Factors affecting cow behaviour in a barn equipped with an automatic milking system

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Anne-Mari Forsberg

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Abstract

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This thesis is based upon two studies performed in the experimental barn at Kungsängen Research Centre, Swedish University of Agricultural Science (SLU), Uppsala, Sweden. The barn is equipped with an automatic milking (AM) system and is designed for 56 cows. During the studies the herd consisted of 45-50 cows of the Swedish Red Breed. Day in lactation and number of lactation varied among the cows participating in the studies.

The objectives of the first study were to investigate which traffic system was optimal for the cows activity, and if there were differences in behaviour and activity depending on social rank. Three traffic systems, free traffic (FT), forced traffic (FO) and selective traffic with controlling gates (SE), were compared. Visits to the feeding area and to the milking unit were distributed at quite regular intervals throughout the day, since feed was available all day. The results indicated that FT was advantageous for the cows, since number of cows in the milking queue was lower and numbers of meals were higher compared to FO and SE. However, the number of cows fetched for milking was lower and the milking frequency was higher during FO and SE. Number of cows fetched did not depend on social rank, however, the low-ranked cows spent less time resting and feeding and more time in the milking queue compared to the high-ranked cows. These effects was higher the more forced the traffic system was.

The objective of the second study was to test the hypothesis that cows choose equally between left and the right side when lying. The cows were observed in the loose house system provided with AM and both cows and pregnant heifers were studied when out on pasture. When kept indoors the cows chose equally between left and right laterality. In the resting area the cows lay facing towards the activity area in approximately 60% of the observations. While out on pasture, cows and heifers which were in the ninth month of gestation chose the left side in 60.7% of the observations.
Keywords: Automatic milking, cow traffic, cow behaviour, lying side, dairy cow

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Licentiate degree

The licentiate degree which requires two years of full-time postgraduate studies, is intended to guarantee, by means of course work and the completion of a dissertation, that the recipient

- has demonstrated an ability to investigate and to solve problems scientifically;
- is conversant with general scientific methods within his or her subject area;
- is knowledgeable within his or her area of expertise and has contributed to the development of this area through his or her own research;
- is able to utilise the scientific literature within the subject area and relate it to his or her result;
- has in the planning and execution of research, as well as in the analysis of results, worked both independently and in the co-operation with others;
- has experience in presenting and discussing research results, both orally and in writing, e.g., before a board of examiners at a final public seminar.

Contents

Appendix

Paper I - II

The present thesis is based upon the following papers, which will be referred by their Roman numerals:

I. Forsberg, A-M., Pettersson, G., Thune, R.Ö., Svennersten-Sjaunja, K. & Wiktorsson, H. 2008. Influence of cow traffic and feeding systems on cows' behaviour and performance when housed in a barn provided with an automatic milking system. (Submitted to Journal of Dairy Science)
II. Forsberg,A-M., Pettersson,G., Ljungberg,T.& Svennersten-Sjaunja,K. 2008. A brief note about cow lying behaviour – Do cows choose left and right side equally? Applied Animal Behaviour Science 114:32-36.

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Abbreviations used in this thesis

AM	automatic milking
DM	dry matter
ECM	energy corrected milk
FO	forced cow traffic
FT	free cow traffic
MJ ME	megajoule metabolisable energy
MU	milking unit
PMR	partly mixed ration
SE	selective cow traffic with controlling gates
SLU	The Swedish University of Agricultural Science
TMR	totally mixed ration
VMS™	voluntary milking system
x	times daily

Introduction

In Sweden, the first automatic milking (AM) system was introduced on a commercial farm in 1997. In Europe, AM systems have been available commercially since 1992 (de Koning and van de Vorst, 2002; Rodenburg, 2002). The initial reasons for the development of AM systems were the increasing costs of inputs and labour in the dairy production and decreasing milk prices (de Koning and van de Vorst, 2002; Samuelsson, 2001).

The labour situation in a barn equipped with AM is different to that in conventional barns. In an AM system, the milking process does not require twenty-four hour supervision, however, this does not imply that working hours are saved. Control and cleaning of the AM system are new tasks which arise. Visual checking of the cows is needed and cows which have excided the maximum time interval since last milking have to be fetched. A positive factor is that the work is less time-bound in the AM system than in the milking parlour system. This enables a more flexible labour input (de Koning and van de Vorst, 2002). Jensen (2004) claimed that the most important reason for investing in an AM system was the wish for less physically hard work followed by more flexibility in daily routines. It was also observed that the high expectations concerning labour parameters were fulfilled in most cases due to smaller work-load, fewer working hours and lessened stress.

A benefit of AM is the possibility to increase milking frequency without extra labour costs which could be one way of optimizing the dairy production. According to Amos et al. (1985) and DePeters et al. (1985), 3x milking was more cost efficient than 2x milking and a production increase of 10 – 15 % has been reported when milking 3 times per day (Amos et al., 1985; DePeters et al., 1985; Allen et al., 1986; Erdman and Varner, 1995). Milk production increased significantly in early lactation, and also during the entire lactation period, with 3x milking in combination with 4x feeding (Wiktorsson, 1971). Österman and Bertilsson (2003) stated that 3x milking increased feed efficiency compared to 2x milking. Despite milk yield increasing significantly the feed efficiency measured as MJ ME per kg ECM (energy corrected milk, Sjaunja et al., 1990) was significantly higher when cows were milked 3 times daily. Increased milking frequency also seems to have a positive influence on animal welfare, for example improved ease of movements when lying down and standing up (Ipema et al., 1988). When cows were milked more frequently they lay down for longer periods before morning milking and needed less time for standing up movement (Österman and Redbo, 2001). Furthermore, the labour costs of milking per kg milk decreased at the expense of larger investments for AM systems compared to conventional milking systems (de Koning and van de Vorst, 1992). Indeed, it has been experienced that in an AM system milking frequency can be higher than twice a day with an increased milk production as a result (Svennersten-Sjaunja et al., 2000; Wagner-Storch and Palmer, 2003; Harms and Wendl, 2004; Melin et al, 2005b; Speroni et al., 2006). One of the challenges of AM is therefore to arrange the management, including cow traffic, to enable a higher milking frequency than two times per day.

Cow traffic systems

Switching from conventional milking to an AM system certainly involves great changes for both cow and herdsman: aspects on cow traffic and milking capacity in a barn with AM system was reviewed by Ipema (1997). In the conventional milking parlour system all cows are brought to be milked all at the same time. This is partly in line with their natural behaviour, since cows prefer to perform their activities simultaneously: a herd of cattle has a clear daily rhythm (Arnold and Dudzinski, 1978). In AM systems with a capacity of approximately 60 cows per MU the cows are milked one at a time throughout the twenty-four hours and they are expected to approach and enter the MU voluntarily. To interest cows in visiting the MU more frequent than twice a day requires management routines and a cow traffic system that will allow all cows in the herd to be milked with a high frequency. This demands that the MU is in function during the entire twenty-four hour period.

