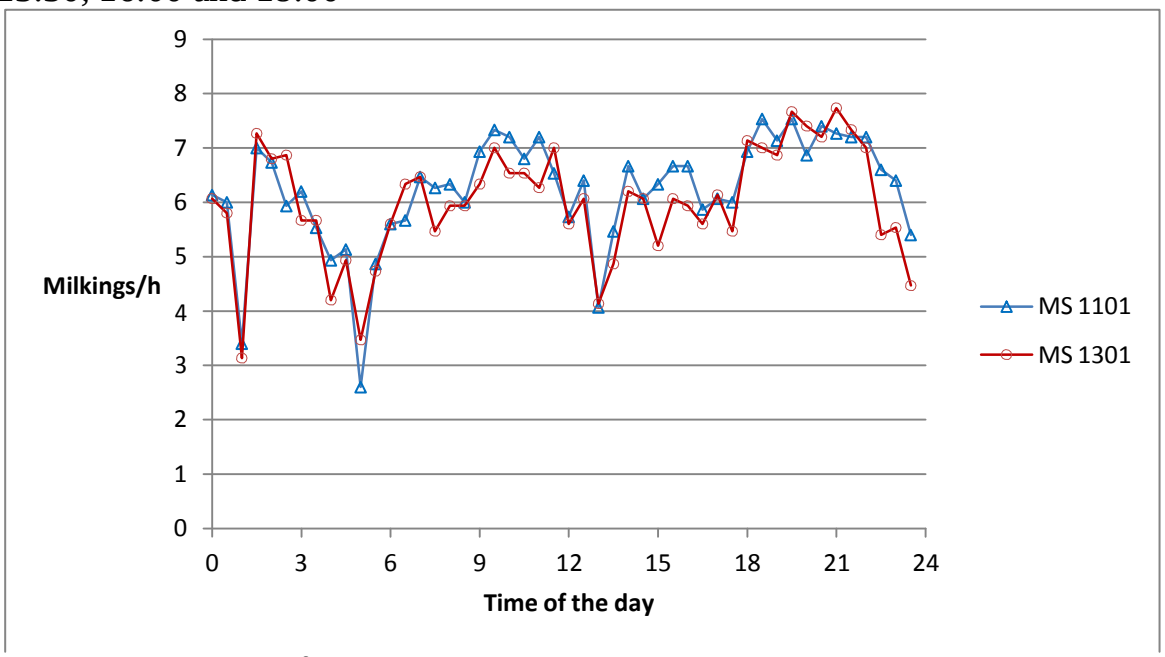


Figure 1. Distribution of milking visits over the day in visits per hour and MS

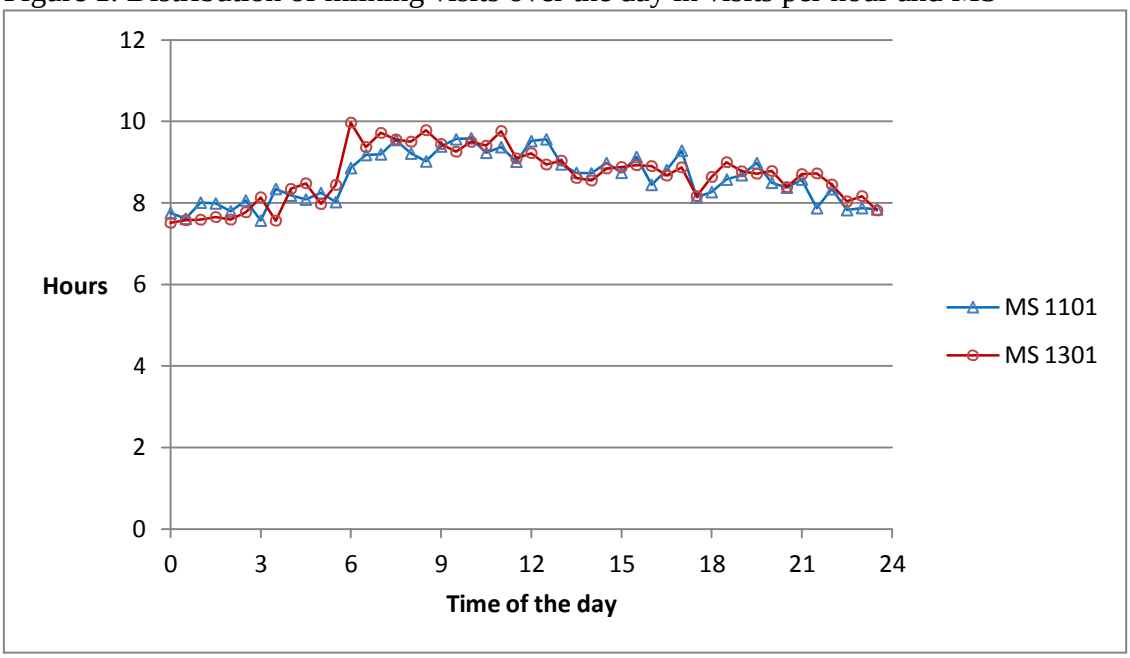


Figure 2. Average milking interval for milking visits over the day

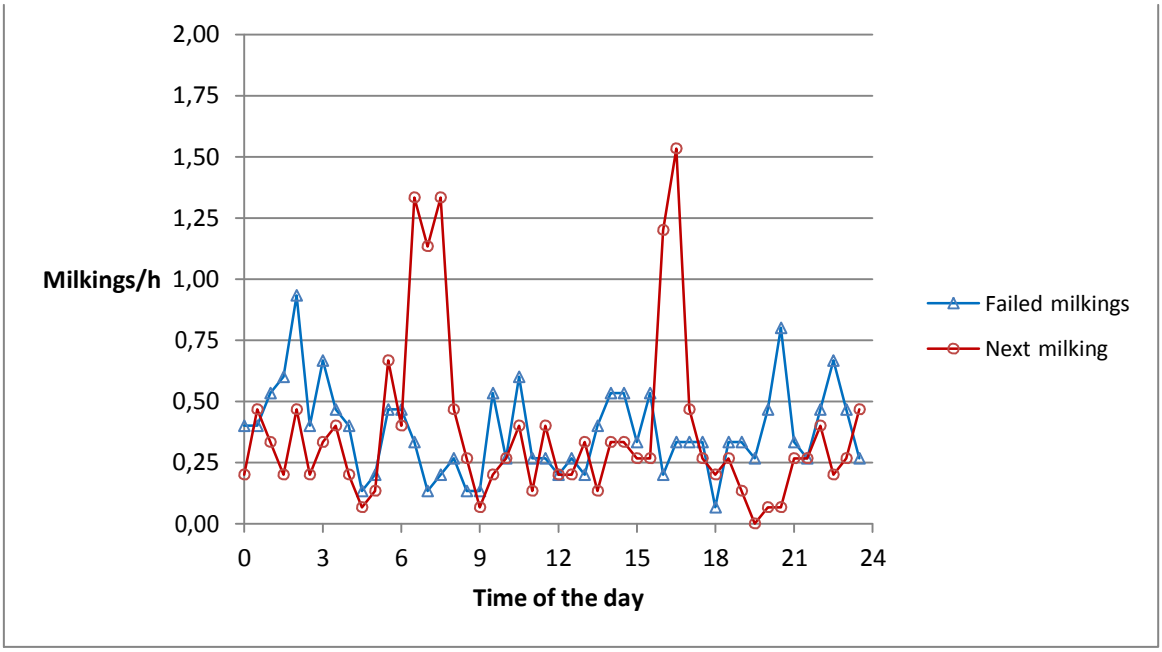


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

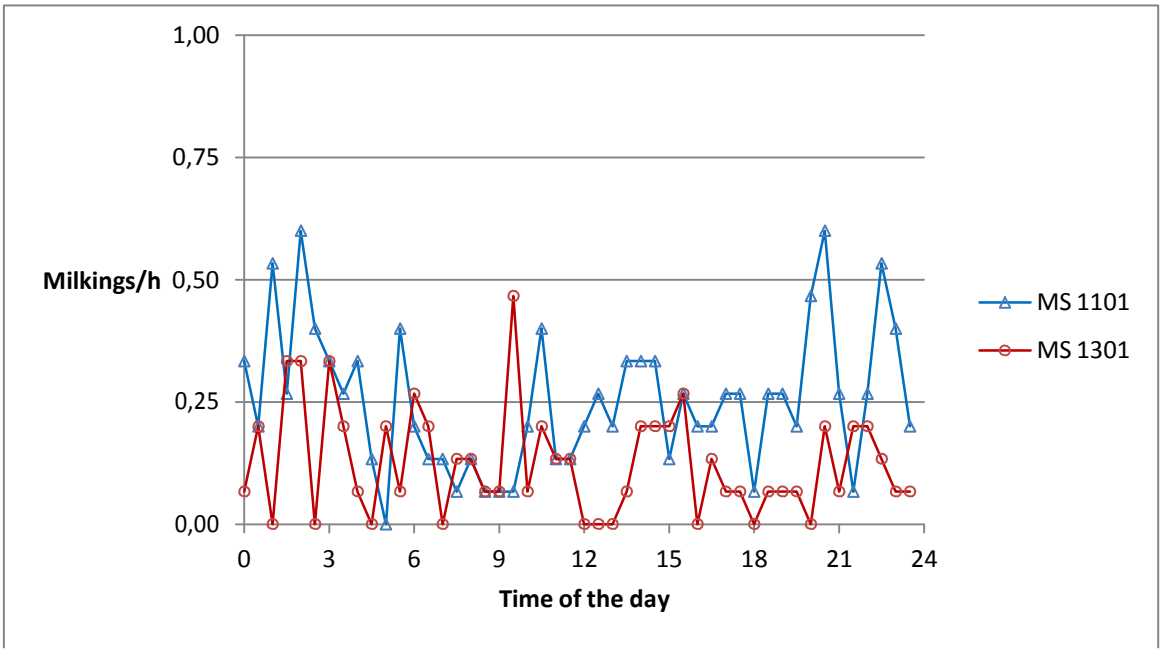


Figure 4. Distribution of failed milkings over the day

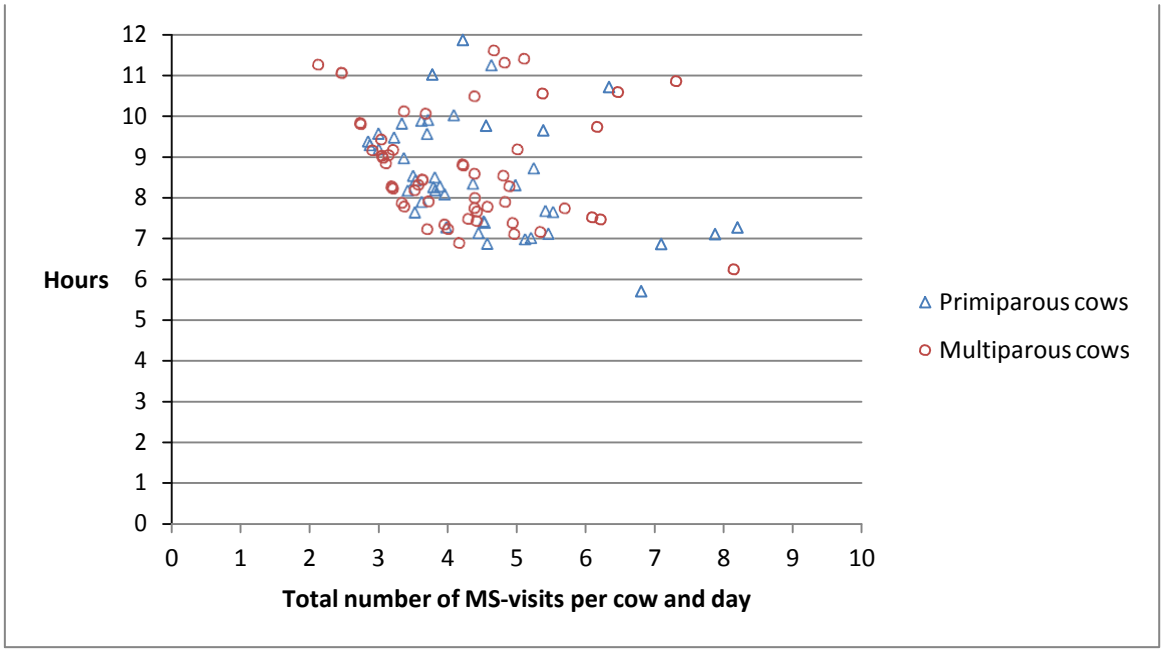


Figure 5. The relation between total number of visits to MS and the milking interval for individual cows

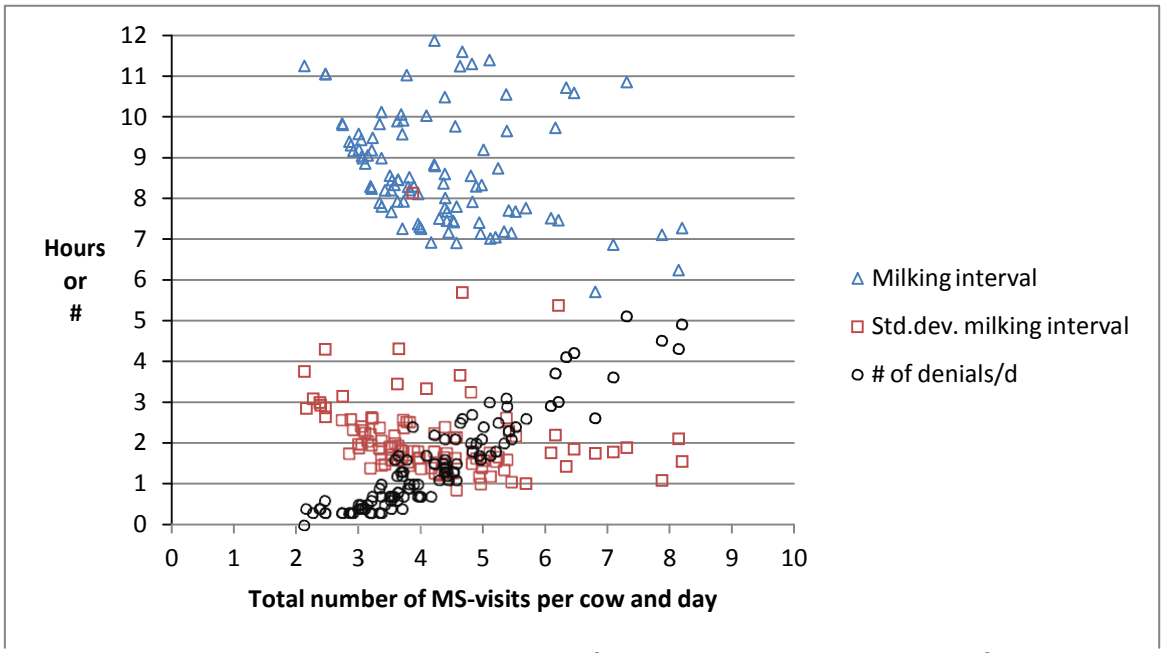


Figure 6. The relation between total number of visits to MS on the number of denied milkings and the effect on average and variation in milking interval for individual cows.

