Sveriges lantbruksuniversitet
Fakulteten för veterinärmedicin och husdjursvetenskap

Swedish University of Agricultural Sciences
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Introduction of heifers to an automatic milking system

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Introduktion av förstakalvare i automatiserad mjölkningsstation

Sarah Widegren

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Abstract

Automatic milking systems (AMS) are part of a growing trend in Sweden and the number of milk-producing farms is decreasing rapidly. One main reason for the AMS is its ability to facilitate work for the farmer. The effects of introduction prior to calving have not been documented earlier and farmers are not in agreement, however they seldom see a problem with the introduction. The aim of this report is to find differences between two groups of heifers, where one group is trained i.e. introduced to the AMS before calving and the other group is introduced after calving. Collected data is from a period of four years.
Introducing a system to the heifer prior to calving, has in this study proved to have positive effects on milking intervals, visits to the feeding station and milk production.
The ranks in the herd prior to introduction were also compared to those after the admittance. The results indicated that an introduction had no larger effects on the cow’s rank in the herd. In summary, training results in a higher milk production, however an introduction during the late part of pregnancy should be avoided as it may have negative effects on the rank of the heifer. Another study shows that cows close to parturition avoid conflicts and can therefore lose their rank in the herd.

Sammanfattning

Automatiska mjölkningssystem (AMS) växer i antal i Sverige men samtidigt minskar antalet mjölkprocucerande gårdar kraftigt. Ett viktigt skäl till AMS framgång är att de underlättar arbetet för lantbrukaren. Tidigare har ingenting dokumenterats vad gäller effekten av olika sätt att introducera kvigor till AMS före kalvning. Lantbrukare har olika uppfattningar om detta men de anser att det sällan blir problem med introduktionen. Syftet med denna rapport är att finna skillnader mellan kvigor som introduceras före kalvning och kvigor som inte introduceras till AMS förrän efter kalvning. Datan som sammanställts är från fyra år.
Att introducera en kviga före kalvning har i denna studie visat sig ha positiva effekter på mjölkningsintervaller, besök till foderstation och mjölkproduktion.
Kvigans rang i flocken före en introduktion jämfördes även mot efter introduktionen. Resultaten indikerar att en introduktion inte hade några större effekter på rangordningen i flocken. Sammanfattningsvis, träning resulterar i en högre mjölkproduktion. Dock borde en introduktion under den senare delen av dräktigheten undvikas eftersom den då kan ha negativa effekter på rangordningen för den individen. En annan studie visar att högdräktiga kor undviker konflikter och kan därför förlora sin rang i hjorden.

Introduction

Automatic milking systems (AMS) are relatively new in Sweden and are part of a growing market. Due to their novelty, studies are required in order to either motivate reasons for their development but also to indicate the best way to use them in order to meet optimum requirements. The technology is designed to facilitate work for the farmer by encouraging the cows to individually visit the milking station (MS). In order for the milking process to run smoothly, the frequency at which the cows visit the MS must be voluntary and continuous over a 24-hour period. Tie-stall housing systems are still the most common form of holding cows in Sweden. However, a trend is growing towards larger loose-housing systems.

A full udder is not enough to motivate a cow to be milked (Lind *et al*, 2000). Therefore, feed stations placed after the robot, are often used to motivate another visit. Forage is most often provided *ad lib*. Cow traffic systems are of free or forced form.

Farmers are of different opinions concerning if heifers should be introduced to AMS before calving. The aim of this report is therefore to investigate how much cow-traffic is affected by an introduction of the heifers to AMS. Also it is of interest to investigate if the order of rank alters after calving compared to before.

In order to attain a continuous visitation to the MS, dominance factors should be considered when the AMS are designed and new farms are built. Differences have been found in behaviour between low-ranking and high-ranking cows.

Literature Background

Cow behaviour and communication

In their natural state the cow has a daily rhythm including activities such as eating, sleeping and ruminating. Body language, smell and touch are the main forms of communication between cows in a herd. At distances, sounds are utilised. When the hierarchy is established, it is often enough for two cows to exchange glances in order to avoid conflicts (Jensen, 1993).

Hierarchal dominance in the herd

Behavioural Patterns

Cows are hierarchal herd animals. Several factors decide the order of rank, such as age, size, development of pregnancy and health state. However, the rank is not precise for all situations, so that a hierarchal dominant cow in a situation which involves feeding may not have precedence to a place to lie down (Jensen, 1993). Selection of individuals and not of groups develops into biological evolution (Beilharz & Zeeb, 1982).

Aggressive behaviour must be kept different from dominance. Dominance occurs when the behaviour of one individual is inhibited in the presence of another. Aggressive actions are often primarily used in the establishment of the direction of dominance. Further aggression is not required in a stable relationship. A dominant animal does not have to show aggressive behaviour, but it may have had to in the past in order to establish its present status (Beilharz & Zeeb, 1982).

An experiment performed by Beilharz and Zeeb (1982) showed that every cow was inhibited in some sense by at least one other cow in the herd. They did not find any alpha animals. Dominance relationships were learnt and long-lasting. The initial decisions were made at different ages. Two cows can be in the same herd and can early in life determine dominance so that even though if later on in life, one cow is much heavier and stronger than the other, it may not be noticeable in their relationship.