The term "cow traffic" means the cows' movement in the barn to perform activities such as feeding, milking and resting. In an AM system cow traffic can be forced (FO), selective with controlling gates (SE) or free (FT). These three cow traffic systems were in use early on for commercial herds but other systems have been subsequently developed, for example Feed First™, which is a combination of the FT and SE traffic systems. With FO, the cows have to pass the MU when moving from the resting area to the feeding area to get access to feed (figure 1). With SE the cows can enter the feeding area via the MU or through controlling gates. If a cow has got permission for milking she is denied passage to the feeding area through the controlling gates. In that case, she has to pass the MU to get access to feed (figure 2). FT offers the cows free access to the feeding area without being hindered or forced by gates (figure 3) (Wiktorsson et al., 2003; Wiktorsson and Sörensen, 2004). Hurnik (1992) concluded that FT may be preferable because in this system the cows have more opportunity to perform the synchronized behaviour of a herd.

In a well-functioning AM system the cows have access to sufficient feeding, resting and milking occasions regardless of social rank. Svennersten-Sjaunja and Pettersson (2008) stated in their review article that the success of AM systems is dependent on active cows that frequently and regularly visit the feeding area and the milking station. Sufficient feed supply is also a prerequisite for high-yielding cows. According to Harms et al. (2005) repeated lack of feed at a certain period of the day resulted in decreased number of milking occasions during the same period. No difference in milk yield between the three traffic systems (FO, FT, SE) was seen, however, clear interactions between social rank and form of cow traffic system were observed regarding the daily rhythm of feed intake and visits to the MU. Further, Harms and Wendl (2004) and Harms (2005) concluded that with selectively guided cow traffic the advantages of FT and FO could be combined. It is also important to consider feeding management when milking frequency is controlled by the cow traffic system.

The effects of different cow traffic systems have been studied in various reports. According to Melin et al. (2005a), cows held in AM systems develop individual feeding and drinking patterns that are consistent over time. Stefanowska et al., (1999a) showed that when optimizing the AM system with "walk-through" selection cow welfare and milking efficiency was improved. In another experiment Stefanowska et al., (1999b) removed what they call the selection stall, and transferred the selection process to the MU. They concluded that if there were no selection stall cows that did not need to be milked enter the MU, and the cow traffic became slow. This reduced the milking efficiency of the AM system. Melin et al. (2005b) observed that short milking permission interval (4 hours), compared to long milking permission interval (8 hours), resulted on average in 3.2 and 2.1 milking occasions per cow per day, respectively, and short milking interval increased the milk yield as expected but the cows fed fewer and longer meals per day.

Grazing also influences milking frequency and cow traffic. In a study Spörndly and Wredle (2004) concluded that a long distance to pasture

(~300m) may lead to decreased milk yield, milking frequency and grazing time despite access to *ad lib.* supply of grass silage in the barn. Jago et al. (2007) showed that minimal levels of concentrate offered during milking had no effect on daily milking frequency. However, there was a decrease in daily milk yield and also in the frequency of visits to the selection unit located out on pasture. Access to drinking water, both out in the far away field and in the barn did not affect milking frequency and milk yield, however, the cows consumed more than 50% of their drinking water out on pasture. They also spent more time grazing compared to cows who only had indoor drinking water (Spörndly and Wredle, 2005). Jago et al. (2007) concluded that automatic milking can be combined with a near-100% pasture diet.

Access to feed to stimulate cow traffic and milking frequency

For optimal cow traffic in an AM system the physiological and behavioural needs of the cows must be considered. As an example, it has been mentioned that voluntary visits to the feeding area are not a problem as long as feed is available, since access to feed is an important factor which drives the cows' activity (Pirkelmann, 1992). Cow behaviour can be influenced by the routines for providing roughage and concentrate (Pirkelmann, 1992). According to de Koning and van de Vorst (2002), free access to feed is an effective way to attain enough milking occasions per cow per day and a prerequisite of optimal cow traffic is that sufficient amounts of roughage should be available during all twenty-four hours. However, in FT, where the cows do not have to pass the MU, this could cause long milking intervals and an increase in the number of cows fetched for milking. For some cows, the concentrate offered in the MU is not sufficient to stimulate voluntary visits when partly mixed ration (PMR) or totally mixed ration (TMR) are available in the feeding area. According to Rodenburg and Wheeler (2002) the availability of TMR in the feeding area is a possible factor contributing to lower voluntary attendance at the MU, which increases the number of fetched cows and labour input.

Feeding concentrate in the MU seems to be a method of influencing physiology and behaviour in a manner suitable for cows housed in a system with AM. It has been reported that feeding during milking increased milk production (Brandsma, 1978; Samuelsson et al., 1993; Svennersten et al., 1995; Johansson et al., 1998) and decreased residual milk and milking time

(Samuelsson et al., 1993) probably as an effect of higher milking related oxytocin release (Svennersten et al., 1995). The pituitary hormone oxytocin is involved in the control of milk let down (Ely and Petersen, 1941). Johansson et al. (1999b) stated that feeding concentrate at the onset of milking seemed to be advantageous with regard to decreased milking time and increased milk flow. Feeding concentrate during milking also increased the cows' motivation to visit the MU (Prescott et al., 1998) which is an important factor to make the AM system work since the cows' motivation for being milked is low.

A prerequisite for a good production during lactation is a well-functioning milking management. Optimal udder emptying requires optimal milk let down. The milk ejection reflex is highly sensitive and can be inhibited if the cow becomes stressed during milking (for review see Bruckmaier and Blum, 1998). It has further been claimed that the oxytocin levels should remain elevated throughout the entire milking for optimal udder evacuation (Bruckmaier et al., 1994). Feeding during milking has been observed to raise oxytocin levels (Svennersten et al., 1995). Interestingly, feeding during milking seems to influence behaviour. The number of social interactions increased as well as the amount of time spent lying down and ruminating, when the oxytocin levels were elevated and milking related cortisol levels were decreased due to feeding during milking (Johansson et al., 1999a; Johansson et al., 1999b).