Farm 3.

62 cows in 1 group. 1 MS. Production level 9 500 kg ECM. Silage and concentrate fed separately. Silage distributed two times a day at 07:00 and 16.30

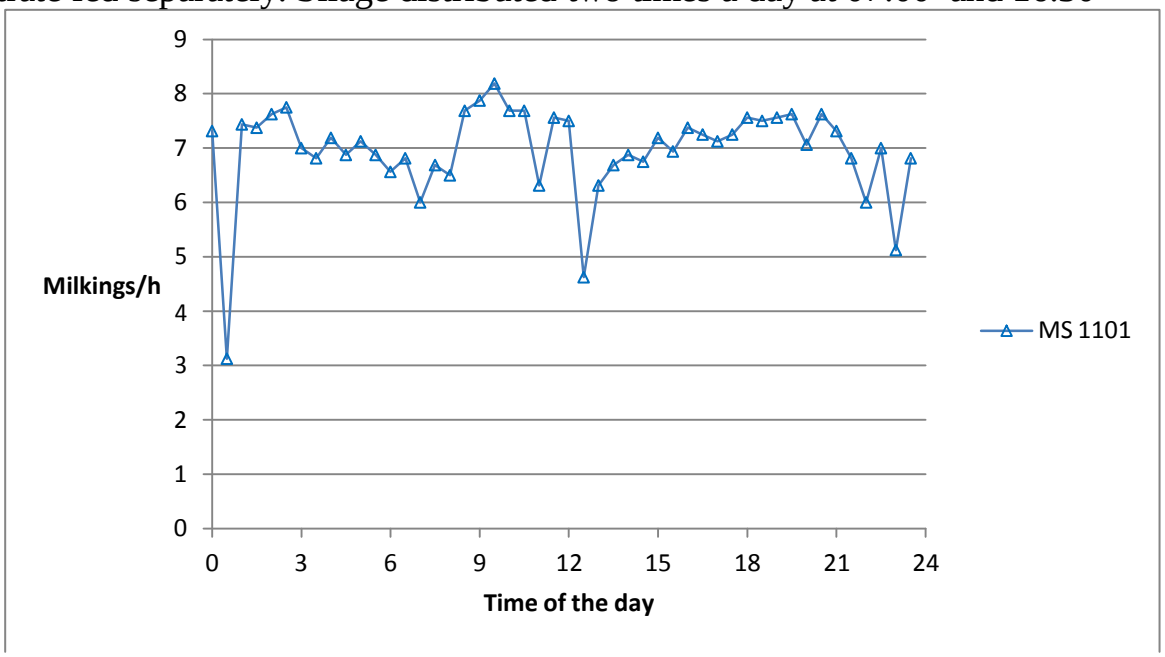


Figure 1. Distribution of milking visits over the day in visits per hour and MS

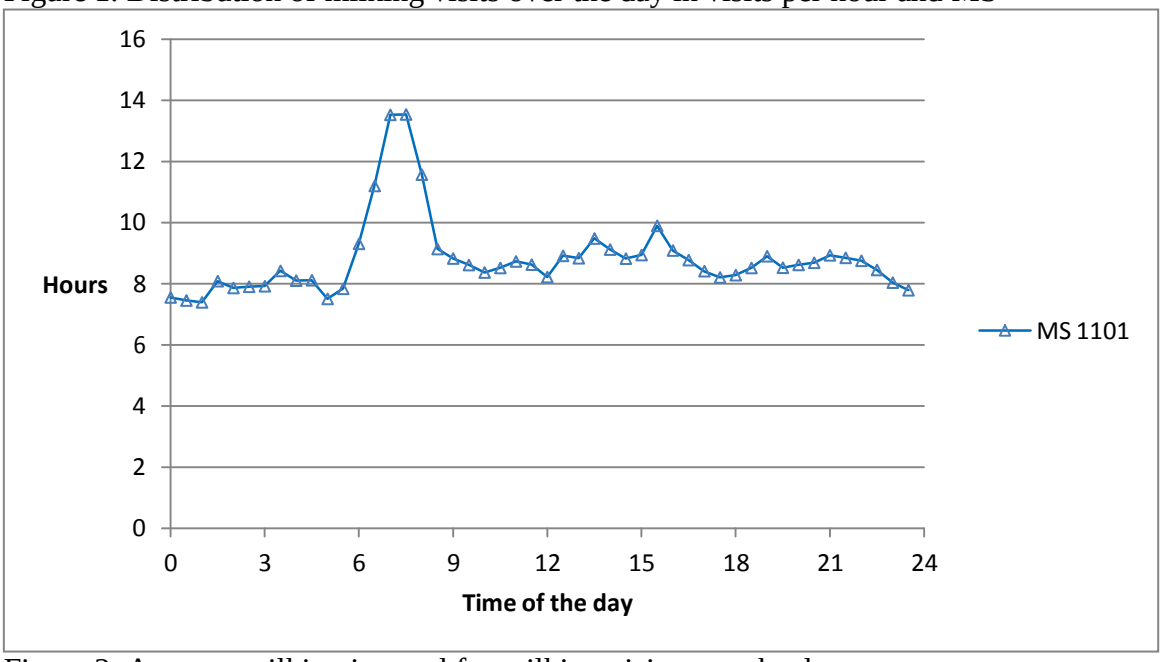


Figure 2. Average milking interval for milking visits over the day

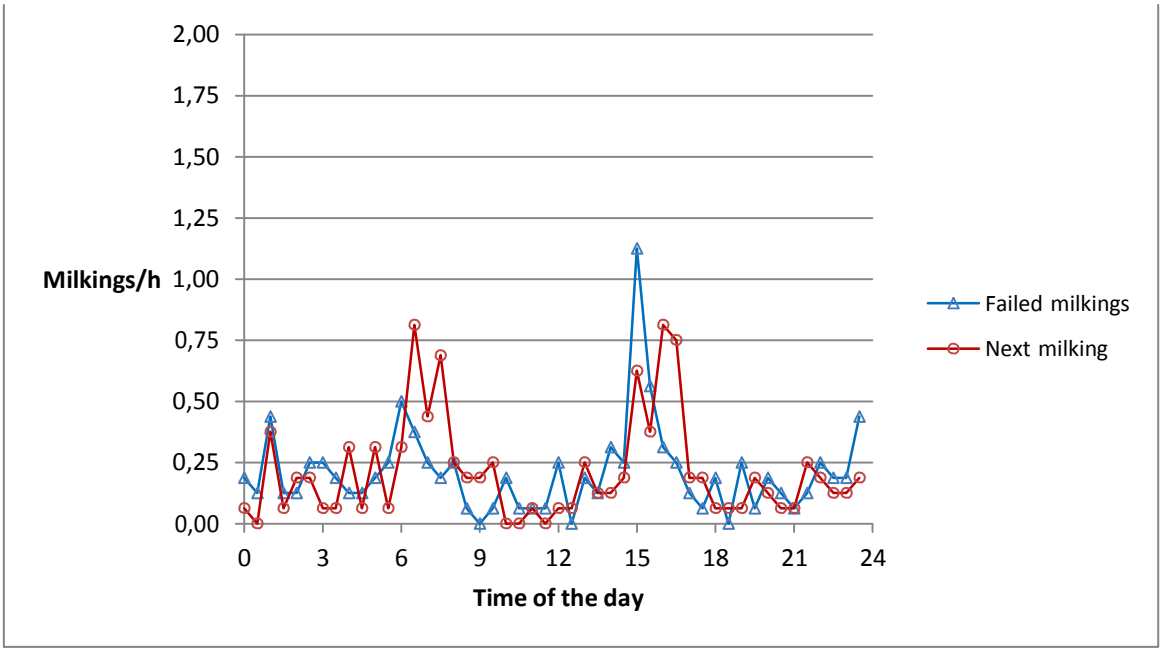


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

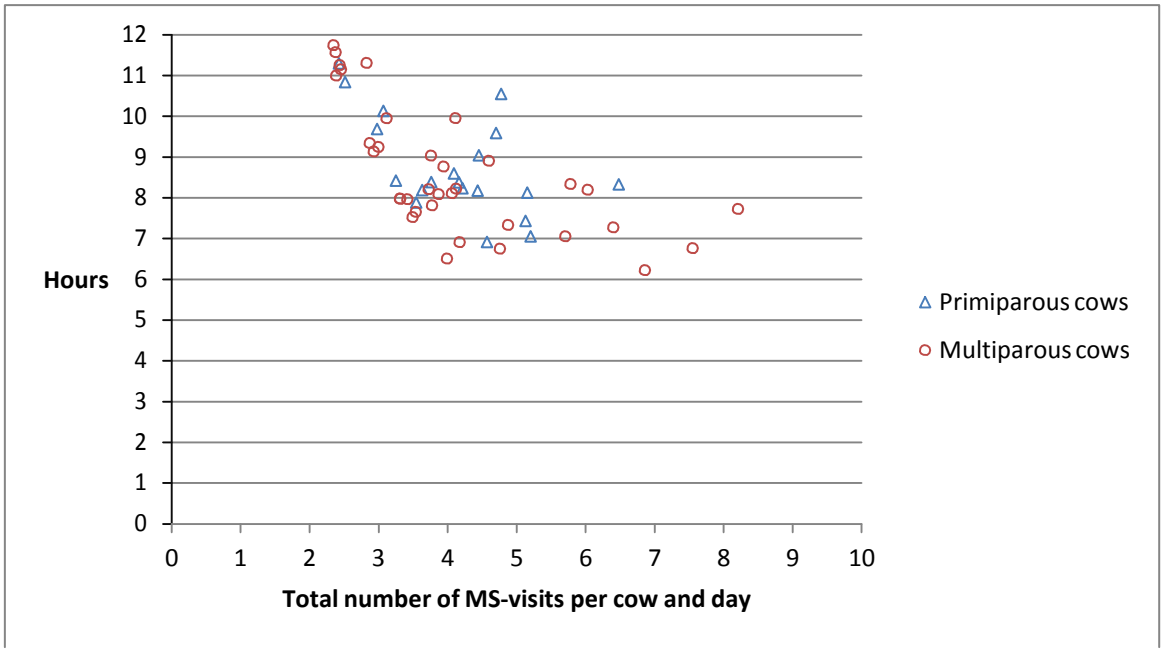


Figure 4. The relation between total number of visits to MS and the milking interval for individual cows

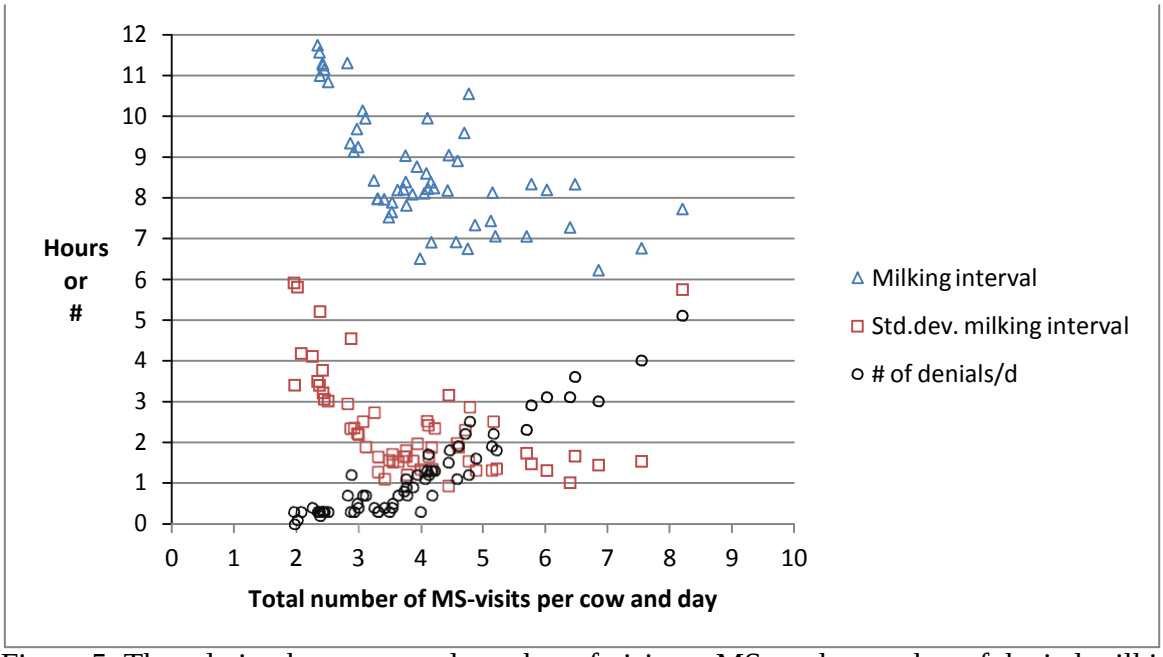


Figure 5. The relation between total number of visits to MS on the number of denied milkings and the effect on average and variation in milking interval for individual cows.

Farm 4.