Some indications were made that cows close to parturition avoided aggressive interactions, so that new cows introduced to the herd at this stage became dominant over them. The presence of horns gave cows advantages in their hierarchal value in the herd, with age (Beilharz & Zeeb, 1982).

The rank of a cow affects her activity in a restricted area as a loose-housing system and also has an effect on the activities of other cows. She may push her way forward and pass several other cows in line. This is mainly due to her dominance in this certain situation. It is thus common that a cow enters the MS directly without having waited at all (Rydberg, 2000).

Cows of a low rank are forced to adjust their behaviours according to those of a higher rank. They are subjected to more threats and are forced to wait for a longer period of time in the waiting pen in front of the MS, than cows of a higher rank (Alm & Möller, 2004). The rank also has an effect on their behaviour, as low-ranking cows are forced to adjust their feeding behaviours and times of milking to the times of high-ranking cows (Mehlqvist, 2003).

Dominance value

A method described by Olofsson (2000) gives each cow in a herd a value of dominance based on how the cows behave around feeding stations with forage. A cow that drives another cow away from the feeding station receives one point in a dominance matrix point system. A dominant cow has twice as many points as the other cow in the cow-pair i.e. to whom she is compared to. The proportion of pairs of cows where a cow was seen to be dominant gives her a dominance value. The value could be 0 – 1, where 1 indicates total dominance.

An experiment performed by Wirenga & Hopster (1990) indicated that low-ranking cows spent less time standing in cubicles when the environment was overcrowded. When overcrowding reached 55%, time spent lying per 24 hours also reduced. The effects of overcrowding were not as pronounced for high-ranking cows. Factors other than social dominance order, which were described to have an effect on the time spent in the cubicles, were age, stage of lactation, feeding system and overcrowding. Of the total time spent in the feeding station, no differences were seen between high- and low-ranking cows. Reduced lying time was however more pronounced for low-ranking cows (Wierenga & Hopster, 1991). Contradicting the latter findings, no differences were found in the lying time or pattern due to social dominance (Ketelaar-de Lauwere *et al*, 1996).

Milking station visits

Low-ranking cows visit the MS more frequently during the night, between 11pm and 5am, than high-ranking cows (Eriksson, 2002). An experiment showed that low-ranking cows visited the MS between 12 pm and 6 am, more often than high-ranking cows. The dominance value of cows was not related to the total number of visits to the MS. High-ranking cows visited the MS more during the day, between 12 am and 6 pm (Ketelaar-de Lauwere *et al*, 1996). Mehlqvist (2003) also found a trend indicating that between 6 am and 12 am fewer low-ranking cows visited the MS, compared to high-ranking cows. Low-ranking cows spent more time in the waiting area in front of the robot and left it more often without having visited the MS (Ketelaar-de Lauwere *et al*, 1996).

Daily rhythm and habits

In the early hours of the morning, midday, and during late afternoon, cows normally graze if in an undisturbed herd. Following grazing, the cows ruminate. Duration of rumination depends on aspects such as the coarseness of the roughage. Between four and nine hours are spent on rumination in a 24-hour period. The cow sleeps during short periods of time during the darker hours of the day (Jensen, 1993).

In a behavioural experiment performed by Rudberg (2000), the most unattractive times of the day to visit the MS proved to be between 7 am and 9 am, also between 2 pm and 4 pm. The cows were fed *ad lib*, but between 8 am and 8.30 am, also between 3.30 pm and 4 pm new roughage was distributed. The latter shows that during feeding time the cows choose to feed prior to being milked. At 10 pm, the frequency of visits to the MS drastically fell.

In an experiment performed by Wagner-Storch & Palmer (2003), feeding rates of cows, at night and early morning in both parlours and AMS were low. Following milking and the delivery of new feed, feeding activity increased for parlour cows. Cows in the AMS increased feeding and milking activity after human intervention at 7 am. Activity at the feed bunk reached a peak at 10 am and carried on to 8 pm in the AMS.

Between 8 am and 1 pm, also 3 to 7 pm, higher percentages of cows visited the MS. Between midnight and 6 am, very few cows visited the MS. The percentage of cows waiting to visit the MS peaked between 8 to 11 am, also between 3 to 6 pm (Wagner-Storch & Palmer, 2003).

Experiments performed by Wierenga & Hopster (1990) showed that in normal conditions, i.e. not overcrowded conditions, less than 4 of 24 hours were spent at the feeding rack. Approximately 3 hours were spent in a walking area, 15 hours in cubicles of which more than 13 hours were spent lying down and approximately 1.5 hours were spent in and around the milking parlour. Overcrowded conditions led to less time spent in the cubicles. The cubicle was found to be the place where the cow could rest and hide.

Holding of dairy cows in Sweden

Since the time of old Egypt, cows have been bound during the stable season. However, this form of holding the cows limits their natural behaviour to some extent (Jensen, 1993). Tie-stall housing systems are however becoming less common, as a trend is growing towards a larger and loose-housing system in Sweden (Olofsson, 2000).

Heifers are often reared in loose-housing systems. An introduction to the AMS usually takes a few days up to a week. A complete introduction where the heifers voluntarily visit the MS takes approximately ten days. Farmers are of different views concerning if heifers should be introduced to the AMS before calving (Mörk, 2003). Melin *et al,* (2005) stated that primiparous cows are well adapted to an AMS after two weeks in the system.