Lying behaviour and resting time

Resting is a major activity for cattle, and their lying behaviour could give an indication of how well the cubicles are adapted to their needs. Most of the studies dealing with lying behaviour have focused on the effect of different designs of the resting area and floor surfaces. According to Houpt (1998) lying time is affected by the environment and cubicle design has a large influence on the ease to lying down. In a loose house system cows lie down for about 13 hours per 24 hours (Houpt, 1998) and the lying time is divided into 8 to 10 bouts.

To ensure the cows' welfare and productivity the resting time should be optimized (Haley et al, 2001). When cows are deprived of both rest and feed, lying takes priority when given the opportunity to choose. This compensatory behaviour indicates that rest is necessary (Metz, 1985; Haley et al., 2001). Thus, reducing the amount of time for the cows to lie down would affect their welfare and their productivity negatively. According to Arave and Walters (1980) lying behaviour, use of cubicles and resting time are important factors when measuring the cows' welfare and comfort.

As mentioned above, Österman and Redbo (2001) found that 2x milking, compared to 3x milking, reduced the total lying time during the hours before morning milking for cows milked in a conventional milking parlour. One possible reason is that cows milked only twice daily have greater pressure built up in their udders and thus experience discomfort when lying down with a full udder. The higher pressure in the udder is probably an effect of longer milking intervals for 2x milking compared to 3x milking. However, there was no difference in total lying time for the whole twenty-four hour period (Wierenga and Hopster, 1990; Krohn and Munksgaard, 1993; Österman and Redbo, 2001) which indicate that the cows compensate for the decreased lying time during the rest of the day.

Krohn and Munksgaard (1993) found that floor surface was more important than udder pressure for the lying down movement, for tied cows. However, Österman and Redbo (2001) concluded that cows milked twice daily use more time for the standing up movement compared to cows milked three times daily. Haley et al. (2001) stated that cows, when kept individually in box stalls (large pens), changed position between lying and standing more frequently than compared to cows kept in standard tie-stalls. This was interpreted as improved ease of movement for the cows standing up and lying down. With soft mattress flooring, lying time increased compared to when housed on concrete flooring. Concrete flooring can be rather slippery when wet which probably affects cow behaviour, making standing up and lying down difficult (Haley et al., 2001).

Normally, when given the opportunity, cows change lying side during every resting period if they have the opportunity to do so (Albright, 1987). However, a cow's choice of laterality does not seem to be random. The slope of the floor, the cow's age and increasing pregnancy have been reported to affect the choice of lying side (Arave and Walters, 1980). In conclusion, only a few studies have investigated cows' lying behaviour and to our knowledge it is not fully evaluated if cows choose equally between the left and right lying side when kept in a loose house system. The hypothesis to be tested is therefore that cows choose equally between left and right lying side.

Welfare considerations

In all management systems, it is important to consider the cows' welfare. A herd consists of cows of different social rank. The low-ranked cows as well as the high-ranked cows must have access to the feeding area and the MU a sufficient number of times per day. It is therefore important to adjust technology to the animals' needs. To attain successful animal husbandry, the cows' basic biological requirements must be respected. Farm animals should have the benefit of adequate air, water and feed supply, safe housing, a sufficient amount of space to prevent injuries, regular supervision and sensible handling during life (Hurnik, 1992). To obtain optimal benefit of the AM system, the herdsman needs to observe the cows and their behaviour (van't Land et al., 2000). For example, lameness influences the motivation to visit the MU. In herds with AM, 5-28 % of the cows were observed to be lame (Klaas et al., 2003). The management skills of the herdsman, the barn layout and the farming conditions are factors which decide how successful the use of the AM system will be. By controlling the milking intervals for individual cows in the AM system it is easy to prevent cows from being milked at too short intervals. It is more difficult to prevent cows from being milked at too long intervals. It will be necessary to fetch cows that have exceeded a maximum interval (de Koning and van de Vorst, 2002) or to guide the cow traffic. The cow traffic system seems to be a key factor for successful management of cows housed in AM-equipped barns. The hypothesis to be tested will therefore be that the more forced the cow traffic system is the more will it affect the cow behaviour.

Objectives

The main objectives of this thesis are

- To evaluate different cow traffic systems in a barn with automatic milking with respect to milking, feeding and resting behaviour
- To evaluate if cows behave differently depending on social rank, in different cow traffic systems
- To investigate if the cows' choice of area in the barn is dependent on social rank
- To investigate if cows prefer one lying side to the other when housed in a loose house system

Material and methods

This thesis comprises two different studies; cow traffic systems Study A (Paper I) and lying behaviour Study B (Paper II). They were conducted at Kungsängen Research Centre, Swedish University of Agricultural Science, Uppsala, in a barn equipped with AM. One part of the second study considering the cows' choice of lying side was performed out on pasture.

Experimental design

Study A - Cow traffic systems

Study A consisted of two separate experiments (Paper I). The first experiment was designed to test three cow traffic systems, FO, FT and SE, in that order. The second experiment was designed for two treatments, SE followed by FT. With FO, the cows had to pass the MU to obtain access to the feeding area (Figure 1).

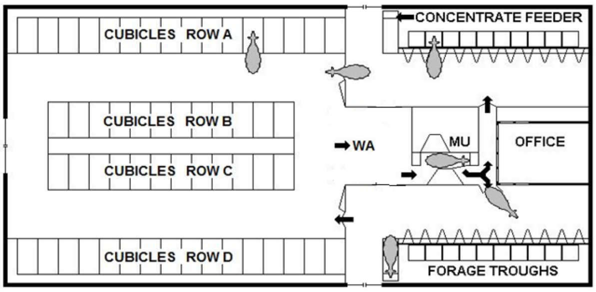

Figure 1. Forced cow traffic.

With SE the cows had access to the feeding area through the MU and the selection gates (Figure 2). If the cows had permission for milking, they were denied passage through the selection gates.

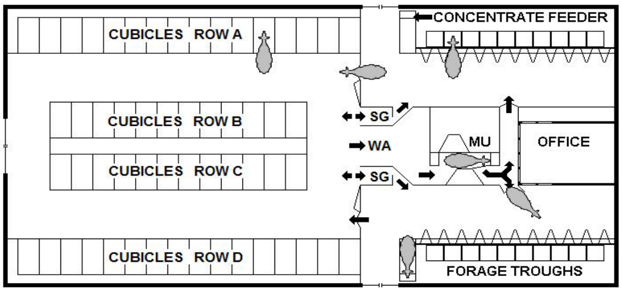

Figure 2. Selective cow traffic with controlling gates.

During FT, the one-way gates were removed allowing the cows to move directly from the resting area to the feeding area without passing the MU (Figure 3).