106 cows in 1 group. 2 MS. Production level 9 600 kg ECM. Silage and concentrate fed separately. Silage distributed two times a day at 06:00 and 16:00

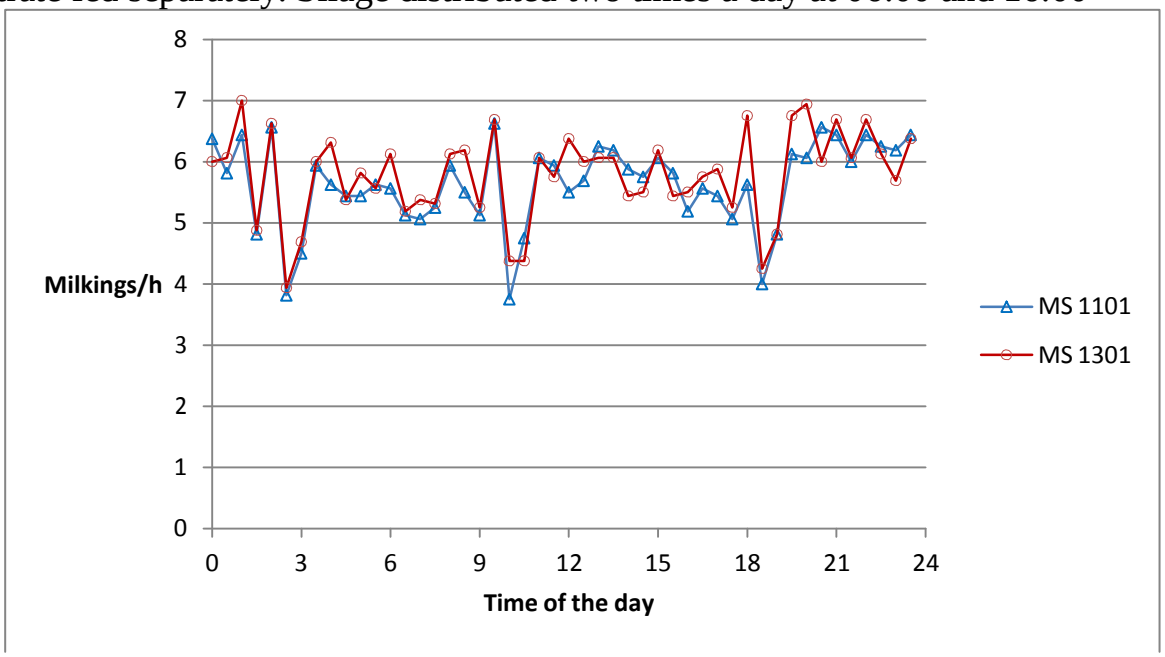


Figure 1. Distribution of milking visits over the day in visits per hour and MS

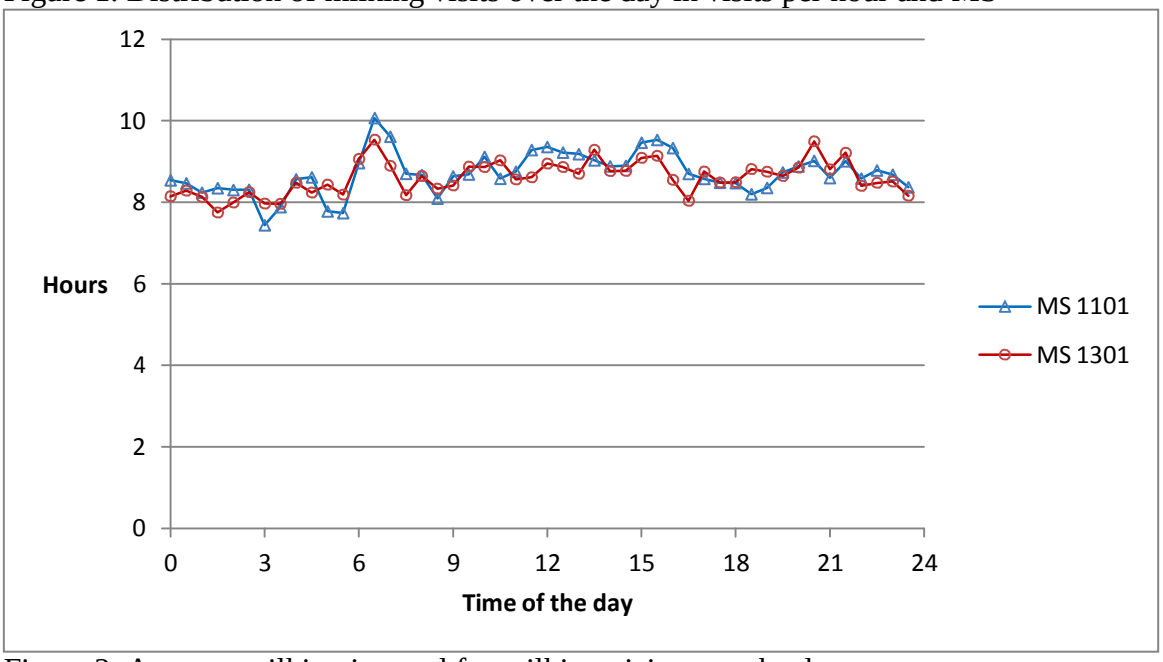


Figure 2. Average milking interval for milking visits over the day

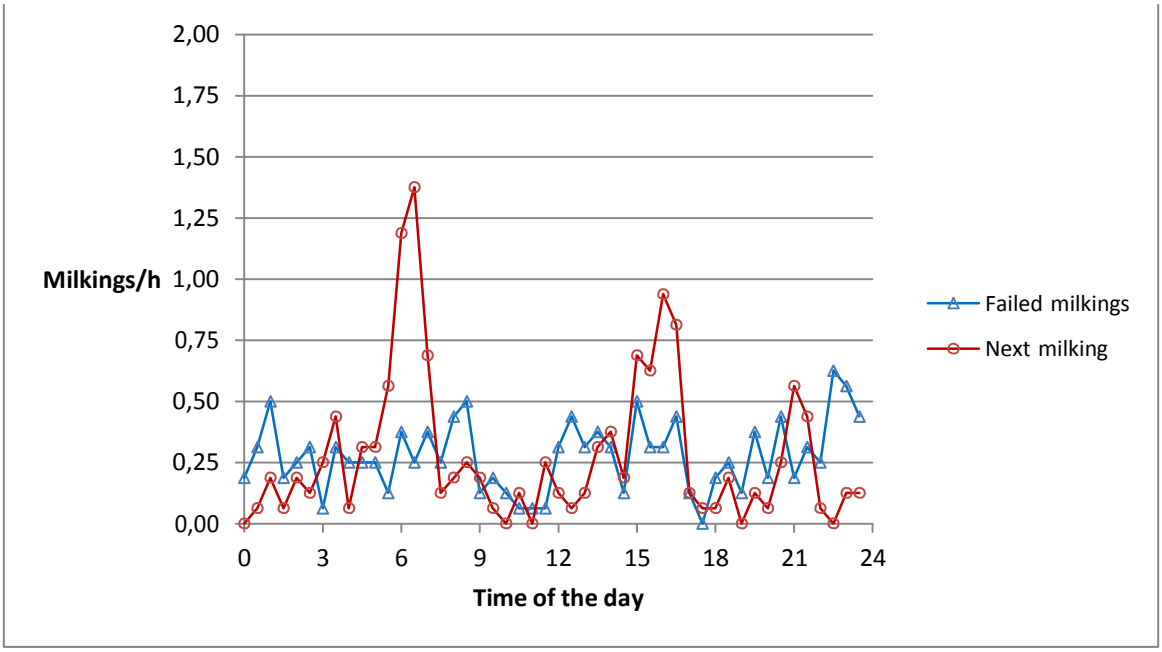


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

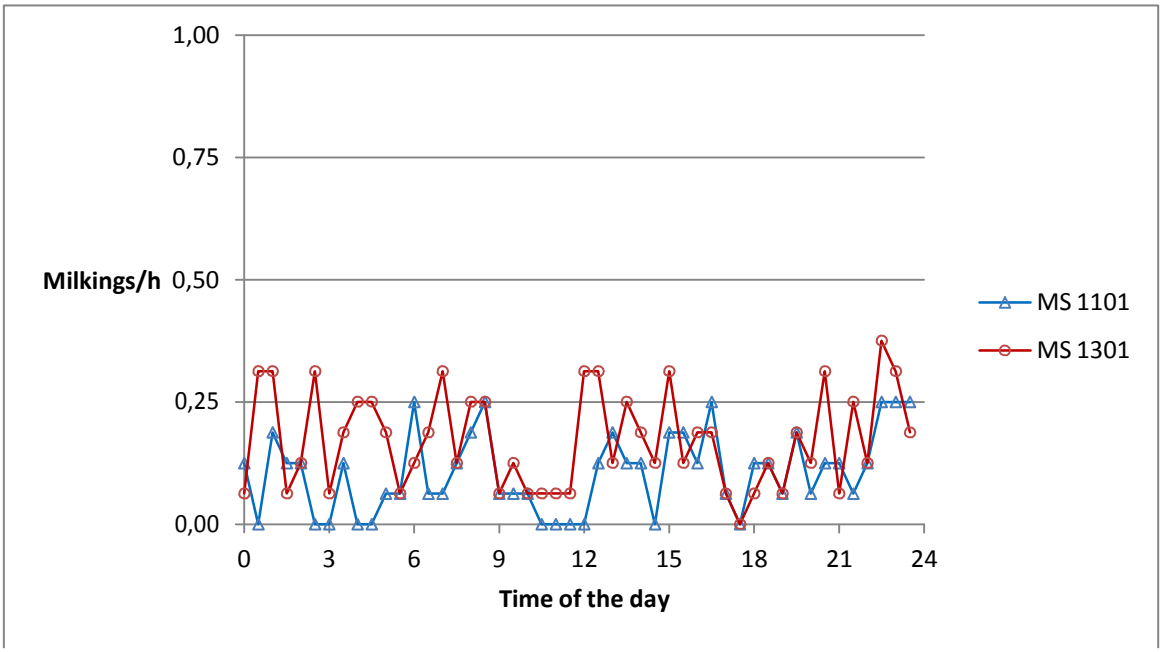


Figure 4. Distribution of failed milkings over the day

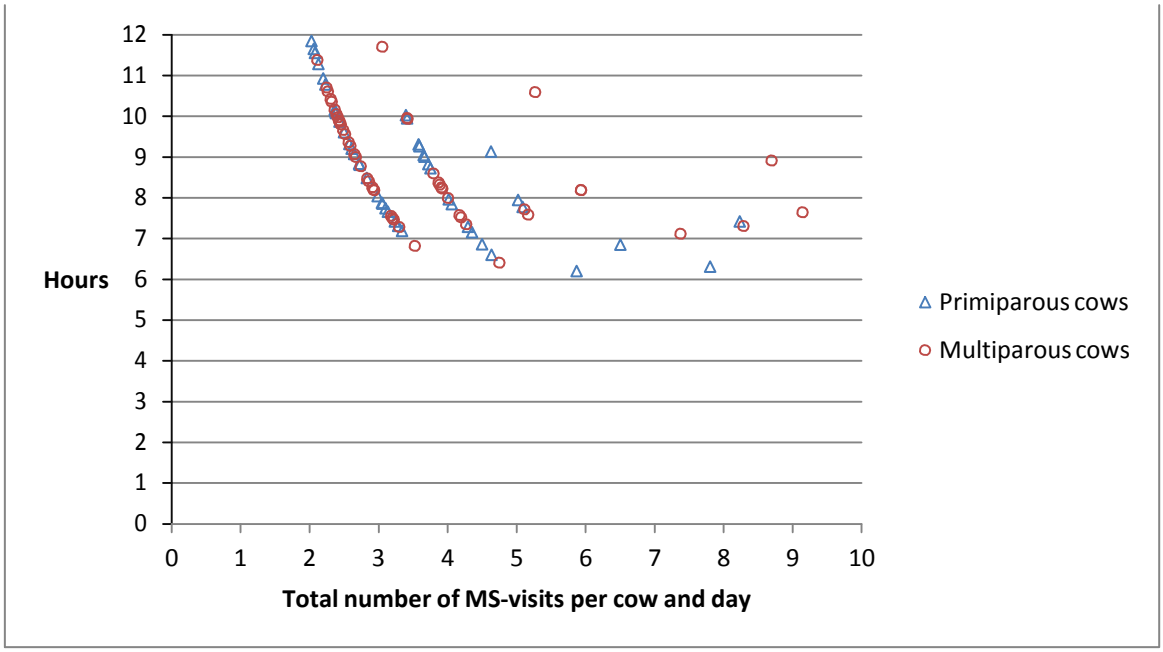


Figure 5. The relation between total number of visits to MS and the milking interval for individual cows. Note: Number of denied milking visit registered without decimals on farm 4.

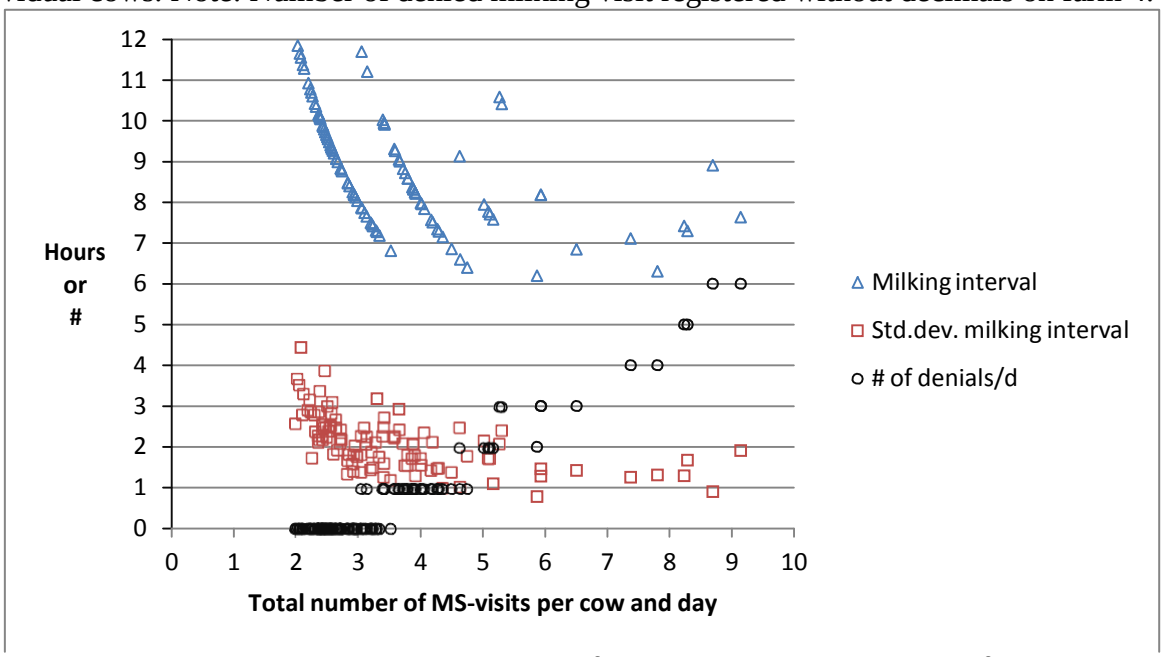


Figure 6. The relation between total number of visits to MS on the number of denied milkings and the effect on average and variation in milking interval for individual cows. Note: Number of denied milking visit registered without decimals on farm 4.