Cow-traffic systems

Cow-traffic systems can be free, forced or intermediate versions of free and forced. In a forced cow-traffic system, the cow is obligated to visit and pass through the MS before reaching the forage. In free cow-traffic systems, the cows voluntarily visit the MS. Forced cow-traffic systems seem to be less attractive to the cows whereas free cow-traffic systems seem to be the less suitable solution for the farmer.

Ketelaar-de Lauwere & Ipema (2000) studied a third type of cow-traffic system requiring the cow to pass through the MS to reach the concentrate, but freely move around and at any time reach forage This form stimulates the cows to visit the MS at regular intervals. Concentrate should be provided every four hours for best eating of concentrate, least leaving of feed and longer laying times.

Munksgaard *et al* (2002) have in one experiment shown that the number of milkings per cow per day was the same for free and forced traffic systems. The type of traffic had no effect on the number of visits to the MS even when milking did not take place. A use of forced traffic was not required as the frequency of milking was high in both systems.

The primary motivation for the cow to visit the MS is feed. A full udder is not enough motivation for a cow to be milked nor is an increased interval since last being milked (Lind *et al,* 2000). In order to achieve a more effective AMS, genetic demands are necessary concerning easily introduced cows who voluntarily visit the milking systems. This in turn improves labour efficiency (Konig *et al*, 2006).

Milking properties and milk yield

Milk let down

A neuroendocrine reflex is activated during milking. The hormones, oxytocin, prolactin and cortisol are released. In monogastric animals, oxytocin has been shown to have an effect on metabolism, behaviour and milk let down (Svennersten-Sjaunja *et al*, 2000).
Oxytocin is excreted from the pituitary gland of the cow. Factors such as stress from a new environment can inhibit oxytocin release. A study indicated that milk let down was inhibited more frequently in AMS than in loose-housing systems and tie-stalls. Feeding cows during milking had a positive effect on milk let down. Cows which spent one day or more with their calf had a more problematic milk let down during the lactation period. Milk let down

occurrence did not differ between heifers that were moved to the stables after calving with or without receiving an introduction before (Jarander, 2006).

Lundgren (2004) showed a trend indicating that oxytocin levels in low-ranking cows seem to be higher than in high-ranking cows both at rest and during milking, in a milking unit. They have a higher basal level but also a higher peak. This may indicate that the low-ranking cows are calmer and do not experience as much stress as the high-ranking cows.

Feeding during milking should be routine when designing new systems due to the fact that oxytocin has positive effects on both production and behaviour of the cow. Small management changes can also lead to significant effects on the physiology of the cow, which can give responses in production and behaviour (Svennersten-Sjaunja *et al*, 2000).

Udder health and Milk quality

In experiments, no differences have been found in cell count of cows in AMS and tie-stalls (Svennersten-Sjaunja *et al*, 2000). Cases of treated mastitis do not differ between before and after an introduction of AMS. Udder health of cows with mastitis is not affected by an introduction to AMS. However, an introduction to a new milking system can cause a temporary decline in udder health (Petersson, 2006).

Milk yield and milk components

Milk of a dairy cow is produced in the mammary epithelial cells in separate mammary glands forming the four quarters of the udder. Food intake increases during lactation and for a short period of time, a high-producing cow can produce milk containing up to 4 times her own maintenance requirement. Milk consists of components primarily taken from nutrients absorbed from the digestive tract. The major components of milk are lactose, fat and protein. Mobilised amino acids and triglycerides from the body can also build these components (Sjaastad, 2003).
During the first weeks following calving, the fat and protein content of milk decreases. At peak lactation, approximately 4 months into lactation, the fat and protein levels are at their lowest in the whole lactation period. Lactose levels increase slightly at first and gradually decline during the months of lactation (Sjaastad, 2003).

Milking frequency has effects on the milk yield. Three milking sessions per day increases the milk yield in comparison to two milking sessions (Hogeveen *et al*, 2000). An increased milking frequency gave a milk yield increase of approximately 9% through 16 weeks of early lactation. However, the higher milk yield was not significant if energy-corrected milk was measured (Melin *et al*, 2005).

An experiment comparing cows milked with a conventional milking parlor to those in an AMS revealed that of 39 days in the summer, milk production by groups of cows was significantly higher (26.4 vs. 25.8 +/- 0.2 kg/d) for cows in the AMS group (Wagner-Storch & Palmer, 2003)

Cow welfare

As cows are living beings it is important that their welfare is not overrun by striving for a better, more efficient production. Cow welfare can be improved in AMS due to the fact that the cow is given more control of her daily routines. On the other hand, if overcrowding occurs so that queues form in the cubicle area, cow welfare is not improved, therefore an AMS must be planned carefully (Lind *et al*, 2000).

The glucocorticoid, cortisol is excreted from the adrenal cortex and is important in the regulation of glucose metabolism. Stress activates an increase of cortisol in the blood. It is therefore an important stress hormone and high and prolonged levels of stress increase its concentration. In order to prevent a blood pressure drop, cortisol reinforces the effect of norepinephrine. Cortisol also increases glucose concentration in plasma and has anti-inflammatory effects (Sjaastad, 2003).