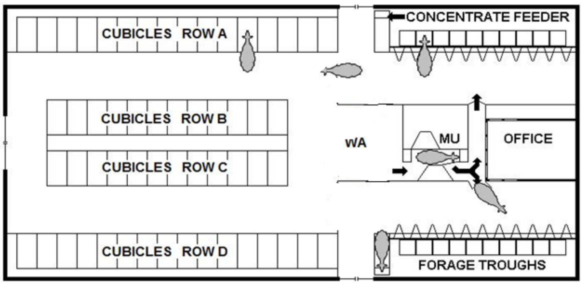

Figure 3. Free cow traffic.

Study B - Lying side

Study B, consisting of three different parts, was a behavioural study on the cows' choice of lying side (Paper II). The first part was performed during a cow traffic experiment and the second was part of an illumination experiment. These two parts of the study were performed in a loose house system with AM. The third part was performed out on pasture where the cows were not influenced by any stable equipment.

Animals

The dairy cows were of the Swedish Red Breed. There were 45 – 50 cows in the barn during the indoor studies. A total of 203 animals (cows and pregnant heifers) of which 30 were in gestation month 8-9, became part of the study out on pasture. The annual milk yield of the herd was approximately 9500 kg ECM and the milk somatic cell count was approximately 170 000 cells/ml milk. The cows' lactation number was between 1 and 5 and the stage of lactation differed since calvings occurred throughout the year.

Housing

The cows were housed in a loose house system provided with AM and automatic feeding. The barn (Fig.1, 2, 3) consisted of a resting area and two identical feeding areas with the MU (DeLaval VMS™, Sweden) situated in between. In connection with the MU there was a 40 m^2 open waiting area. From the waiting area the cows could enter either the MU or the two controlling gates (DeLaval Smart gate™, Sweden) depending on time since last milking and the applied cow traffic system. When leaving the MU the cows could choose which feeding area to enter. The part of the barn composed of the waiting area, the MU, the controlling gates, the feeding area and the personnel entrance, was called the activity area. The rest of the barn was the resting area, which was divided into three parts; the distant part with 14 cubicles, the middle part with 28 cubicles and the close part with 13 cubicles. The close part was nearest the activity area and the distant part farthest away from the activity area. A one-way gate prevented passage from the resting area to the feeding area. In each feeding area there were 10 roughage feeding troughs (BioControl A/S, Norway) and one concentrate feeder (AlfaFeeder). The floor in the scraped alleys had concrete surface and the manure was removed with a manure scraper (DeLaval, Sweden). There were 56 cubicles in the resting area, divided into four rows. The cubicles were provided with rubber mats and the bedding material consisted of cut straw and shaving.

Feeding

During experiment 1 in Study A in which three different cow traffic systems were compared, the cows were fed PMR consisting of silage, concentrate and hay or straw *ad lib.*. During experiment 2, the cows were fed roughage consisting of silage and hay *ad lib.*. During the cow traffic study, in both experiment 1 and 2, fresh roughage was provided about four times per day and concentrate was fed in the automatic feeding stations according to the individual cow's milk yield. During SE and FO in experiment 1, the cows were offered 0.5 kg (100g/min) concentrate in the MU on every milking occasion and during FT, they were offered 1.5 kg (300g/min) concentrate. During FT and SE in experiment 2, the cows had access to 1 kg concentrate on every milking occasion.

During the first part of Study B, the feeding was as described in experiment 2 in Study A. During the second part the cows were fed silage *ad lib.* and they had access to approximately 1 kg hay per cow per day. Concentrate was provided in the concentrate feeders and in the MU as in Study . During the third part, the cows were out on pasture and were supplemented with roughage and concentrate according to milk yield.

Fresh water was continuously available from one water bowl in each part of the feeding area and four water bowls in the resting area. Out on pasture four water bowels were available.

Milking

The cows were milked in a system with AM (DeLaval VMS™, Sweden), and when entering the MU the cows were identified by a neck transponder. The milking frequency in the herd averaged 2.4 times per cow and day. Permission for milking was given 6 hours after the latest milking occasion. The staff usually fetched every fourth hours (between 05:00 and 17:00) those cows that had not been milked within 14 hours. The MU was available for milking 22 hours/day on average.

Registrations and recordings

Study A - Cow traffic systems

The computerised management system allowed for registrations of the cows entering different areas of the barn. When entering the milking station, the selection gates, the concentrate feeder and the roughage feeder troughs, the cows were identified by a neck transponder. In the MU, the milk yield and time of milking were registered on every milking occasion. The amount of feed consumed and time of every visit in the feeding troughs were registered in a separate system. The definition of a meal was several visits to the feeding troughs within a defined period. If there were more than one hour between two visits it was defined as different meals. This is in accordance with Olofsson (2000).

In the first experiment, a platform was built from which the behavioural studies were carried out. The observations were made manually by the same person in each experiment and were noted in a protocol. The observations were carried out during eighteen four hour periods, a total of three days and nights. The number of cows in each area was registered every tenth minute except for in the resting area which was observed every twentieth minute.

Ten focal cows were selected from the herd depending on ranking order. The cows' social rank was determined according to Olofsson (2000) and Rutter et al. (1987). The positions of the focal animals, five high-ranked and five low-ranked, were registered during the behaviour studies (see above). During FT in experiment 2, the cows' choice of part of the resting area was noted every 20th minute during eighteen four hour periods.

Study B - Lying side

Recordings of cow behaviour were made with instant direct observation. During the first part the observations were made in 18 periods of four hours each. The cows' choice of laterality was noted every 20th minute, but not on an individual basis with the exception of the ten focal animals. The focal cows were selected due to social rank. During the second part the cows were manually identified every 12th minute during 4*48 hours, and their choice of laterality was noted. During the study performed out on pasture 203 animals in varying stages of lactation participated. Thirty of them were in late gestation (both heifers and non-lactating cows). The observations were performed during an 8 week period at random times between 06.00 and 18.00 at day time. One or two observations were performed per day.

Statistical analyses

In Study A the data was analysed separately for each experiment using the procedure MIXED in SAS (SAS Institute, 2004) with cow as a random variable and cow traffic system as a fixed effect. In Study B the data was analysed and tested in procedure FREQ and procedure MIXED in SAS.

Results

Visits to the feeding area

Between 18% and 20% of the cows was observed in the feeding area at any given time; there was no difference between cow traffic systems. However, the number of meals varied significantly from 3.9 to 12.1 meals per cow per day. The more the traffic was forced, the fewer was the number of meals per day. Irrespective of social rank, cows spent most time in the feeding area during FT, approximately 5 – 6 hours compared to 4 – 4.5 hours during FO (Paper I).