Farm 5.

93 cows in 1 group. 2 MS. Production level 10300 kg ECM. Silage and concentrate fed separately. Silage distributed automatically 16 times a day at 00:10, 03:00, 04:30, 06:00, 07:30, 08:30, 09:30, 11:00, 12:30, 14:00, 15:30, 16:30, 18:00, 19:30, 21:00 and 22:00

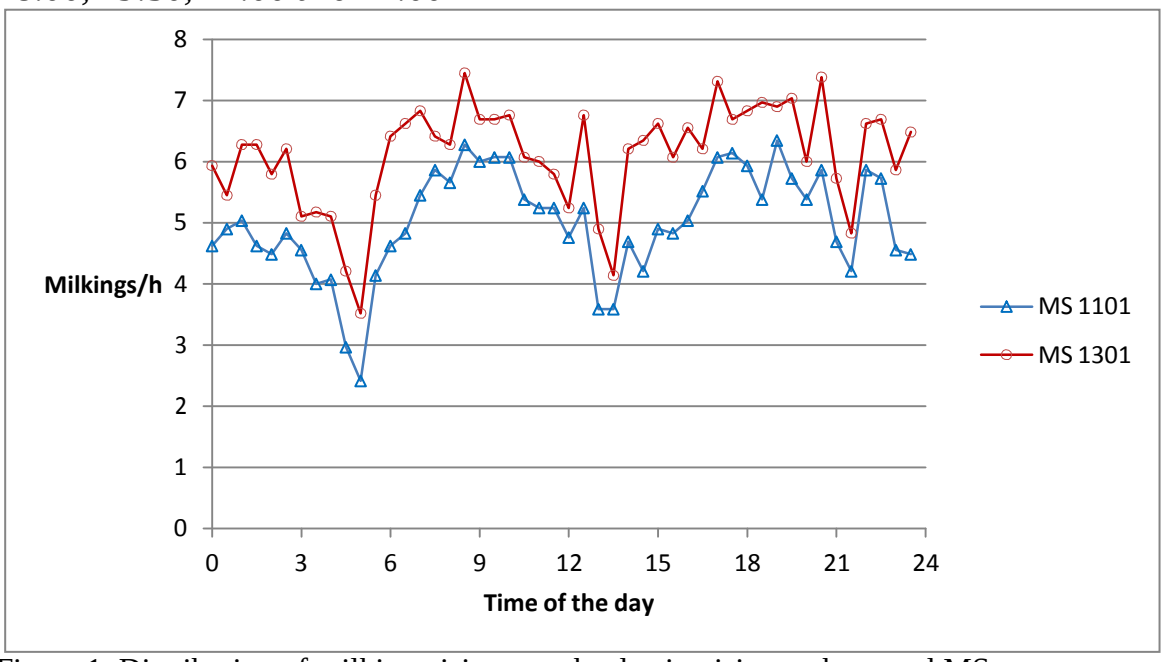


Figure 1. Distribution of milking visits over the day in visits per hour and MS

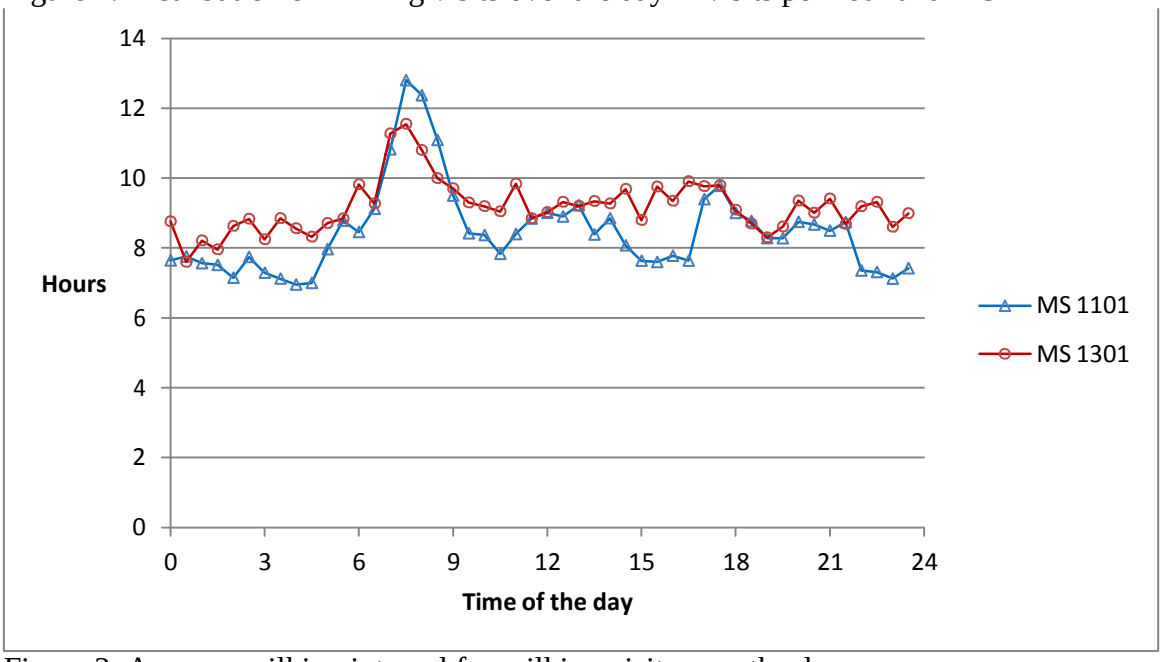


Figure 2. Average milking interval for milking visits over the day

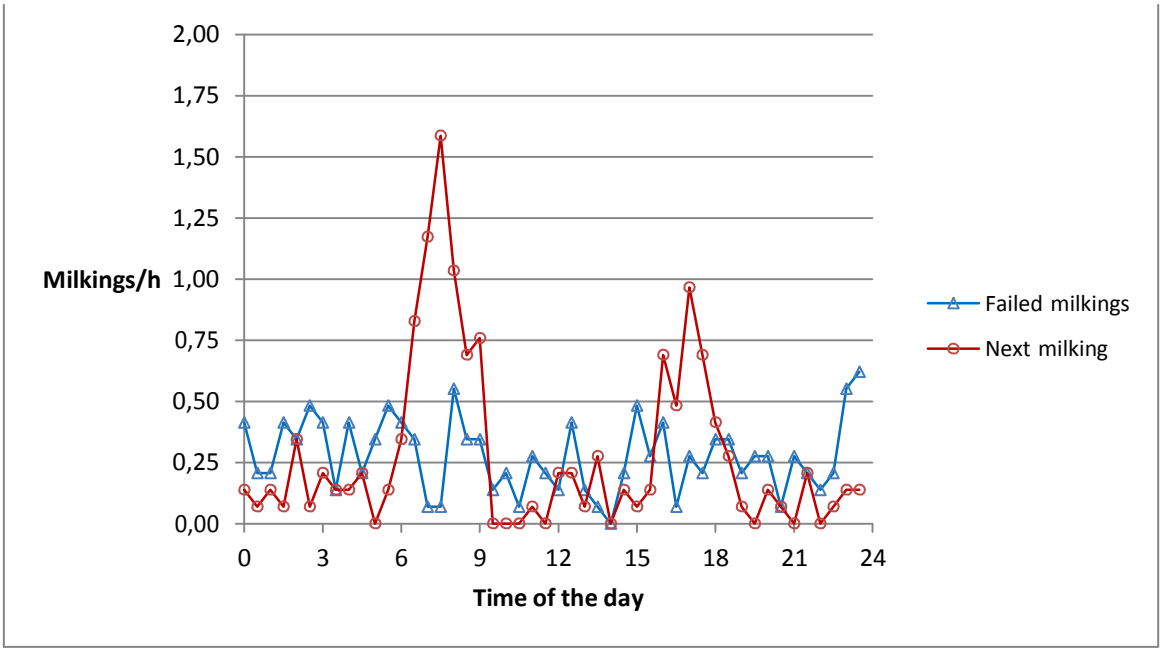


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

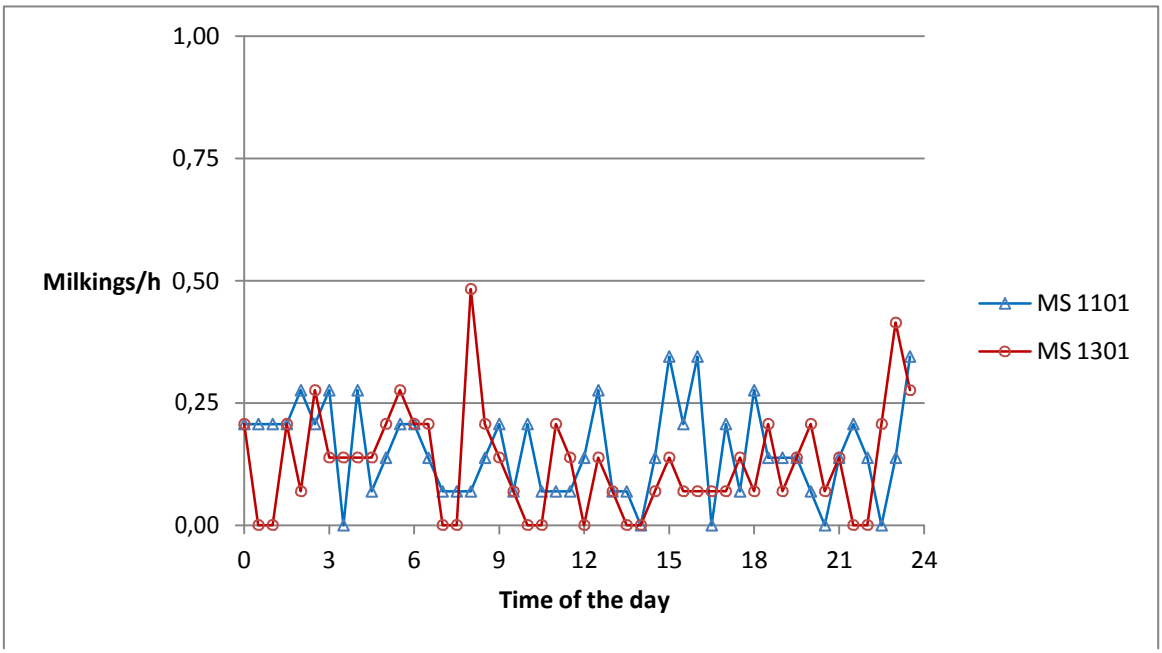


Figure 4. Distribution of failed milkings over the day

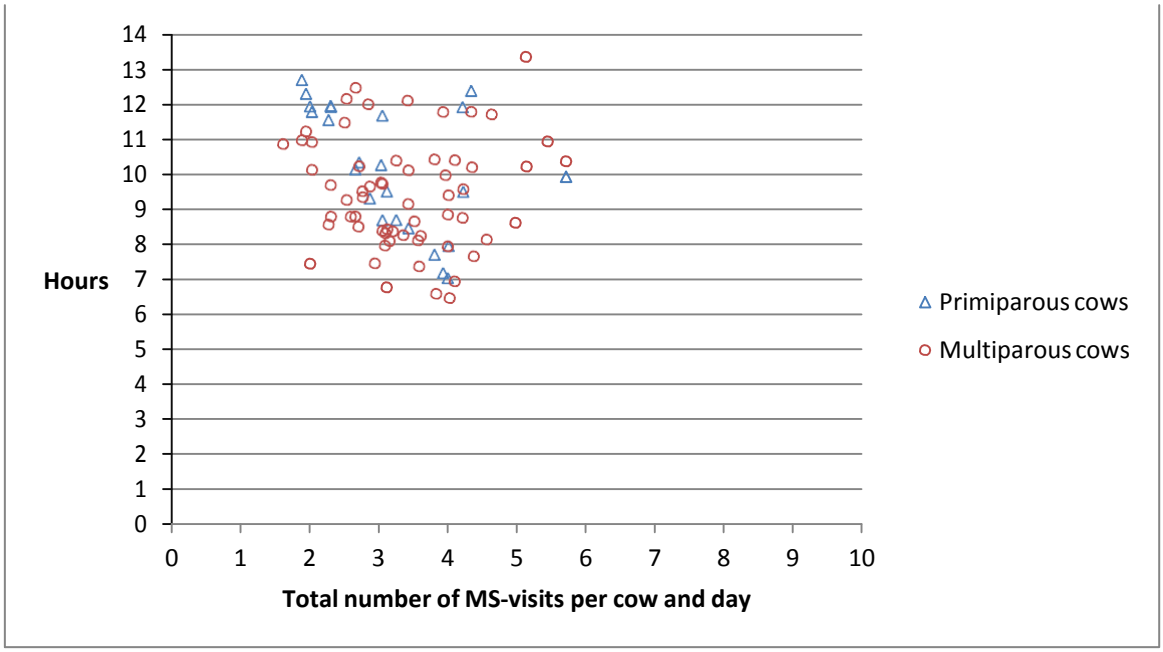


Figure 5. The relation between total number of visits to MS and the milking interval for individual cows.

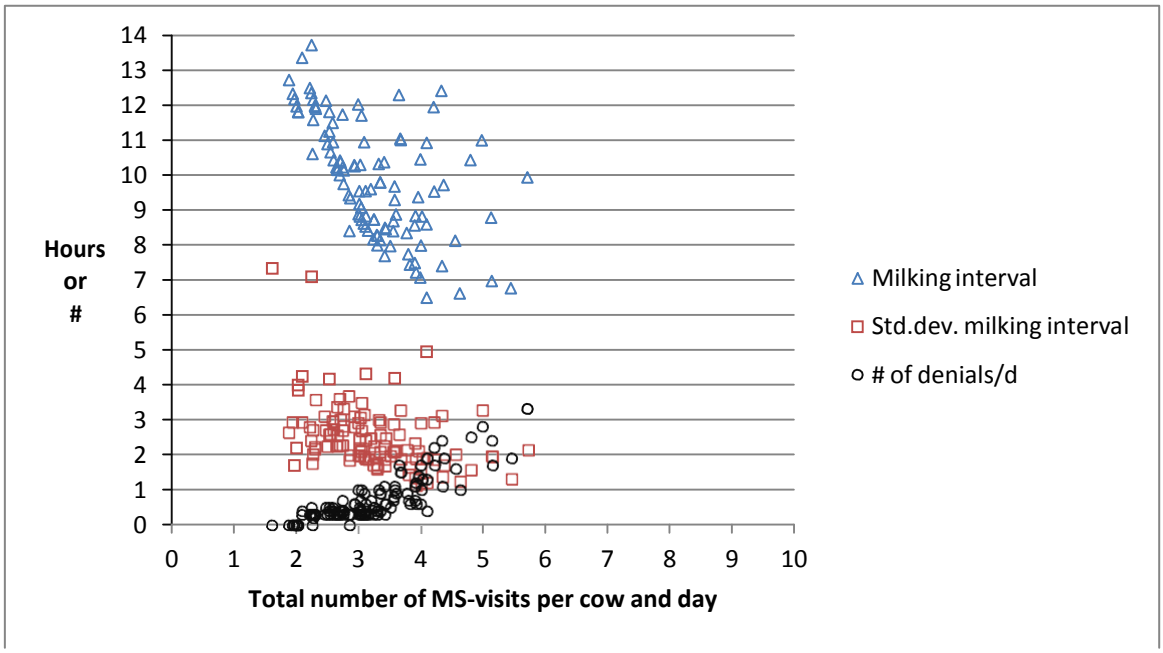


Figure 6. The relation between total number of visits to MS on the number of denied milkings and the effect on average and variation in milking interval for individual cows.