Cortisol-values in the blood have been measured in cows of different rank in order to determine any experiences of stress. At rest, cortisol-values were lower in low-ranking cows compared to high-ranking cows. Low-ranking cows had a mean value of 12.2nmol/l compared to 16.9nm/l in high-ranking cows. During milking, the lower cortisol-values persisted for the low-ranking cows with 21.6nmol/l compared to 35.5nmol/l in the high-ranking cows. Cortisol-concentrations increased earlier in the high-ranking group of cows (Eriksson, 2002).

An experiment performed by Alm & Möller (2004) showed that cows in an AMS experienced the time before they could enter the MS as being more stressful than for cows in a conventional system. The cows held in the conventional system were fed *ad lib* and were kept in a loose-housing system and milked by hand in a herringbone stall. Whilst waiting to enter the MS, high-ranking cows showed aggressive behaviour approximately five times more than the low-ranking cows.
The cows in the AMS experienced the milking process as more stressful than the cows in the conventional system. The AMS cows had slightly higher cortisol levels, and lower oxytocin levels. A higher cortisol level can also be explained by the fact that the cows had higher levels even before entering the MS (Alm & Möller, 2004).

No differences in cortisol levels were observed between cows in milking parlours and cows in AMS. The latter may indicate that stress reactions are similar to both groups of cows (Gygax *et al*, 2006).

Detection of disease is an objective of AMS. Clinical and sub-clinical ketosis can be detected automatically by automatic breath sampling and regularly measuring ketones and urea in milk. As ketosis is common in early lactation, this can be of major importance (Mottram, 2000).

The development of automatic milking systems

Conventional dairy production is characterised with monotonous manual work for the farmer, inducing musculoskeletal problems in the long run. Risks for injury are significantly higher for a farmer working in a herringbone or tandem stall than in an AMS due to the fact that the time required of the farmer for milking is much less in AMS. Also, feeding is often more automated in AMS than in smaller systems. Musculoskeletal problems are avoided more in AMS as the robotic arm operates the larger extent of the heavy, recurrent and one-sided milking chore. From an ergonomic point of view, AMS is meritable and should therefore be taken into consideration when making new investments (Qiuqing *et al,* 2006).

Several manufacturers of AMS compete on the market today. Since 2000, more than 420 robots have been sold in Sweden, by DeLaval, a large manufacturer of AMS. When larger renovations or new building takes place, in about 80% of the cases, investments are made in robots and automatic systems. Today, there are 7438 milk producing farms in Sweden, indicating a decline in number of approximately 8% during the past years. A trend is growing towards larger, more automatic systems (Johansson, 2007).

Table 1: Development of number of governmentally accepted AMS in the Scandinavia 1996-2006 (Gyllenswärd, 2007)

Country	**1996-12-31**	**1997-12-31**	**1998-12-31**	**1999-12-31**	**2000-12-31**	**2001-12-31**
Danmark	0	3	21	70	102	160
Finland	0	0	0	0	2	9
Island	0	0	0	2	2	4
Norge	0	0	0	0	1	6
Sverige	0	0	4	16	43	66

Country	**2002-12-31**	**2003-12-31**	**2004-12-31**	**2005-12-31**	**2006-12-31**
Danmark	221	322	394	418	483
Finland	25	55	108	159	216
Island	9	16	24	38	61
Norge	15	28	51	107	195
Sverige	91	224	260	300	377

Introduction of heifers in loose-housing systems

Mörk (2003) sent questionnaires to farmers in Sweden and compiled a report on their answers regarding an introduction of heifers to AMS. The study showed that many heifers are reared in loose housing systems and have no larger troubles conforming working herds. They were most often moved to the herd before calving and when in the AMS, most first lactating cows voluntarily visited the MS. Regarding an introduction to the MS before calving, farmers were of two opinions. Some believed that it was disadvantageous as it took time from milking if they were introduced beforehand. Others found an introduction to be advantageous.
The heifers must adapt to a new environment and many new experiences when the introduction to the system takes place. Becoming familiar with the MS robotic arm is required from them, but simultaneously they are required to produce high milk yields and even to maintain and attain body weight, in order to stay healthy (Mörk, 2003).

Aim of the study

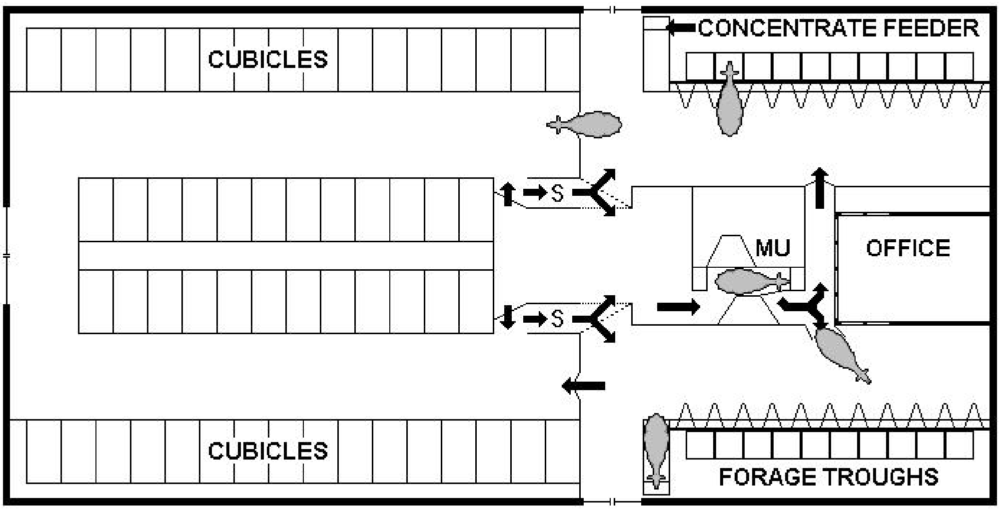
It is of interest to see if the heifers have advantages from being introduced to the AMS prior to calving. When introduced prior to calving, the heifers are pregnant and if introduced after calving, they are newly calved and in great need of feed and nutrition.

