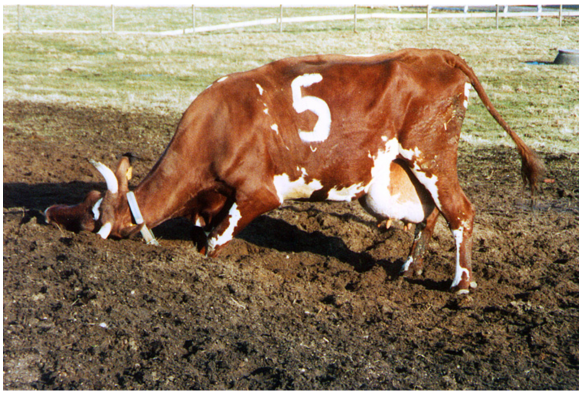
Exercise of Tied Dairy Cows During the Winter

Aspects of motivation and preference

Jenny Loberg



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Abstract

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The aim was to investigate whether tied dairy cows have a motivation to move *per se* when exercised during winter and whether they prefer to be outdoors or indoors when exercising. In the first experiment tied dairy cows were observed when exercised outdoors every day, twice a week or once a week. In the second experiment the preference of tied dairy cows for being indoors or outdoors during exercise was tested in two types of preference tests. Cows exercised at longer intervals walked and trotted more than did cows exercised at shorter intervals. The cows that were exercised once and twice a week explored the environment more during exercise than did cows that were exercised every day. The increase in movement with duration of confinement indicates that the cows' motivation to move built up with time. An alternative explanation is that the walking and trotting was a response to the novelty of the exercise area. However, we did not observe a build-up of explorative behaviour with time. The cows did not show a preference for exercise either indoors or outdoors. Preference for being outdoors or indoors may therefore be independent of the motivation for movement. In future studies this preference may be assessed in a situation where the motivation for movement is controlled. In conclusion, tied dairy cows increased the amount of movement with increased length of indoor confinement. Also, the amount of explorative behaviour was greater for cows exercised less frequently than for cows exercised every day. Finally, tied dairy cows did not show a preference for indoor or outdoor exercise.

Keywords: dairy cows, motivation, preference test, locomotion, explorative behaviour

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"Tjoho tjoho, tänker Mamma Mu. Man kan inte jämt stå och tugga och glo bara för att man är en ko."
Ur "Mamma Mu gungar" av Jujja och Tomas Wieslander

Till min mormor, Mary
Till minnet av min morfar, Olle

Contents

Appendix

Papers I-II

The present thesis is based on the following papers, which will be referred to in the text by their Roman numerals:

I Loberg, J., Telezhenko, E., Bergsten, C., Lidfors, L. 2004. Behaviour and claw health in tied dairy cows with varying access to exercise in an outdoor paddock. Applied Animal Behaviour Science 89, 1-16.

II Loberg, J., Andersson, K., Jensen, M.B., Lidfors, L. 2005. Dairy cows' preference for exercise indoors or outdoors assessed by two different preference tests. (Submitted)

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Introduction

History of tying dairy cows in Sweden

In Sweden farmers have tied their cows indoors during the winter since the middle ages (Myrdal, 1999). At that time some farmers let the cows out during the winter to let them drink from a hole in the ice (Myrdal, 1999). This practice was continued even into the 17th century; however, in some documents from those days it was stated that cows should not be let out during bad weather. In adverse weather conditions the farmer had to bring the water into the barn (Myrdal, 1999). Loose housing systems for dairy cows in Sweden were described as early as the late 18th century (Zelow, 1816), but not until the 1950s did farmers start to accept these systems and it was tried out in about 100 herds in Sweden (Ekesbo, 1966). Even today about 70% of the dairy farms that are enrolled in Sweden's official milk-recording programme have a system of tying up their cows (Jonas Carlsson, personal communication).

In June 2004 there were 403 702 dairy cows on 9 147 farms in Sweden (http://www.sjv.se/webdav/files/SJV/Amnesomraden/Statistik%2C%20fakta/Husdjur/JO20/JO20SM0402/JO20SM0402.pdf; 23-Feb-2005). In Norway, Finland, Austria, Switzerland, the Baltic countries and Bavaria in Germany the tied-up housing system is still the most common.