Farm 6.

60 cows in 1 group. 1 MS. Production level 9 500 kg ECM. Silage and concentrate fed separately. Silage distributed automatically 8 times a day at 03:00, 06:00, 09:00, 12:00, 15:00, 18:00, 21:00 and 24:00

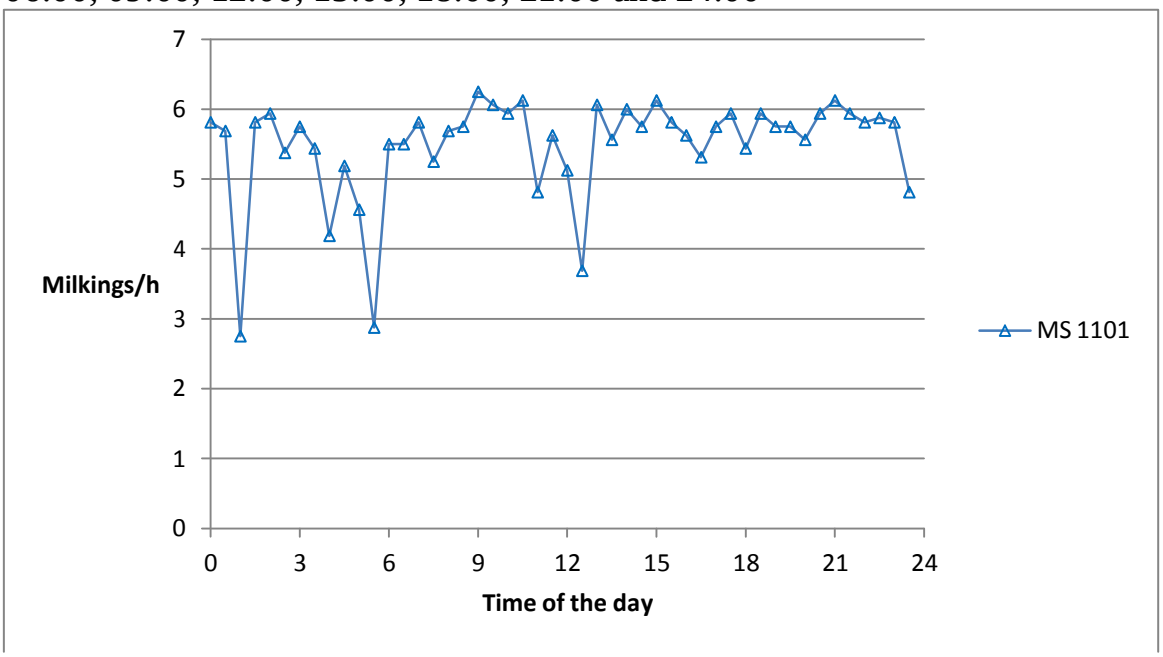


Figure 1. Distribution of milking visits over the day in visits per hour and MS

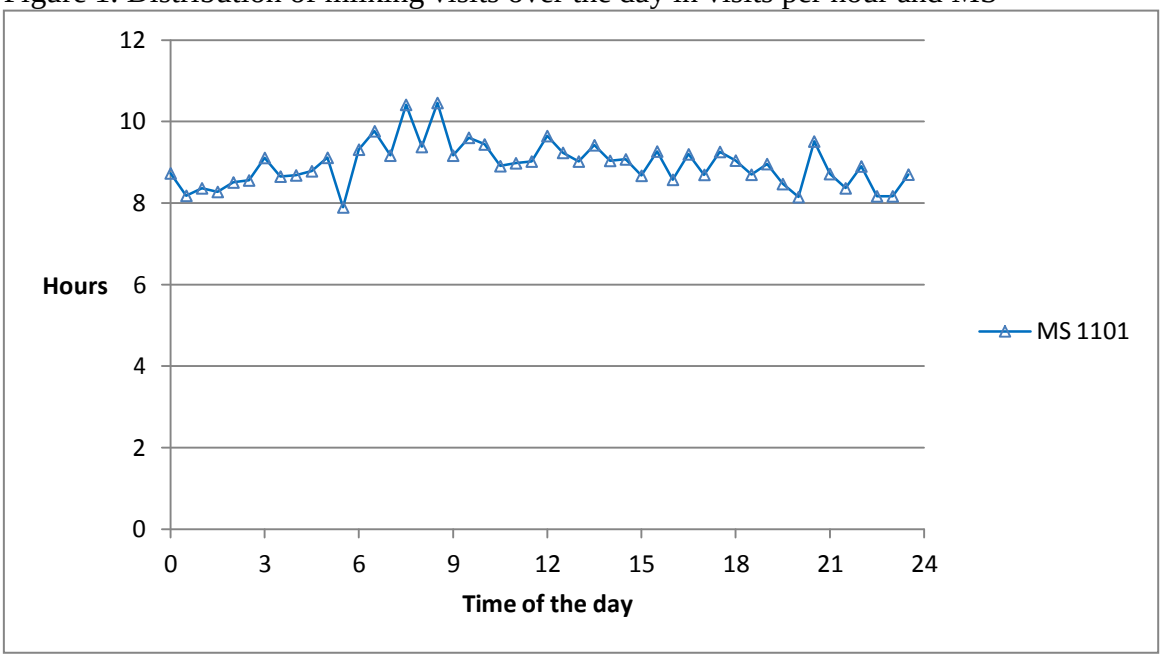


Figure 2. Average milking interval for milking visits over the day

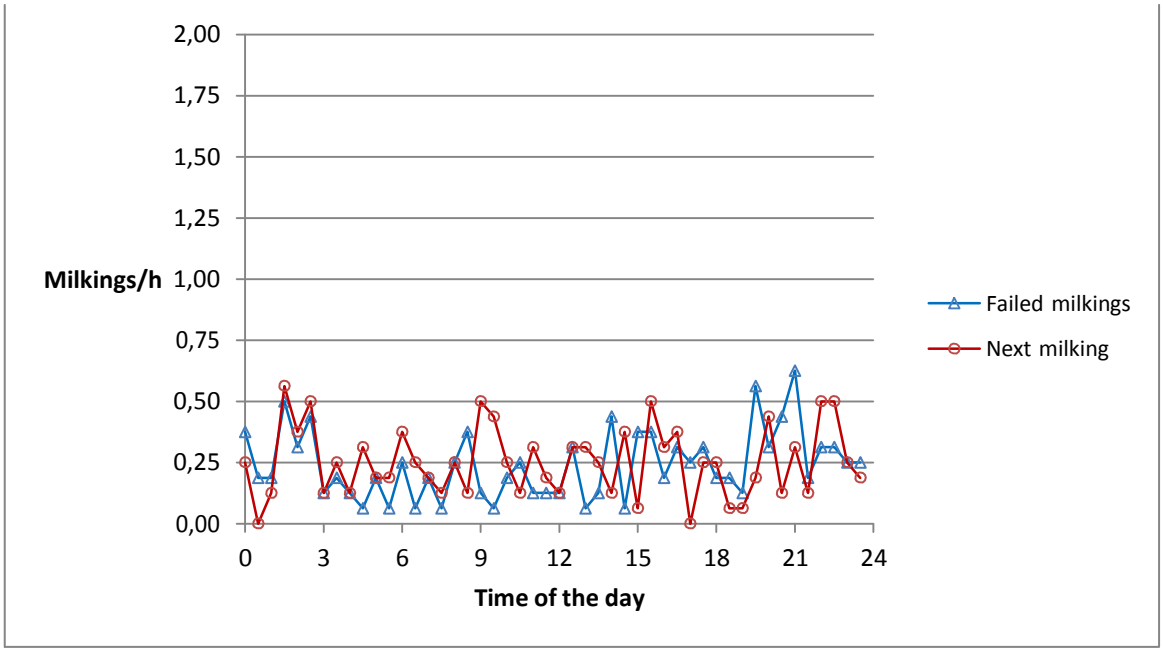


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

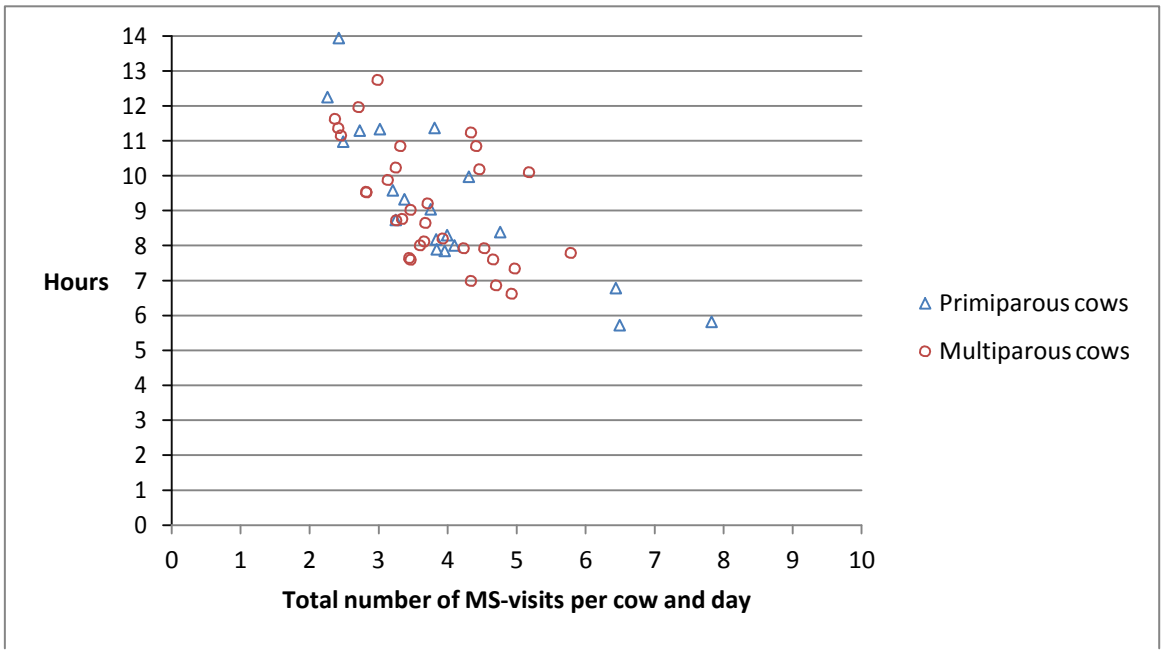


Figure 4. The relation between total number of visits to MS and the milking interval for individual cows.

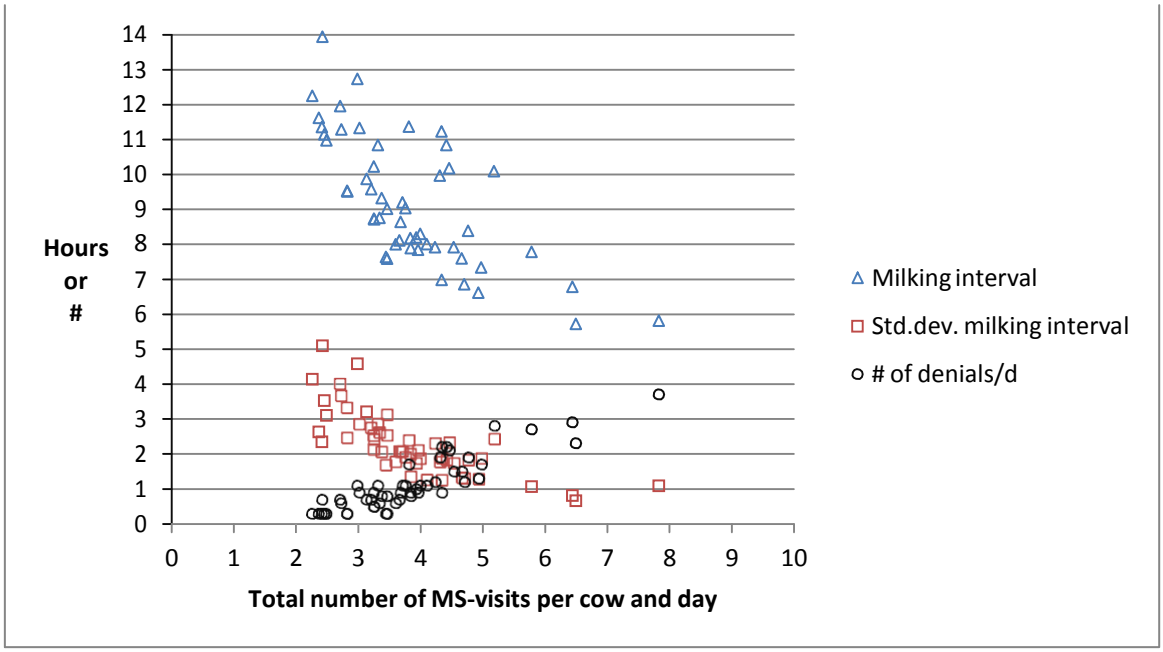


Figure 6. The relation between total number of visits to MS on the number of denied milkings and the effect on average and variation in milking interval for individual cows.

Farm 7.

102 cows in 1 group. 2 MS. PMR, concentrate fed to high yielding cows separately. PMR distributed five times a day at 09:00, 11:30, 16:00, 18:00 and 24:00/01:00 and 22:00.