The feed utilization, expressed as kg DM feed consumed per kg milk produced, was significantly more efficient with FO and FT compared to SE in experiment 1. The roughage made up 37% of feed during FO and 35% during FT compared to 46% in SE. However, in experiment 2 the result was the opposite showing higher efficiency during SE compared to FT (Paper I).

Visits to the milking unit, milking interval and milk yield

The number of milking occasions varied between 2.0 and 2.6 per day and differed significantly between cow traffic systems. The more forced the cow traffic, the higher was the milking frequency and the shorter were the milking intervals. The number of passages through the MU during FT was higher in experiment 2 (3.2 passages) compared to experiment 1 (2.5 passages). In the first experiment, milk yield varied between 25.8 kg/day and 29.7 kg /day while in experiment 2 it varied between 27.8 kg/day and 32.6 kg/day. There was statistically significant differences in milk yield between the traffic systems in experiment 1, and experiment 2 as well. In experiment 1 the milk yield during FO (29.7 kg per cow a day) and FT (29.0 kg per cow a day) was significantly higher than during SE (25.8 kg per cow a day). Contrary to this, the milk yield during SE was higher (32.6 kg per cow and day) compared to FT (27.8 kg per cow and day), in experiment 2 (Paper I).

The cow traffic systems affected both the number of cows in the milking queue and the number of cows which had to be fetched for milking. The more the cow traffic was forced the more cows in the milking queue and the less cows to be fetched for milking. Fetched cows measured as percent of milking occasions, occurred with a significantly higher frequency during FT compared to SE (Paper I). During FT in experiment 1, as many as 26% of the milking occasions were preceded by a cow having to be fetched, but during SE only 1.7% of the milking occasions were preceded by cows having to be fetched for milking.

Effect of feed availability on diurnal pattern

Feed was available during all twenty-four hours; visits to the feeding area and number of milking occasions were almost regularly dispersed. However, a negative effect on visits to the feeding area was seen during SE in experiment 1, due to only a small amount of accessible PMR (less than 2.5 kg DM/cow) being available in the early morning. The number of cows visiting the feeding area decreased from 14 to 5, whereby the number of milking occasions decreased from 6 per hour to 3-2 per hour (Paper I).

Visits to the resting area

The time spent in the resting area varied between 14.5 and 18.5 hours, of which 12-17 hours were spent in the cubicles. During experiment 2 the time spent in the resting area, and in the cubicles, was significantly higher during FT than during SE for both high-ranked and low-ranked cows. When managed in FT the cows spent between 14.6 and 16 hours in the cubicles, compared to 12.9-13.1 hours in SE. There seemed to be an individual reference for area in the barn but most of the cows preferred the distant and the middle part of the resting area, however not statistically significant (Paper I).

Social rank

There was a significant difference between high-ranked and low-ranked cows regarding time spent in the milking queue during experiment 1. Furthermore, the low-ranked cows spent less time in the resting area and in the cubicles compared to the high-ranked cows and the difference was highest during SE in experiment 1, but the difference was not statistically significant. During experiment 1 the low-ranked cows spent numerically less time in the feeding area compared to the high-ranked cows. (Paper I).

The high-ranked cows were observed in the cubicles in 48% of the observations as compared to 39% for the low-ranked cows. The high-ranked cows were observed more frequently in the middle part of the barn while the low-ranked cows were observed more frequently in the distant part. These observations were performed only during FT in experiment 2 (Paper I).

Table 1. The focal cows choice of part of the resting area during 3 observation days, presented as percent of observations. The distant part is furthest away, and the close part is nearest to the activity area.

Cow number		Distant part %	Middle part %	Close part %	Total %
High rank	742	8.2	10.5	0	18.7
	528	0	10.3	7.0	17.3
	796	11.7	6.0	2.3	20.0
	758	12.3	3.5	4.1	19.9
	727	2.9	12.5	8.7	24.1
% obs/cow		35	43	22	100
Low rank	823	7.1	2.9	3.1	13.1
	779	3.8	15.2	0	19.0
	828	12.8	7.6	4.0	24.4
	886	7.8	5.2	12.4	25.4
	833	10.5	6.2	1.4	18.1
% obs/cow		42	37	21	100

Lying side

In the second study (Paper II) the lactating cows chose equally between left and right lying side and no effect of lactation stage or age was found.
However, approximately 60% ($P<0,001$) of the cows lay facing towards the activity area. In the study with cows on pasture there was a significant preference for left lying side during the last gestation month; in 61% of the observations the pregnant animals chose left lying side. It was also observed that cows preferred lying in a cubicle free from neighbouring cows and lying feet to feet to a neighbouring cow was more frequent than lying dorsal to dorsal.

General discussion

Good management routines as well as cows having access to sufficient quantities of high quality feed are prerequisites for attaining profitable milk production. Furthermore, in systems equipped with AM it is important that the milking occasions are evenly distributed throughout the day for optimal benefit from the investment. The individual cows' production capacity is also important to take advantage of, and to achieve this the feeding and milking frequency must be optimal for all cows. To make this possible, in a loose house barn with voluntary AM the cow traffic system can be considered as a key factor.

Effect of cow traffic systems on milk production and milking frequency

One of the benefits of AM is the possibility to increase milking frequency without extra labour. Milking frequency in AM systems, in which the cows voluntary choose when to be milked, can be partly controlled by using pre-set time intervals and control gates when granting admission to the different areas of the barn. It was observed (Paper I) that the cow traffic system significantly influenced the milking frequency in the way that the more forced cow traffic the more milking occasions, which is in accordance with the findings by Ketelaar-de Lauwere et al. (1998), Harms et al. (2002) and Harms (2005). The explanation is that during FO, the only way to reach the feeding area was through the MU. The higher number of milking occasions and shorter milking intervals during FT in experiment 2 (Paper I) compared to experiment 1 could most likely be explained by in experiment 1 the cows were fed PMR containing 55% concentrate on DM basis, while the concentrate was fed separate from the forage in experiment 2. When the PMR contained a high percentage of concentrate, PMR was probably more tempting than the concentrate in the MU. Therefore, despite the higher amounts of concentrate offered in the MU during FT in experiment 1, the number of passages through the MU without being milked was lower (0.5 visits per cow per day) compared to experiment 2 (0.9 visits per cow per day).

In all the traffic systems that were studied, the cows were fed concentrate in the MU, with the aim of tempting them to visit the MU voluntarily. Advantages of offering access to feed during milking, is not only to motivate the cows to visit the milking unit (Prescott et al., 1998) but also to improve the milk let down (Svennersten et al., 1995). In the present study the effect of feeding during milking, on milking frequency, was not evaluated since the cows always received a concentrate allotment during milking. Noteworthy was, however, that lack of roughage or access to only small amounts in the early morning as during SE in experiment 1, was followed by a decrease in number of milking occasions, or at worst no milking occasions at all (Paper I).