Material and Methods

At Kungsängen Research Centre, HUV, SLU, Uppsala, records are systematically taken on the Swedish Red dairy cows in the AMS. This report is primarily based on behaviour studies from 2001 and from collected data from 2003-2007.

Each cow has a unique transponder so that each of her actions is registered in a computer. The computerised system was installed in 1998 and allows researchers to observe the daily rhythm of any single cow regarding when she chooses to eat, to be milked and so forth. The cows are housed in a loose-housing system with DeLaval's Voluntary Milking System (VMS™). The MS measures milk yield and content for each cow and records its results. The cows are enforced by a forced cow traffic system with pre-selection gates. When a cow reaches the selection gates (S), she is either sent to the feeding area with forage troughs and concentrate feeders or to the waiting area in front of the MS. The latter being if she has not visited the MS for a certain length of time. After being milked she is directed directly to the feeding area, figure 1.

Figure 1: A schematic view of the loose-housing system at the Kungsängen.



The only time the cows do not have access to the MS is when it is being washed, three times a day. The cows have *ad lib* of silage. Concentrate is portioned individually for each cow and offered in the MS and concentrate feeders.

Animal behaviour studies

During the autumn of 2001, two animal behaviour studies were performed on 12 pregnant Swedish Red primiparous cows. The aim of the study was to register how heifers adapt to AMS depending on if they are introduced prior to calving or if they are directly let into the system during their first lactation.

Twelve heifers, all of which were expected to calf between October 5th and 29th were stalled in the AMS barn. Six of the twelve heifers were introduced to the system prior to calving. These heifers were removed from the barn a period before the expected calving date. All heifers were let into the AMS barn 10-15 days after calving.

At 9 am, three heifers were introduced into the herd. Their behaviours were observed during two hours. After this, the heifers were aided through the MS to the feeding area where they were enclosed and given the opportunity to feed. A maximum of four heifers were introduced per time. After calving, the cows exposed to an introduction were stalled in pairs with cows which were withheld an introduction.

Twice a day, i.e. at 8.20 am and 3.20 pm, the animals were led through the MS. Feeding of concentrate in the robot was also introduced. Cows who voluntarily visited the MS prior to the planned time were recorded. If they had visited the MS since the last time the helper was there, they were not collected for introduction.

Collected data

Data from 1 January 2003 – 1 April 2007 was collected and statistically analysed using procedures of SAS®(1996). The aim of collecting this data was to see possible differences in cow traffic and to understand the development of rank of the cows before and after calving.

The cows trained were done so at an average of two weeks before calving and were introduced as heifers before they were too close to parturition, i.e. not later than 4 weeks before calving. It is also important to mention that they were never introduced singly as this enabled the development of the herd to go smoother.

High- and low-ranking cows were determined according to the method proposed by Olofsson (2000). Dominance values for the training period and the period after calving up to week 20 of lactation were calculated separately. The dominance values have been calculated within the actual group of cows who were present in the stable together with the heifer. This differs from the method proposed by Olofsson (2000) as the dominance value should be calculated within the same group of individuals. Due to the fact that the collected data is from a period of over 4 years with a continuous introduction and removing of cows in the herd, this was not possible. Trained and untrained cows have however been introduced continuously during the studied period.

The GLM-procedure used in the variance analysis of dominance values had the model;
$Y_{ij} = \mu + t_i(0 \text{ or } 1) + e_{ij}$
Where t = untrained (i=0) or trained (i=1).

Milking interval, feeding interval, length of feeding area visits and daily yield was analysed by the MIXED procedure, with cow as a random effect, according to the model;
$Y_{ijk} = \mu + t_i + l_j + tl_{ij} + e_{ijk}$
Where t = treatment (untrained, trained)
l = lactation week, 1,2,3,…20
tl = interaction between treatment and lactation week

The formula for the regression analysis was;
$DV_a = \alpha + \beta * DV_b$
DV_a = Dominance value after calving
DV_b = Dominance value before calving.