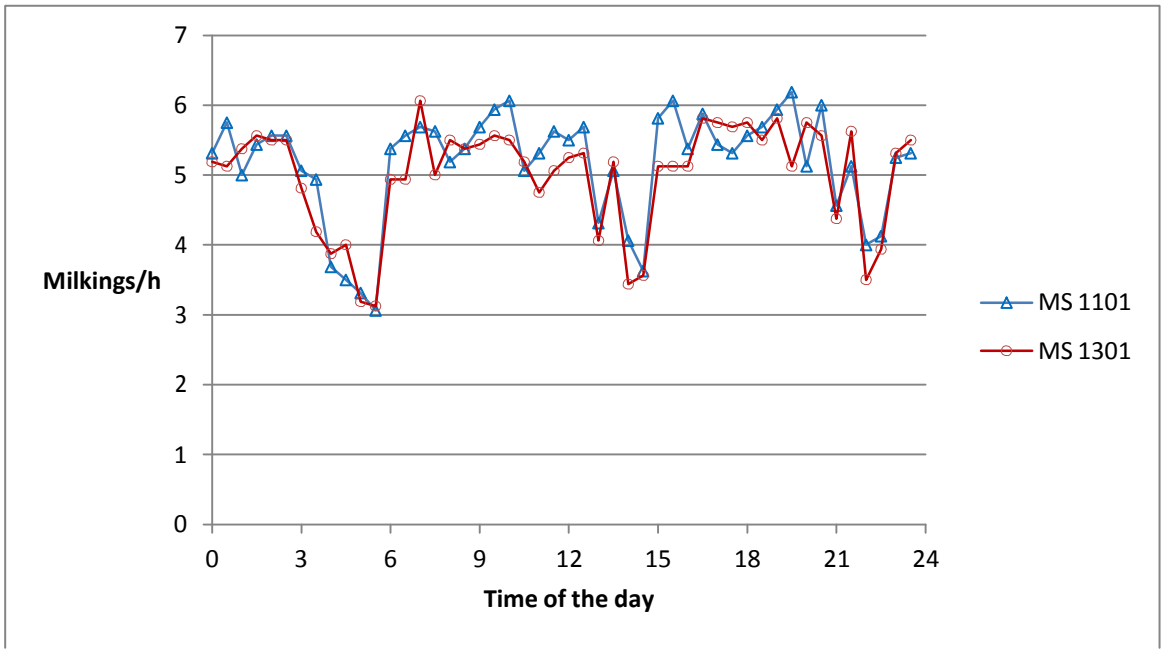


Figure 1. Distribution of milking visits over the day in visits per hour and MS

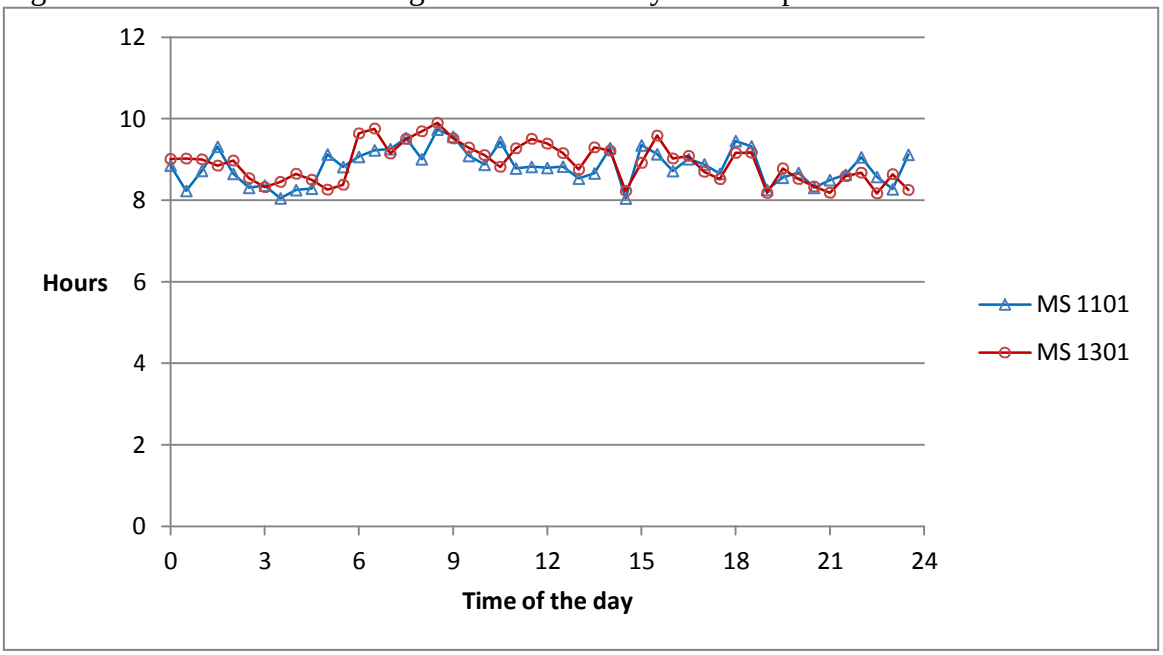


Figure 2. Average milking interval for milking visits over the day

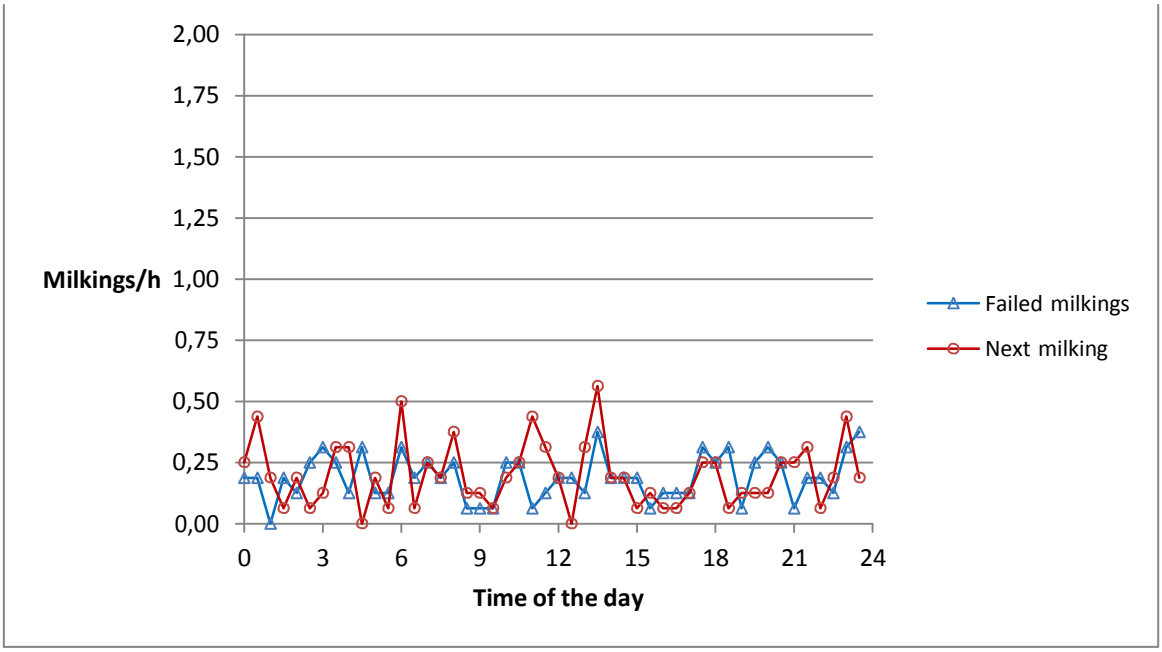


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

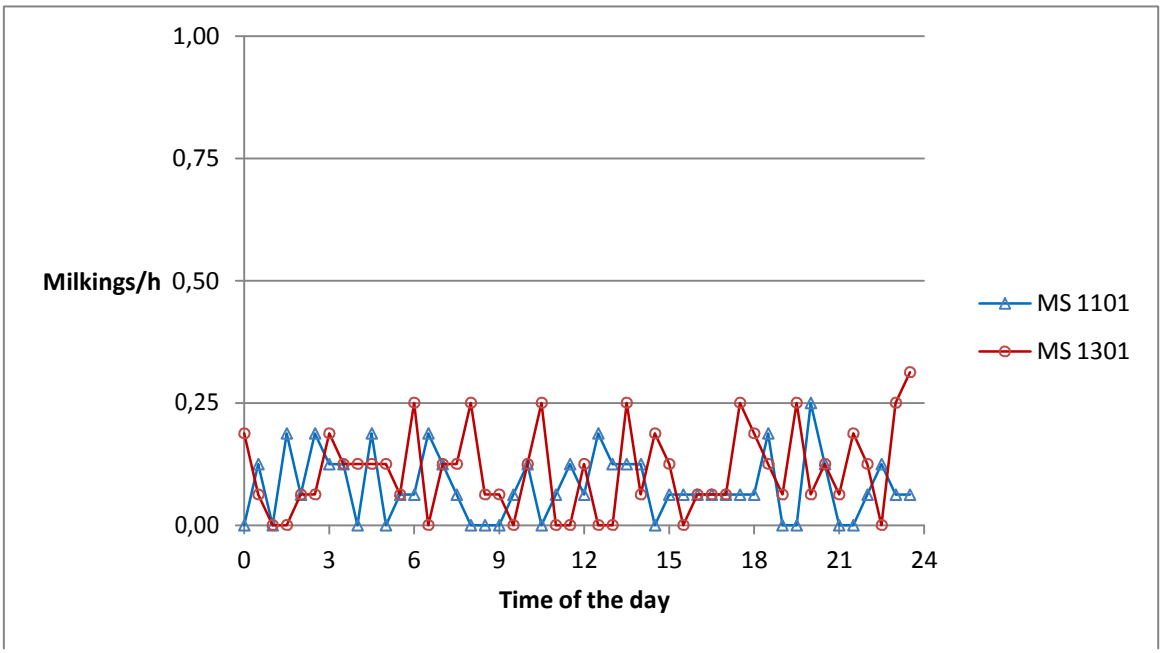


Figure 4. Distribution of failed milkings over the day

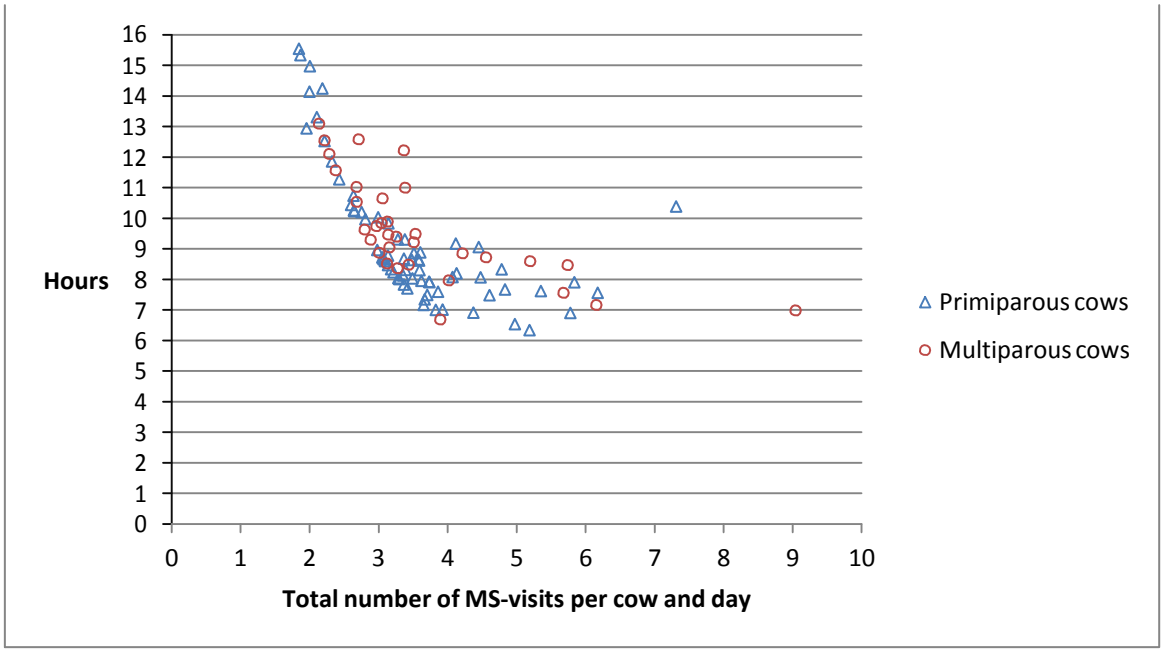


Figure 5. The relation between total number of visits to MS and the milking interval for individual cows

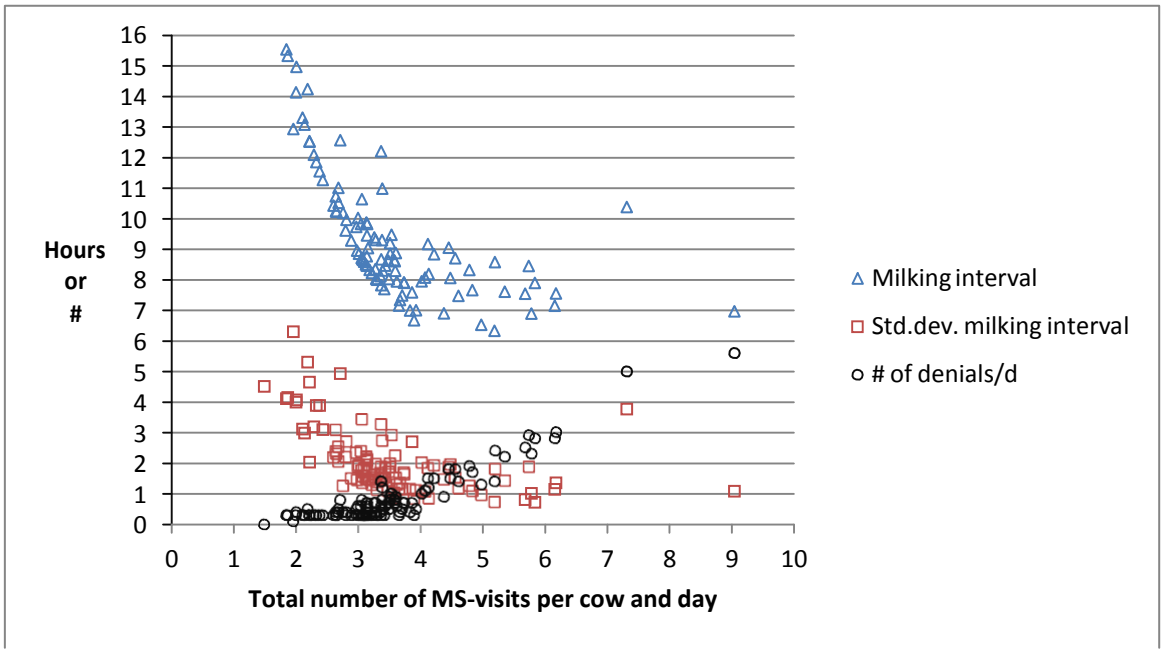


Figure 6. The relation between total number of visits to MS on the number of denied milkings and the effect on average and variation in milking interval for individual cows.