Advantages and disadvantages of tie stall housing

The advantages for the farmer who has a tied-up housing system for his or her cows are many. For one, it is easy to give the cows individual feeding. Also, the system facilitates discovery of any health problems among the animals and detection of cows in heat. During milking in the stall the farmer comes in close contact with the cows and this makes the cows less difficult to handle. In a study by Loberg (2002) it was found that cows housed in tied-up systems were easier to approach and touch in a test situation than were cows housed in loose housing with Automatic Milking Systems (AMSs). The tied cows also had a shorter flight distance to humans, showing less fear of people than did the loose-housed cows. The advantages for the cows of being in a tied-up system can be that the farmer (knowing his or her cows and their dominance relationships) places the cows in the tie stalls in such a way as to that minimize the risk of subdominant cows being prevented from lying down by dominant cows.

A disadvantage for the farmer is that when the herd is large it takes longer to milk tied cows than cows held in loose housing with a milking parlour. The procedure of attaching the milking cluster by crouching down twice a day can also wear out the knees (Pinzke & Gustafsson, 1995). The disadvantages for the cow are obvious. In my mind, the tie stall restricts the cow's movements and normal social contact and the possibility to both choose a lying place and groom.

Tie stall systems and exercise in organic farming

Regulations in organic farming within the European Union (EU) (EC directive 1804/1999) state that cows housed in tied-up systems have to be exercised regularly. This is a step towards a prohibition of keeping animals tied in organic production, to come into effect in 2011. In Sweden the Board of Agriculture had to decide what should be considered “regular exercise” and investigate the practical implications for the farmers. During two winters nine different organic dairy farms in Sweden participated in a documentation study in which they exercised their tied dairy cows at intervals they felt they could manage. A questionnaire was sent to all organic dairy farmers in Sweden that had a tied-up system (Loberg & Lidfors, 2002). One of the main conclusions from both the documentation and the questionnaire was that poor weather conditions had an impact on the farmers’ ability to let their cows outdoors. Only 20% of the farmers had exercised their cows but the majority answered that they would be willing to exercise their cows at least once a week.

Motivation, preference and needs

“Motivation” is a concept used in ethology to describe why an animal performs a certain behaviour at a certain time. It can be defined as the internal state of the animal, which is the net result of both external and internal stimuli (Toates, 1986; Manning & Dawkins, 1998). Different models of motivation have focused on how different behaviours are controlled. Some researchers have focused on homeostatic models in which the deviation of physiological parameters in the body triggers behaviour in the animal, which serves to restore the parameters to a set-point. These types of models have been used to explain the motivation for thirst and hunger, for example (Toates, 1986).

Other researchers have divided behaviours into two groups, those internally driven and those externally driven (Toates, 1986). In Konrad Lorenz’ model from 1950 the strength of motivation is a function of external incentives (i.e. external stimuli) and internal state (Toates, 1986). By “internal state” Lorenz means an intrinsic tendency to perform behaviour, with the strength of that tendency building up as a function of time since the last performance. In Lorenz’ model the performance of the behaviour *per se* lowers the tendency. In the 1970s Bindra proposed that motivational states arise from an interaction between internal stimuli (organismic states) and external stimuli (incentive stimuli) (Bindra, 1978).

The most influential researcher today of motivational theory is Frederick Toates, who has been developing new models of motivation since 1980. In the most recent model of motivation proposed by Toates (2004) he also includes cognition, expectations and emotions.

An animal’s preference for different types of environments or resources has become an important field to study when questions arise about how the animal experiences its situation. With increasing concern about the welfare of our domestic animals the preferences of the animals give us better knowledge about how to improve their housing and handling. When investigating an animal's preference for a specific resource, the assumption is that the animal makes the choice in its own best interests (Fraser & Matthews, 1997). The connection between motivation, preference and need could be described as follows: an animal shows a preference for an environment or stimulus that provides an outlet for the motivation or that satisfies a need.