Results

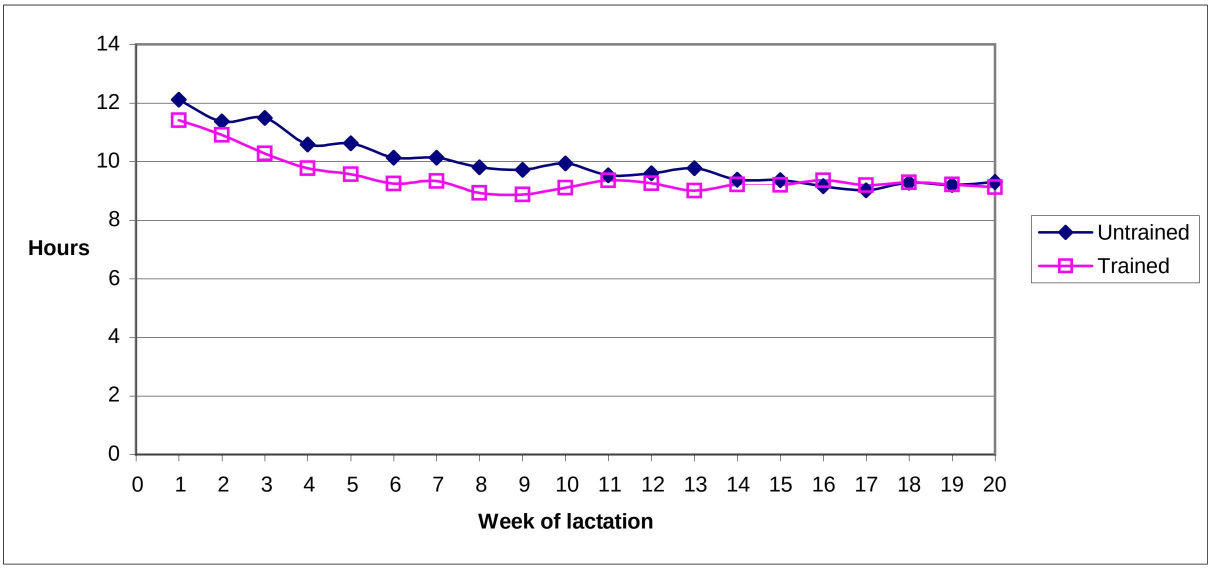
Behaviour study

Observations of the twelve heifers indicate that it takes 1-11 days for the heifers to learn to go through the MS on their own. Once the selection gates became known to the cows, passing the MS was no problem.

Milking interval

The results indicate a difference between trained and untrained cows during the first 10 weeks of lactation as seen in figure 1. The trained cows had a shorter milking interval between milking sessions, indicating that they were milked more often for the whole period *($p<0.05$)*. Following this period on to 20th week of lactation, no differences could be found. It seems as the untrained cows required longer time to become acquainted with the new environment, but after ten weeks in the new system they seem to be just as well adapted as the trained cows.

Figure 1: Milking interval for trained and untrained cows.

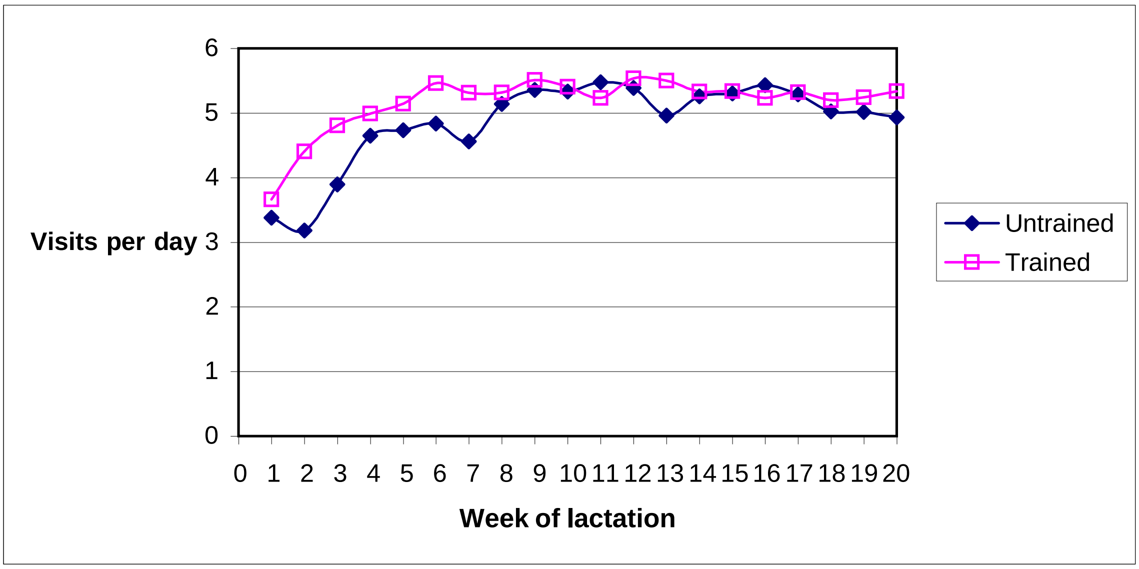


Visits to the feeding area

The number of feeding area visits is calculated from the identifications in the forage troughs and the concentrate stations. A feeding area visit was regarded as ended when a cow wasn't identified somewhere in the feeding area within 1 hour.