Farm 8.

40 cows in 1 group. 1 MS. Production level 8 000 kg ECM. Silage and concentrate fed separately. Silage distributed five times a day at 07:00, 11:00, 16:00, 19:30 and 23:00.

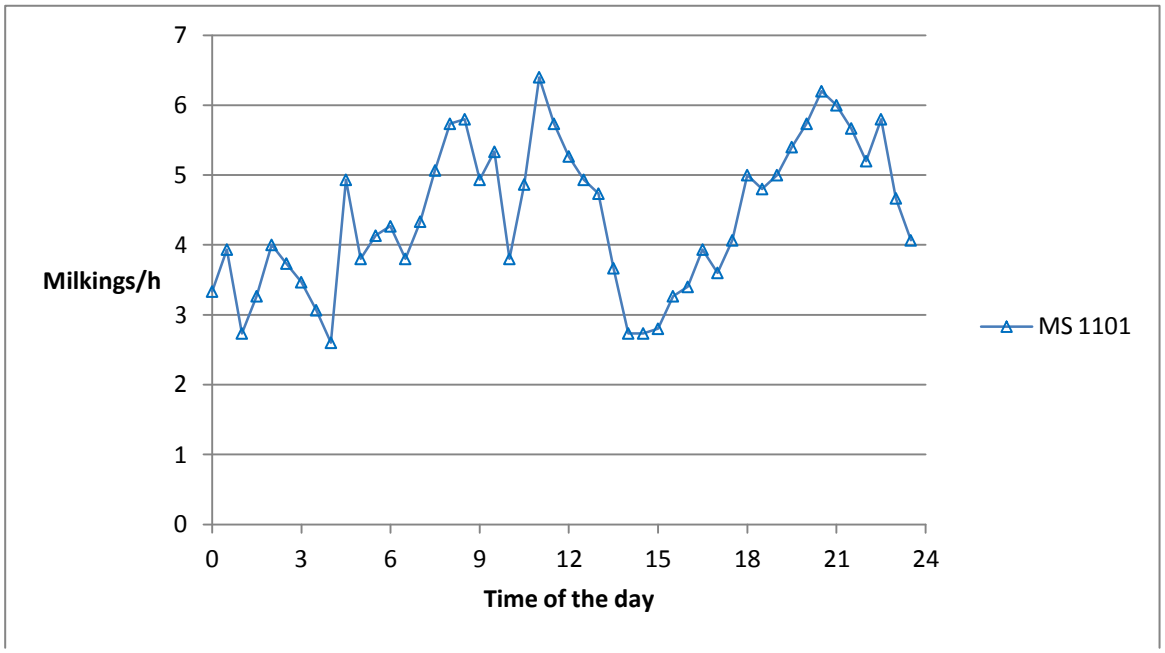


Figure 1. Distribution of milking visits over the day in visits per hour and MS

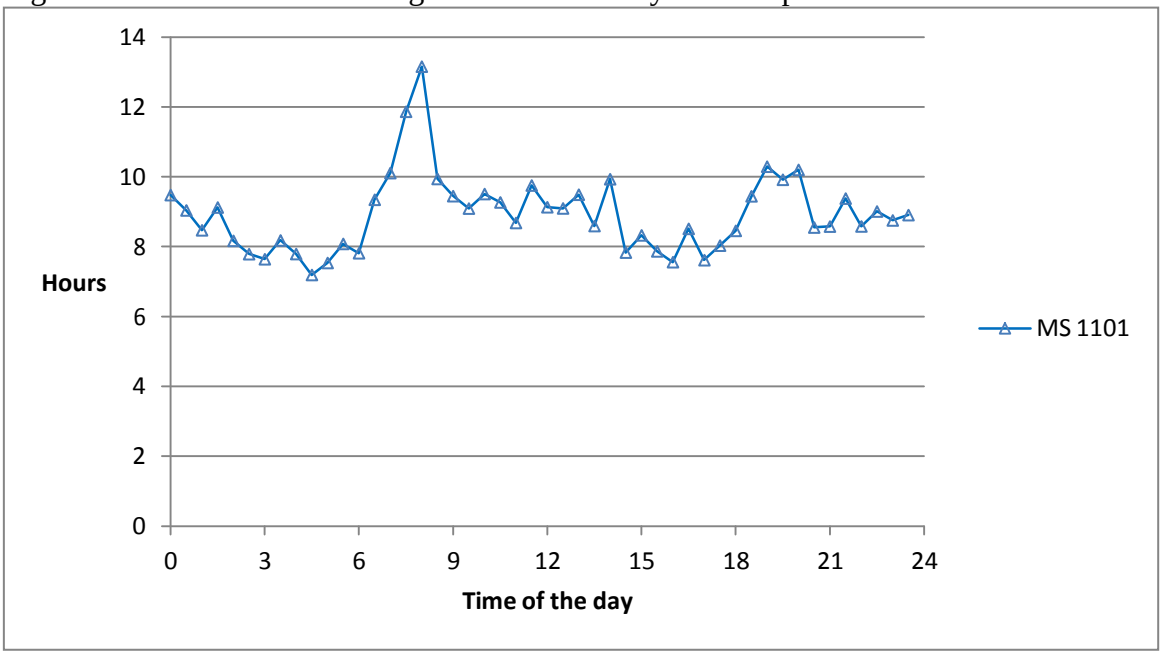


Figure 2. Average milking interval for milking visits over the day

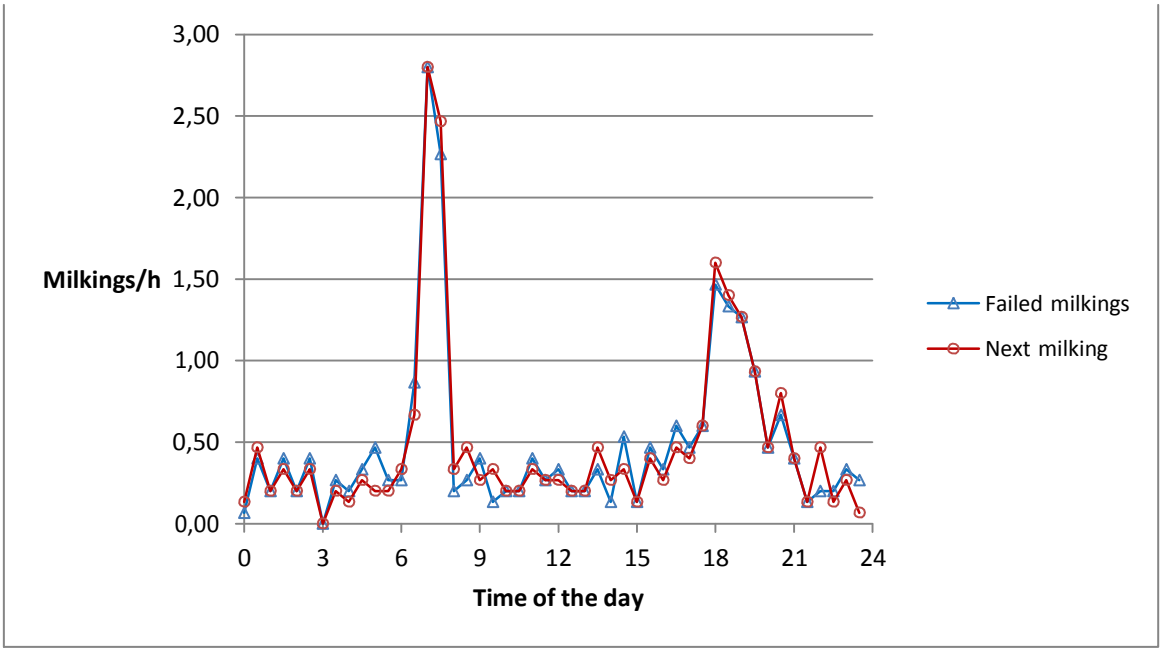


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

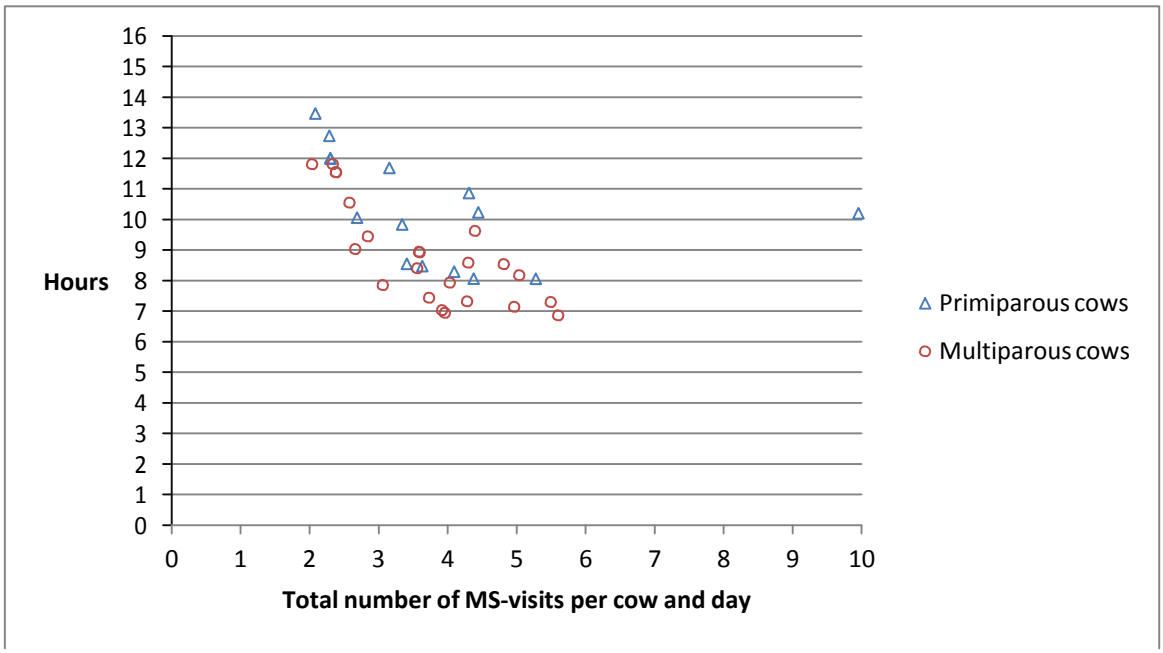


Figure 4. The relation between total number of visits to MS and the milking interval for individual cows

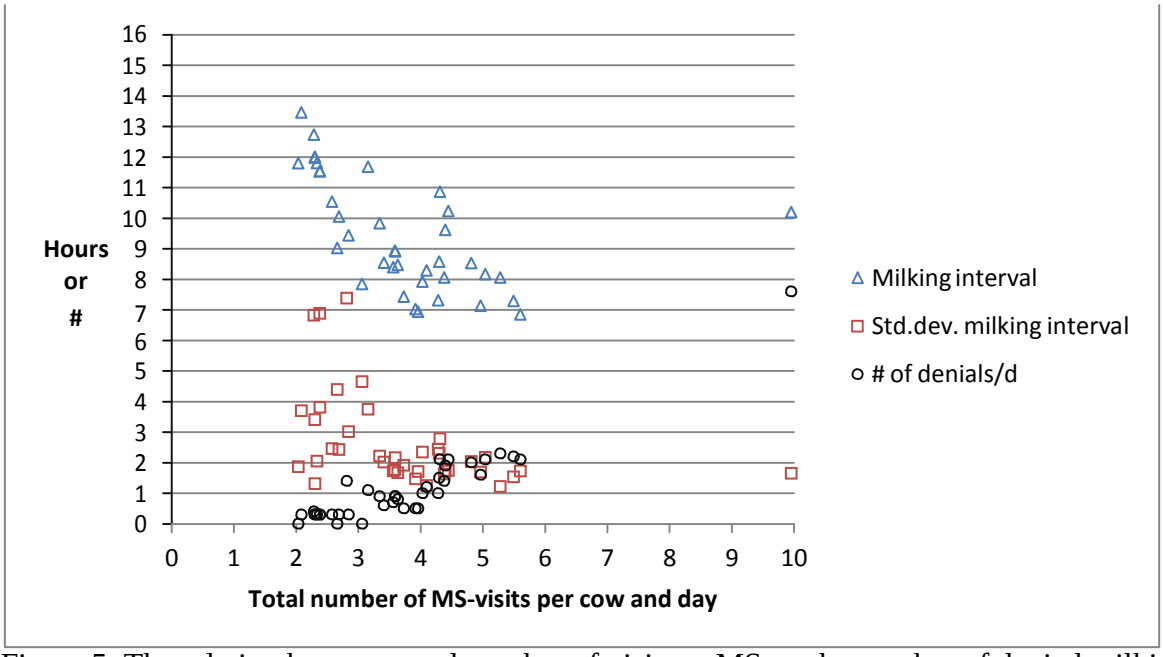


Figure 5. The relation between total number of visits to MS on the number of denied milkings and the effect on average and variation in milking interval for individual cows.

Farm 9.

90 cows in 2 groups. 2 MS. Production level 8 800 kg ECM. PMR and concentrate fed separately. PMR distributed three times a day at 06:00, 11:00 and 17:00.