The cow traffic system had a statistically significant effect on milk production, when comparing FO and FT to SE (Paper I). The difference in milk yield between the cow traffic systems, was in contradiction of Gygax et al. (2007). However, the significantly shorter milking interval during FO, compared to FT in experiment 1, did not result in higher milk yield (Paper I), in contradiction of Svennersten-Sjaunja et al. (2000), Harms and Wendl (2004), Melin et al. (2005b), and Speroni et al. (2006). This is difficult to explain, however, the longer time spent in the milking queue, the shorter time resting and the forced feeding pattern during FO in the present study, could be a reason. Furthermore, in spite of significantly higher milk yield during FO compared to SE, the milking interval did not differ significantly. A possible explanation could be the lower percentage of concentrate in the PMR during SE. An additional explanation to the higher milk yield during FO could be that despite the lack of significant difference in milking interval there was anyhow a non-significant difference between FO and SE, resulting in a significantly higher number of milking occasions during FO. However, the difference in milk yield between the traffic systems could also be related to days in lactation. FO was the first treatment and SE the last, thus, a decrease in milk yield was expected during SE. In experiment two, the significantly higher milk yield and shorter milking interval during SE compared to FT could be explained by the significantly higher number of milking occasions during SE (Paper I). This would be in accordance with Svennersten-Sjaunja et al. (2000), Harms and Wendl (2004), Melin et al. (2005b), and Speroni et al. (2006).

FO may increase the frequency of visits to the MU but also restrict the cows' behaviour, and may therefore be questionable (Ketelaar-de Lauwere et al, 1998). Before entering the feeding area the cows have to pass the MU.

The limitation of access to the feeding area in FO caused long time waiting in front of the MU (Paper I). This does not necessarily cause stress according to Melin et al. (2005c), who observed that cows when being denied passage through the control gates, showed no evidence of being stressed. This statement was based on the lack of difference in milk cortisol concentrations, among the cows. Anyhow, the time spent in the milking queue could be used in more appropriate pursuits for the cows, such as feeding or resting. This was observed during a period of FO before the Study A started. The cows were not forced to remain in the waiting area but were allowed to return to the resting area. The number of fetched cows was noted, and the result indicates that the cows grew tired of waiting in the milking queue and returned to the resting area. Thus, in FO the number of fetched cows became higher, 4% of milking occasions (personal communication, Gunnar Pettersson 2001, data not published), than in SE 1.7 % of milking occasions (Paper I). Fetching cows is expensive with regard to labour time, but long milking intervals could easily affect the daily milk yield negatively which is undesirable from the herdsman's point of view. Further, with long and irregular milking intervals the risk of mastitis increases. (Hillerton and Winter, 1992). The high number of fetched cows during FT (Paper I) is in accordance with Harms et al. (2002), and it could be explained by the free access to the feeding area.

Effect of cow traffic system on feeding behaviour

With free access to roughage, feeding is divided into 7-10 meals (Pirkelmann, 1992) and cows usually spend up to 10 hours per day feeding (Faverdin et al., 1995). It can therefore be argued that in a well-functioning system cows ought to have similar possibilities and time to perform such behaviours. It was observed that the cow traffic system influenced aspects of the feeding behaviour such as number of meals per day and time spent in the feeding area (Paper I). According to Olofsson (2000) a meal is defined as one or several visits to the feeding troughs within a defined period. If more than one hour had elapsed between two visits they were set as different meals. Melin et al., (2005a) found that the major part of the variation in feeding patterns was due to differences between individual cows, and the onset of a meal is not a totally random process but depends on satiety. The less number of meals per cow per day during FO indicates that the cows were eating in a forced way during FO. This is in accordance to Munksgaard et al. (2005) who state that the rate of feed intake increases when cows have limited access to the feeding area. Quite contrary to FO it was easy for the cows to obtain access to feed during FT, and they did not have to consume the feed in the same forced manner as in FO. The FO could provoke negative effects on cow welfare due to reduced access to feed, and induce an unwanted behaviour from system point of view such as entering the feeding area from the reverse (Melin et al. 2007). The effect of social rank on number of meals was not evaluated in the present study, only the time spent in the feeding area. The results indicated that the low-ranked cows spent more time in the feeding area during FT, but the difference was not statistically significant (Paper I).

The feeding visits were regularly dispersed throughout the day, for all cows (Paper I). However, free access to feed, as with FT, could cause long milking intervals and an increase in the number of fetched cows due to the cows' preference for feeding compared to milking (Prescott et al., 1998). The reason why number of milking occasions decreased and the number of fetched cows increased during FT in experiment 1 (Paper I), which is in accordance with Harms (2005), could be that the cows were offered free access to PMR containing a high percentage of concentrate (55% concentrate on DM basis), compared to SE and FO. The concentrate offered in the MU was probably not sufficient enough to stimulate voluntary visits (de Koning and van de Vorst, 2002) when combined with PMR containing a high percentage of concentrate. However, Morita et al. (1996) state that separate feeding of concentrate and roughage cause unnecessary traffic cycles without any roughage consumed, and therefore recommend TMR feeding. Quite contrary to that the result from the present study could be interpreted as the concentrate ration in the MU being more tempting when combined with roughage only, or PMR containing just a small amount of concentrate.

There was no significant difference in consumed kg DM between the cow traffic systems (Paper I), in contradiction of Melin et al. (2007) who found that the cows had higher dry matter intake during FT compared to other traffic systems. Tolkamp et al. (2002) stated that cows, when offered feed containing a high percentage of concentrate, consumed a higher amount of feed on DM basis, per day, compared to cows offered feed with a lower percent of concentrate. However, a higher feed utilization (Paper I) (less kg DM per kg milk per day) was observed during FT and FO compared to SE in experiment 1, which probably depended on the higher percentage of concentrate in the PMR in FT and FO. The lower percentage of concentrate allotted in SE was because the cows were in a later stage of lactation. The difference in feed utilization between SE and FT in experiment 2 could probably be explained by the significantly lower milk yield (3.2 kg per cow and day) during SE, compared to FT and that the cows were in a later lactation stage during SE.

Resting behaviour and choice of lying side

During all experimental periods the time spent in the resting area was sufficient for resting (Paper II). Normally dairy cows spend 13 hours per day lying (Houpt, 1998). The fact that the cows were lying in the cubicles about 14 hours per day (Paper II), indicates that the cubicles offered the cows enough space to perform their normal resting posture. Provided that the cows are offered adequate space and a well-managed system, most types of housing situations will work (Albright, 1987).