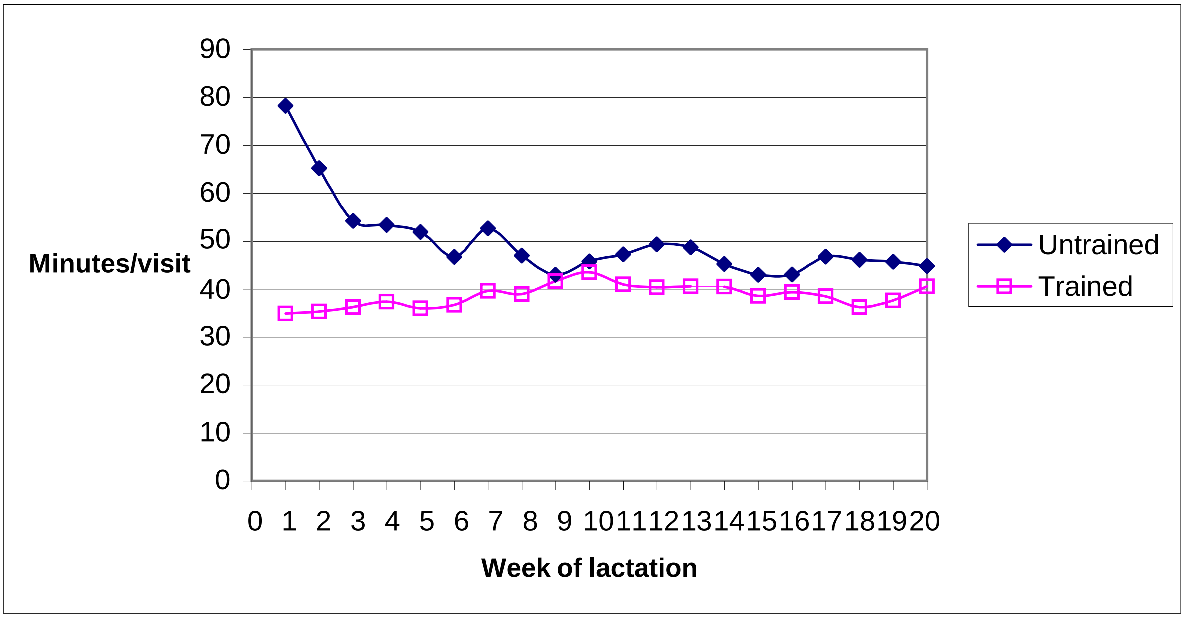
Differences were found during the first ten weeks of lactation, indicating that trained cows visited the feeding area more often than untrained cows during this period. Both trained and untrained cows increased their number of visits during the first weeks of lactation. The trained cows however reached their peak of visits already at week 5, which was much earlier than for the untrained cows who reached their peak at week 11. The peak for trained cows was also somewhat higher than for untrained cows. The overall differences could not be proven statistically but a trend could be seen (*p<0.16*). However there was a significant interaction between treatment and lactation week (*p<0.05*). See figure 2.

Figure 2: Visits to the feeding station per day by trained and untrained cows.



A significant difference could be seen between the two groups regarding the length of time spent in the feeding area (*p<0.001*). The trained cows adjusted quicker than the untrained cows, shown as a statistically significant interaction between treatment and lactation week (*p<0.001*). Even here, approximately 10 weeks were required for the untrained cows to adjust to the new environment. See figure 3.

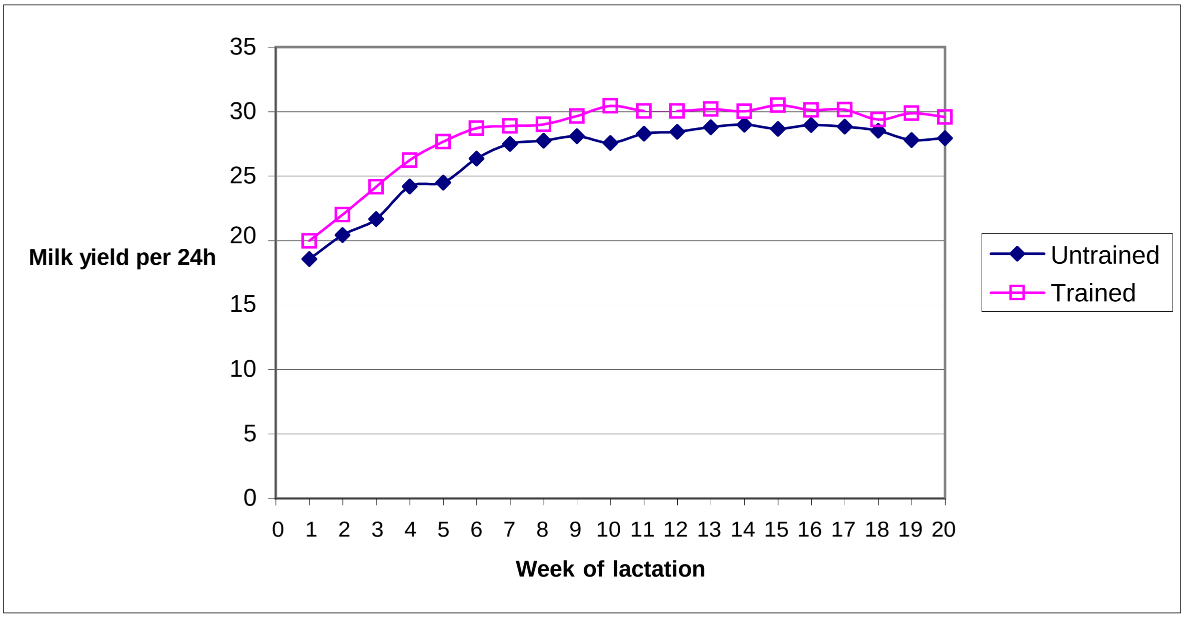
Figure 3: The length of a visit to the feeding station for untrained and trained cows.