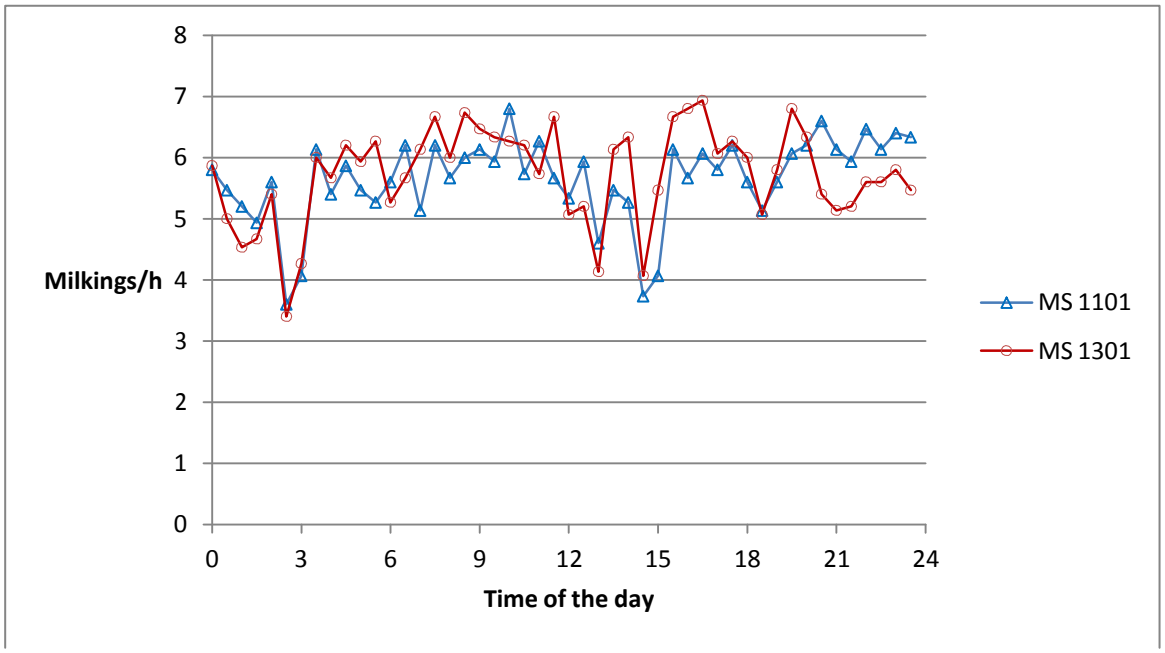


Figure 1. Distribution of milking visits over the day in visits per hour and MS

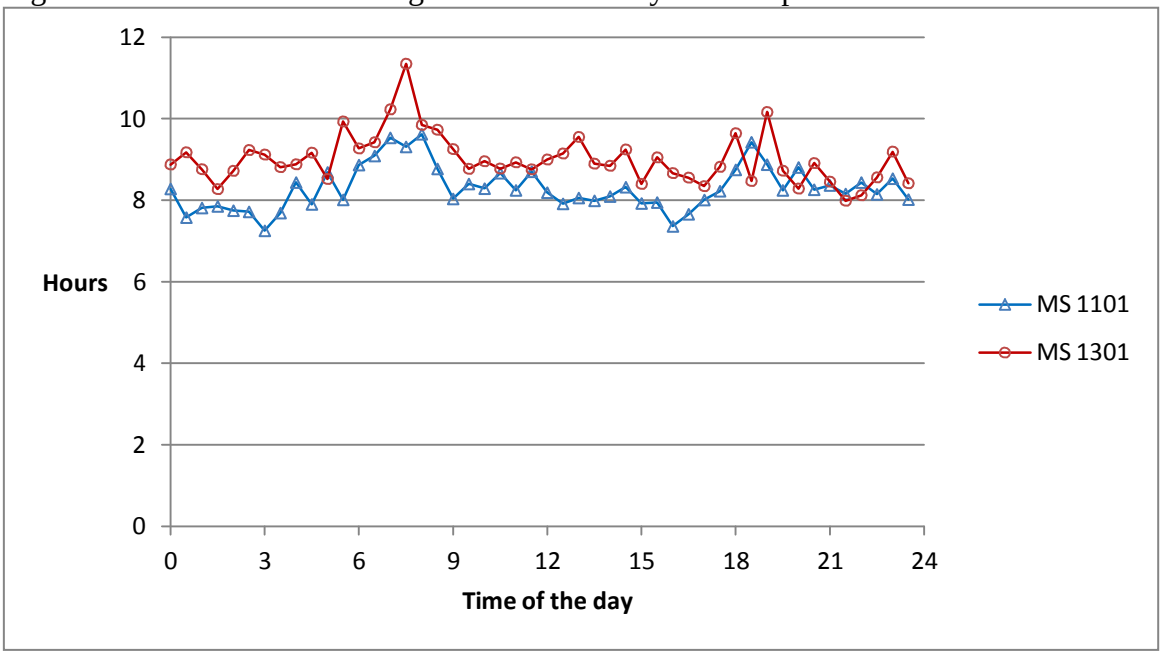


Figure 2. Average milking interval for milking visits over the day

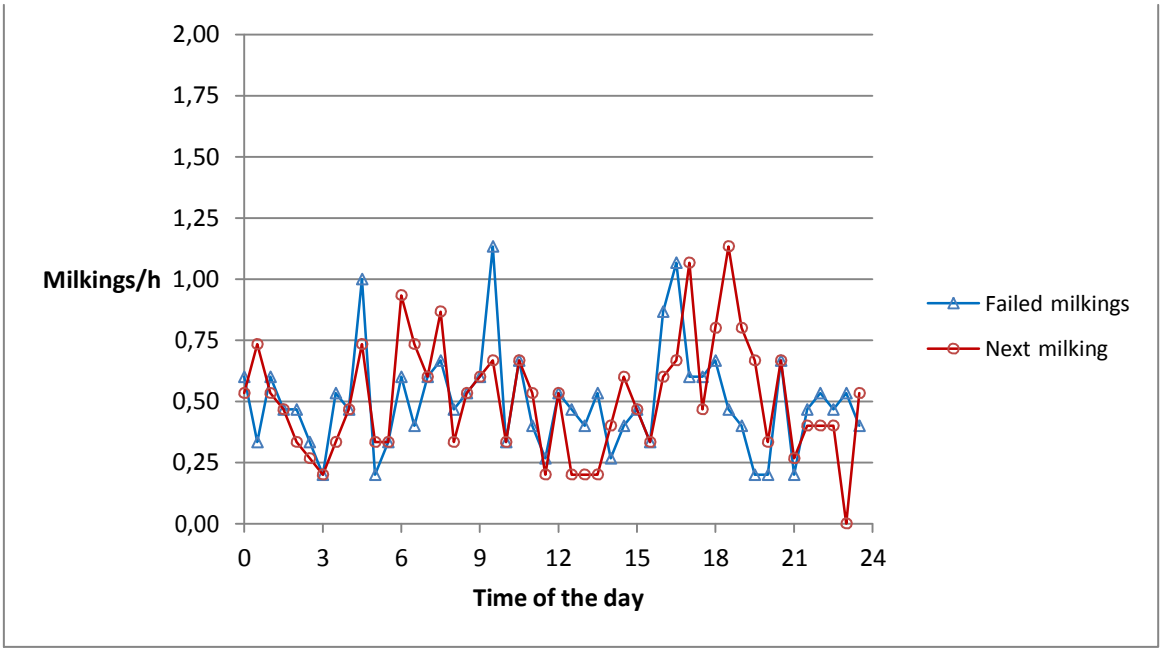


Figure 3. Overall distribution of failed milkings and the consecutive milkings following failed milkings (Next milking) over the day

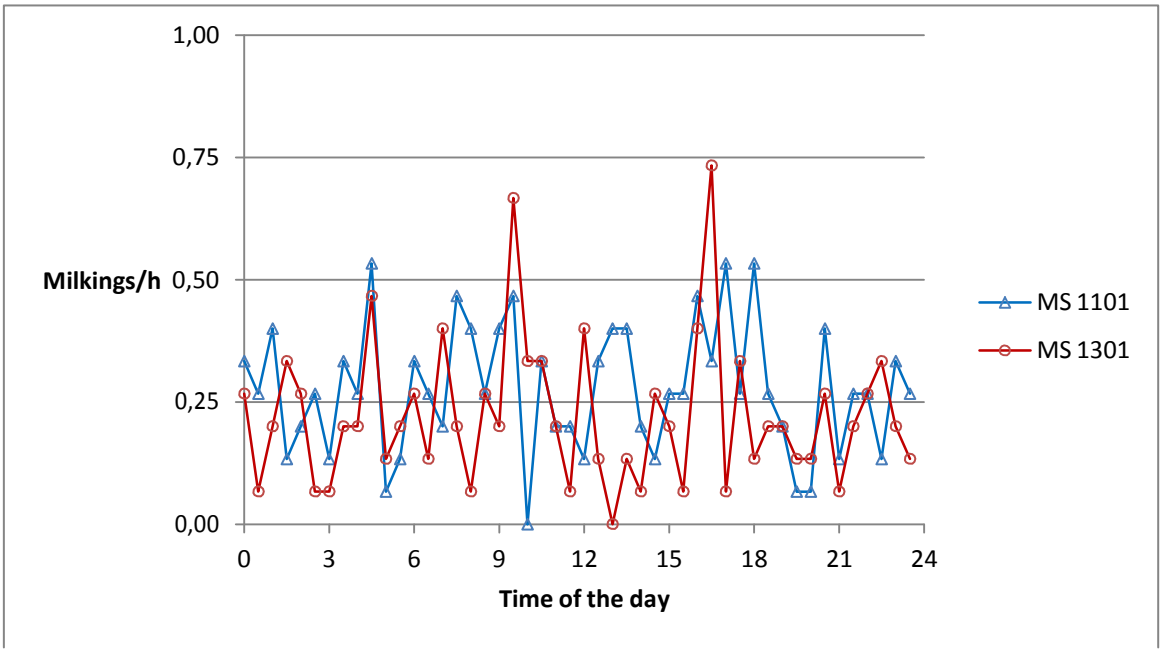


Figure 4. Distribution of failed milkings over the day

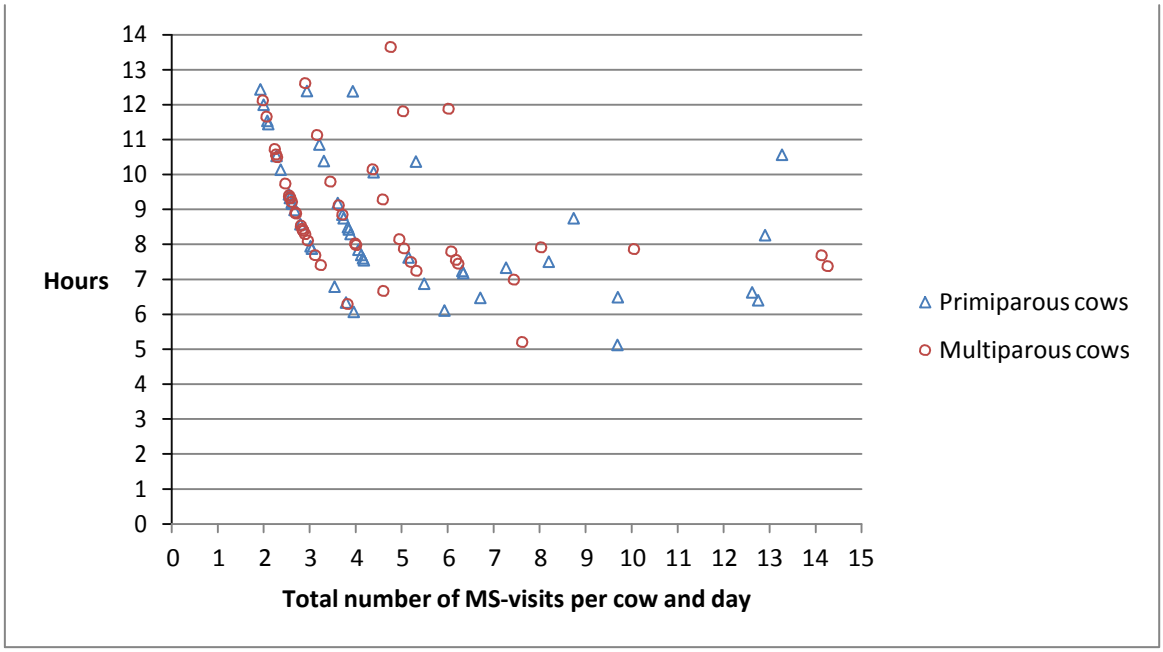


Figure 5. The relation between total number of visits to MS and the milking interval for individual cows. Note: Number of denied milking visit registered without decimals on farm 9.

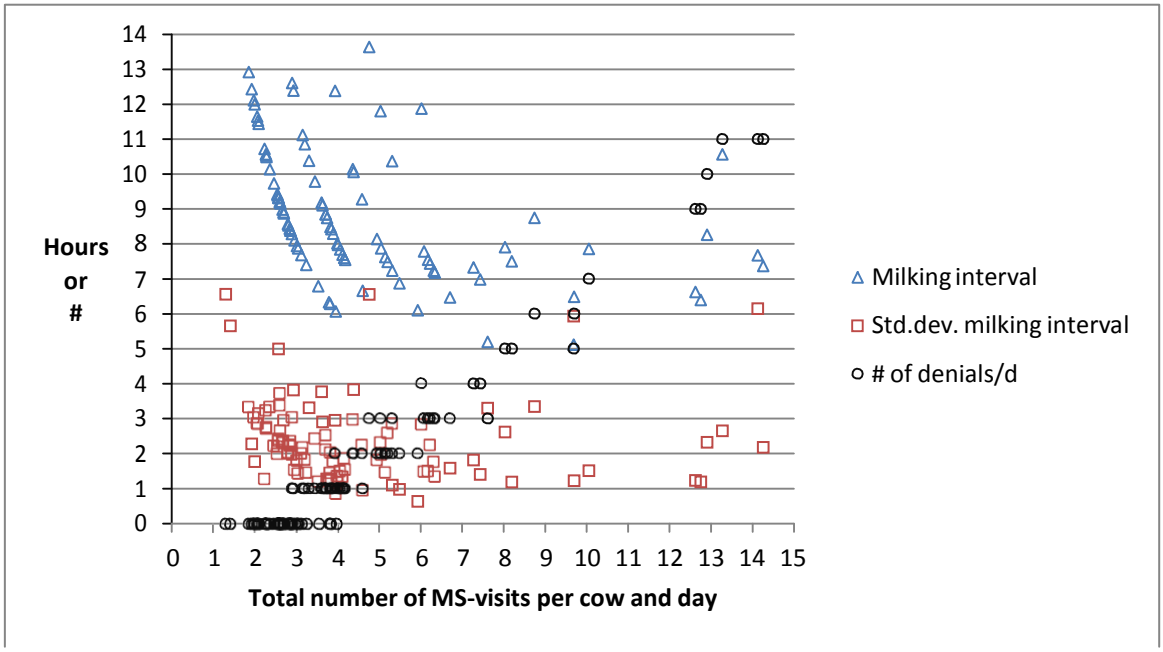


Figure 6. The relation between total number of visits to MS and the number of denied milkings and the effect on average and variation in milking interval for individual cows. Note: Number of denied milking visit registered without decimals on farm 9.

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