Very few studies have been made to evaluate if the cows prefer one lying side to the other side, and Haley et al. (2001) states that very little is known about the effect of cubicle design on the activity and lying behaviour of cows. However, cubicle design is known to be important for optimising resting behaviour (Haley et al., 2001); the cows' motivation to lie down increases when deprived of the opportunity to lie down (Houpt, 1998; Haley et al., 2001).

It was observed that the cows' preferred lying facing toward the activity area (Paper II), which could be interpreted as the cows wanted to have control over what happened in that area. To our knowledge this behaviour has not been observed in earlier studies and could be a potential factor to consider when evaluating barn layouts. On herd level, however, the cows did not prefer one lying side to the other, in contradiction of Arave and Walters (1980) who observed that both cows and heifers preferred left lying side. However, in the present study it was observed that during the last gestation month, when animals were out on pasture, there was a significant preference for left lying side. This preference is probably due to discomfort experienced when lying on the right side as the foetus enlarges into the right abdominal cavity (Arave and Walters, 1980).

It was also observed that the cows' preferred lying in a cubicle free from neighbouring cows (Paper II), indicating that the cows prefer some distance to the herd-mates, when they have the opportunity to choose. If this was not possible, there was a significant preference for lying facing the same direction as the adjacent cow, and further, when lying facing the different direction from the adjacent cow, there was a significant preference to lying feet to feet. These results contradict Arave and Walters (1980), and are difficult to explain. When lying dorsal to dorsal there is a beneficial effect of protecting udder and legs from being tread on, but this effect is not obvious when lying feet to feet.

Effect of the cows' social rank on their behaviour

It was observed that the cow traffic systems affect cow behaviour differently, depending on the cows' individual social rank (Paper I). Access to fresh feed during all twenty-four hours made it possible for the low-ranked cows to get access to feed by adapting their feeding visits to fit in with those of the high-ranked cows. The FO system had an influence on the low-ranked cows making adaptation of feeding more difficult.

The low-ranked cows' spent less, or equal, time in the cubicles compared to the high-ranked cows in contrast to the findings of Metz and Mekking (1984) who found that the low-ranked cows remained longer in the cubicles. The authors interpreted this as a way for the low-ranked cows to avoid aggression from the high-ranked cows The reason that the low-ranked cows in the present study did not spend more time in the cubicles, than the high-ranked cows, was probably because they could avoid aggression without having to stay in a cubicle. This implies that there were no limitations of space in the AM system.

Our result which states that the low-ranked cows were observed more frequently in the distant part of the resting area contradicts Olofsson and Svennersten-Sjaunja (2004) who found that the low-ranked cows more often were situated close to the MU when resting.

In accordance with Ketelaar-de Lauwere et al. (1996) and Melin et al. (2006) the low-ranked cows spent more time in the milking queue compared to the high-ranked cows; this effect was seen during FO and SE (Study A). During FO the difference with regard to social rank was statistically significant, which points out the reason why the FO is questionable; the restriction in behaviour for the low-ranked cows. In FT no effect on the low-ranked cows was seen, probably because in this system the cows always had free access to the feeding area, they were not forced to pass the MU to get access to feed. The adaptation of the low-ranked cows' visits to the MU and also to the feeding area are effects of social rank, with the intention to avoid agonistic interactions with high-ranked cows (Ketelaar-de Lauwere et al., 1996; Harms et al., 2005). This is also in agreement with Kondo and Hurnik (1990) who state that the cows' motivation to engage in physical forms of agonistic interactions will be stronger when an important resource becomes restricted.

Prerequisites for a well-functioning AM system

As mentioned earlier, access to enough feed and milking occasions during the twenty-four hours, are prerequisites for a well-functioning AM system. During FT the cows have free access to the feeding area but this is not enough since the primary condition is that feed, not only the feeding area, should always be available. Lack of feed leads to a decrease in number of visits to the MU, since access to feed is the key factor tempting the cows to visit the MU. Further, twenty-four hour access to feed is necessary to ensure that the cow traffic system functions optimally for the low-ranked cows as well as for the high-ranked cows. To ensure that the AM system works for the low-ranked cows there needs to be space enough for the low-ranked cows to avoid agonistic interactions.

Improvement of cow traffic systems

In this study three different cow traffic systems (FO, SE and FT) were studied, however, other systems are now available. Stefanowska et al. (1999a) investigated walk-through selection with the intention of optimising the AM system to improve cow welfare and milking efficiency. In this system the cows are always given entrance through a gate. If a cow does not have permission to be milked she is guided to the feeding area. In the Feed First™ (DeLaval) system the cows always get access to the feeding area through a one-way gate. After feeding the cows are let through to the MU if they have got permission for milking, otherwise they are directed to the concentrate feeders and the resting area. In these systems the cows are always given a positive response at the gate and get access to the feeding area.

A prerequisite for a well-functioning system is that feed is always available in the feeding area, otherwise all systems will be as limiting as FO. The fact that the cows are never denied at the gate is an improvement of the system. Access to feed during all twenty-four hours is another improvement demonstrated in the present study, which should be seen as a fundamental prerequisite of a well-functioning system. With FT and Feed First the cows always obtain access to feed, even if there is a stoppage, on condition that feed is available in the feeding area. Furthermore, in a system with guided traffic, if there is a stoppage all gates should be opened, offering the cows access to the feeding and the resting area.

Conclusions

The main findings are that the cows behaved differently in the three cow traffic systems that were evaluated, and an effect of restriction of the resources was seen.

FO system may improve the frequency of visits to the MU but also restrict the cows' behaviour, and is therefore not recommended. The more FO the less number of meals per cow per day, but consumed kg DM did not differ between the traffic systems. Despite a higher milking frequency and shorter milking interval with FO the milk yield did not increase

There was a significant difference between high-ranked and low-ranked cows, especially during FO. Compared to the high-ranked cows, the low-ranked cows spent less time in the cubicles, less time in the feeding area, but more time in the milking queue. This effect was not seen in FT. During SE in experiment 2, there was no difference due to social rank between the cows, with the exception of low-ranked cows spending more time in the milking queue.

The lactating cows chose equally between left and right lying side and no effect of lactation stage or age was found. However, there was a significant preference for left lying side during the last month of gestation for cows and heifers out on pasture.

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Populärvetenskaplig sammanfattning

Denna avhandling baseras på två studier utförda i ett lösdriftsstall utrustat med ett automatiskt mjölkningssystem, vid Kungsängens forsknings-centrum, Sveriges Lantbruksuniversitet (SLU) Uppsala. Stallet hade plats för 56 kor, men under försöken utgjordes kogruppen av 45 – 50 kor, av rasen svensk röd boskap (SRB). Ålder och laktationsstadium varierade i försöksgruppen.