Milk yield

The milk yield was significantly higher for trained cows than for untrained cows as can be observed in figure 4, ($p<0.05$). The trained cows reached a higher peak than the untrained cows and even after 20 weeks of lactation, the untrained cows did not attain such a high milk yield as the trained cows.

Figure 4: Milk yield for trained and untrained cows.

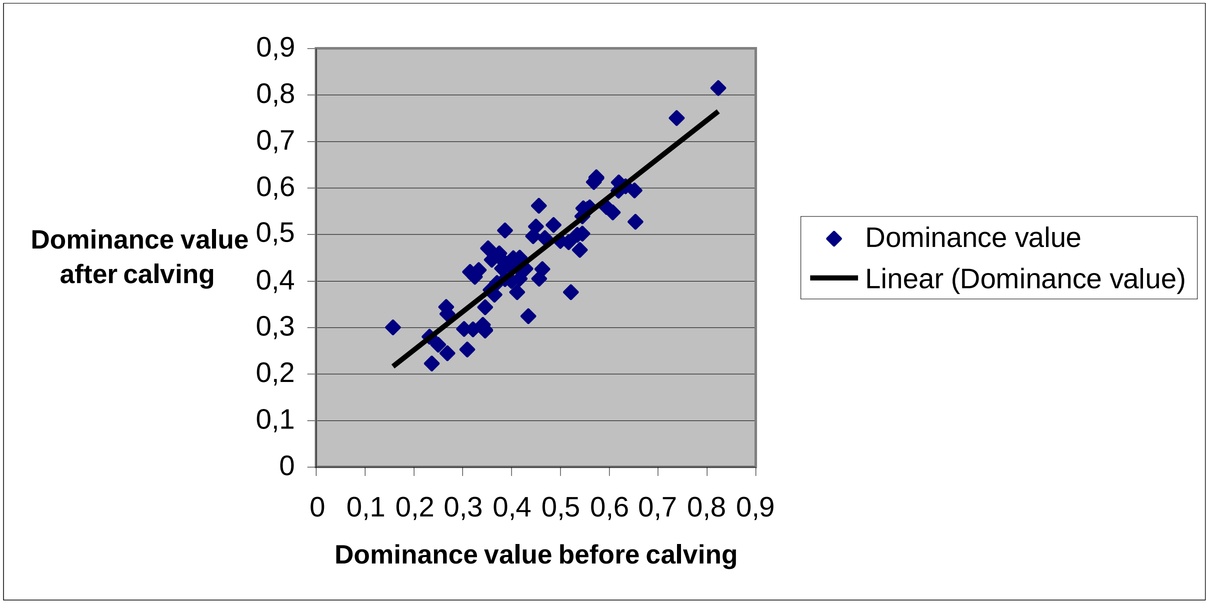


Dominance values and effects of calving

The dominance values after calving do not differ between trained and untrained cows. For trained cows, the average dominance value was 0.446 and for untrained cows, 0.457 ($p<0.69$).

For the trained cows, there is a significant positive relation between the dominance values before (DV_b) and after calving (DV_a) as $DV_a=0.086+0.824*DV_b$ ($R^2=0.80$, $p<0.001$) and seen in figure 5. The cows seem to find their place in the herd and also keep it when they return from calving.

Figure 5: The relation between calculated dominance values before and after calving.



Discussion and Conclusions

The results in this study indicate that an introduction of the animals to the AMS has positive effects on milking interval and visits to the feeding area, in turn giving a higher milk yield. Hogeveen *et al*, (2000) stated that three milking sessions a day are better than two as the cow then produces more milk. This agrees with the results in this paper as the milk yield was higher for the trained cows that also had shorter intervals between milking sessions.

As every cow is a unique individual, there will always be differences in how the cows experience entering the milking parlours and MS. Gygax *et al* (2006) indicated that cortisol-values were similar for cows in AMS and milking parlours. Stress reactions did not differ between the systems. This however can also depend on factors such as the length of time the cows have been in the system. During an introduction the results may be different.

During late pregnancy and after calving, the cow is in need of large amounts of feed. To minimise a negative energy-balance, the cow should be offered as much feed as possible. Any attempts to establish the rank in the herd require energy. Beilharz & Zeeb (1982) indicated that heavily pregnant cows avoided aggressive interactions so that new cows introduced to the herd became dominant over them. Due to the mentioned reasons, heifers should be introduced approximately a month before calving.

It may be easier for the heifer to adapt to the new environment before calving compared to after calving. Before calving, the heifer can take her time. She has a lower feed consumption than after calving and there is no risk for injuries which can occur post-calving. After calving, hormonal adjustments together with the fact that the cow may have to wait in line to enter the MS are factors which can be stressful. Following calving, the feed requirements also increase.

The results of this study show that it is beneficial for the cows to be introduced to a new environment, in this case AMS, before calving. Any new environmental aspects require time to adapt to, so it should also be important to be aware of how the cows are held prior to introduction, as this may have effect on the overall adaptation time. A smooth and easy introduction must be the best solution both for the farmer and cow. The introduction should however not be closer than a month to calving. Natural fluctuations in the number of milk-producing cows in the herd occur and by revising them, it should be possible to introduce cows without being forced to have extra spaces for heifers waiting to calf.

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