I Sverige introducerades det första automatiska mjölkningssystemet för kommersiellt bruk 1997, men i Europa har det funnits sedan 1992. Ett motiv för att utveckla automatiska mjölkningssystem var ökande kostnader för bl.a. foder och arbetskraft kombinerat med sjunkande mjölkpriser. Med automatisk mjölkning blir lantbrukaren inte lika tidsbunden, men ändå måste tillräckligt med tid avsättas under dagen för tillsyn och arbete i stallet. Mjölkningar, foderkonsumtion, kornas hälsostatus m.m. ska följas upp. Ännu en fördel med automatisk mjölkning är att antalet mjölkningar per dygn kan ökas utan extra arbete. En förutsättning för att det automatiska mjölkningssystemet ska utnyttjas fullt ut är att korna frivilligt uppsöker mjölkningsstationen flera gånger per dygn.

Syftet med arbetet var att studera hur kotrafiksystemen påverkade kornas mjölknings-, fodersöks- och vilobeteende, samt att utvärdera om kor med olika social rang betedde sig olika i de studerade kotrafiksystemen. Studien utfördes under två på varandra följande år. Under det första året jämfördes tre olika trafiksystem, fri trafik, styrd trafik och styrd trafik med selektionsgrindar. Under det andra året jämfördes fri trafik och styrd trafik med selektionsgrindar. Fri trafik innebär att korna har möjlighet att förflytta sig mellan de olika avdelningarna i stallet när de vill. Det innebär att de kan vila när de vill, de har fri tillgång till foderavdelningen och de styrs inte till mjölkningsstationen. Med styrd trafik, å andra sidan, har korna enbart fri tillgång till liggavdelningen, men de har inte tillgång till foderavdelningen utan att först passera mjölkningsstationen. Den styrda trafiken med selektionsgrindar är en kombination av fri och styrd trafik. Korna har då fri tillgång till foderavdelningen inom ett tidsintervall, oftast de första 6-7 timmarna efter senaste mjölkning. Inom den perioden kan kon passera via selektionsgrinden till foderavdelningen. Då tidsintervallet överskrids får kon nytt mjölkningstillstånd och är då tvungen att passera mjölkningsstationen för att få tillgång till foder. I alla trafiksystem kan korna fritt förflytta sig från foderavdelningen till liggavdelningen via en envägsgrind. Det är tillgången till foder som är drivkraften för kornas förflyttningar mellan de olika avdelningarna, eftersom korna är mer motiverade att äta än att mjölkas. En förutsättning för att kotrafiken ska fungera är att tillräcklig mängd grovfoder alltid finns tillgänglig i foderavdelningen.

Vid den fria trafiken under första delen av studien var antalet mjölkningar färre än vid styrd trafik men det var ingen skillnad i mjölkmängd, och ingen skillnad i mängd konsumerat foder. En trolig anledning till detta resultat är att med styrd trafik tvingades korna att köa under längre tid vid mjölkningsstationen, och de använde kortare tid till att äta, vilket påverkade mjölkavkastningen negativt. Vid den styrda trafiken blev kön till mjölkningsstationen lång, eftersom det var den enda vägen till foderavdelningen, vilket resulterade i att vissa kor tröttnade på att vänta och återvände till liggavdelningen. Det var främst de lågrangade korna som använde mycket tid till att köa vid mjölkningsstationen. Vid den fria trafiken hade korna tillgång till foder i foderavdelningen hela dygnet och det resulterade i att andelen kor som måste hämtas till mjölkning ökade, jämfört med den styrda trafiken. För att locka korna att själva uppsöka mjölkningsstationen tilldelas oftast en mindre mängd kraftfoder, en så kallad ”lockgiva”, under mjölkningen. Det visade sig i denna studie att det inte var tillräckligt för att locka korna till mjölkning vid fri trafik om grovfodret är mixat med en stor andel kraftfoder.

Vila är viktigt för kor, t.o.m. viktigare än foder, och deras liggbeteende kan ge en indikation på hur bra liggbåsen är anpassade efter deras behov. Den tid korna ligger påverkas av miljön, och utformningen av liggbåsen påverkar hur lätt det är för korna att utföra läggnings- och resningsrörelser. I ett lösdriftsstall ligger korna normalt mer än halva dygnet och liggtiden är fördelat på flera kortare perioder.

Syftet med den andra studien var att undersöka om kor föredrar att ligga på en speciell sida eller om de ligger på båda sidorna lika mycket. Enligt tidigare försök tycks inte valet av liggsida vara slumpartat utan påverkas av olika parametrar som exempelvis golvets lutning, kornas ålder och dräktighetsmånad. Resultatet visade att korna valde vänster och höger sida lika mycket, utom under den sista dräktighetsmånaden då kor och även dräktiga kvigor valde att ligga på vänster sida. Troligtvis berodde valet av vänster sida på att fostret tog stor plats på höger sida. Det visade sig också att korna, då de låg i liggbåsen, till ca 60% valde att ligga vända med ansiktet mot den del av stallet där all aktivitet pågick.

Slutsatser

- Kornas beteende varierade i de tre olika trafiksystemen, och effekt av begränsade resurser kunde påvisas.

- Det styrda systemet påverkade besöksfrekvensen till mjölkningsstationen men det begränsade samtidigt kornas beteende, och kan därför inte rekommenderas. Ju mer styrt trafiksystem desto färre måltider per ko och dag, men mängden konsumerat foder var inte lägre i jämförelse med de andra trafiksystemen, vilket ledde till att korna hade högre äthastighet. Trots en högre mjölkningsfrekvens och kortare mjölkningsintervall ökade inte mjölkmängden.

- Det var skillnad mellan kornas beteende beroende på social rang, framförallt då kotrafiken var styrd. De lågrangade korna tillbringade kortare tid i liggbåsen, kortare tid i foderavdelningen, men längre tid i mjölkningskön, jämfört med de högrangade korna. Effekten av social rang visade sig inte vid fri trafik. Vid styrd trafik med selektionsgrindar under det andra året påvisades ingen skillnad mellan kor beroende på social rang, förutom att de lågrangade korna tillbringade mer tid i mjölkningskön.

- De lakterande korna valde lika mellan höger och vänster liggsida, och ingen effekt beroende på laktationsstadium eller kornas ålder kunde påvisas. Dock föredrog kor samt dräktiga kvigor att ligga på vänster sida under sista dräktighetsmånaden.

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