In the wild, animals are believed to optimize their fitness and reduce the energy cost and consequently perform behaviours that each moment increases the possibility of survival. Animals in captivity are often prevented from performing a behaviour which in a natural context would increase fitness and reduce cost. Since in captivity this behaviour is no longer connected to fitness or cost, it has sometimes been claimed that animals in captivity do not have a need to perform that behaviour (Dawkins, 1990). However, the proximate mechanism underlying the behaviour may still be activated and the animals may still experience suffering when prevented from performing the behaviour (Dawkins, 1990).

The concept of "behavioural need" has been a subject of debate in the ethological community. A "behavioural need" is a behaviour that the animal needs to perform irrespective of the environment, even if the goal of the behaviour is fulfilled (Jensen & Toates, 1993). This type of behaviour is thought to inflict welfare problems if the animal is deprived of performing it (Hughes & Duncan, 1988). Petherick & Rushen (1997) state that if such ethological needs exist they are likely to be proximate needs. Still, we cannot assume that all natural behaviours that an animal is prevented from performing in captivity cause suffering (Dawkins, 1990). In order to gain better knowledge of the consequences of preventing the expression of specific behaviours, the behaviours needs to be tested empirically.

How to measure motivation and preference

There are different ways to measure motivation and preference in an animal.

Rebound

One straightforward way of measuring motivation is first to prevent the animal from performing a behaviour, and then to give it the opportunity to perform the behaviour. The amount and intensity with which the behaviour is performed (the "rebound") reflect the importance of the behaviour. One classic example of this is a study by Vestergaard (1980) in which it was found that hens performed dust bathing more quickly and for a longer time with increasing time of deprivation.

Demand functions

Another way of measuring motivation when an animal has been deprived of performing the behaviour is to use a method called "operant conditioning", in which the animal has to learn to connect bar pressing, key pecking or opening a push door with an award. Then the strength of its motivation to gain access to the reward is measured by the amount of work the animal is prepared to perform in order to receive the reward. This technique was originally tested by Thorndike in the late 19th century and later developed by Skinner in the mid-20th century to investigate learning ability in animals (Chance, 1999). The technique has also been used to measure the strength of motivation (Holm, Jensen & Jeppesen, 2002; Olsson, Keeling & McAdie, 2002; Jensen *et al.*, 2004). Once the animal has learned to press a key or push a door to gain access to a preferred resource the price of that resource can be raised (in other words, the animal has to press more times or the door gets heavier to push). Resources that animals are willing to pay a high price for are said to be "necessities", and the demand for them is referred to as "inelastic". By contrast, those resources that animals are not willing to work for are said to be "luxuries", with an elastic demand for them (Dawkins, 1990).

Preference tests

Different types of preference tests have been used in the field of applied ethology to address questions about what animals prefer (Held, Turner & Wootton, 1995; Jones, Wathes & Webster, 1998; Bradshaw *et al.*, 2000; Kristensen *et al.*, 2000) and, through applying the results, improve animal welfare (Fraser & Matthews, 1997). When using preference tests it is of outmost importance to make sure that we have identified the animals' true preferences in the test. Also, we need to be aware that the design of the test and the animals' previous experience can influence the result (Fraser & Matthews, 1997). In a preference test the animal is given the opportunity to choose between different resources (to provide an outlet for the same motivation) and this can be done in different ways. Two of the most common preference tests are either to use a Y- or T-maze where the animal makes a choice based on previous experience (Marin & Jones, 2000; Pajor, Rushen & De Passillé, 2003) or to let the animal move between resources in preference test apparatus and record the time or frequency of visits to the different resources (Beattie, Walker & Sneddon, 1998; Van de Weerd *et al.*, 1998).

When using operant conditioning we can combine motivation and preference testing in such a way that measuring the different strengths of motivation for different resources will also tell us which resource is most preferred (Lindström, 2000).

Motivation and preference testing in cattle

Several studies have been performed on both motivation and preference in cattle. Cows and calves have been trained with operant conditioning to test their motivation for different types of social contact (Holm, Jensen & Jeppesen, 2002) and for lying down after deprivation for various lengths of time (Jensen *et al.*, 2004). The motivation for locomotor behaviour in cattle has been investigated in calves and heifers. In a study comparing the behaviour of calves held in small pens with loose-housed calves upon release into a new environment, the calves that had been held in small pens were the only ones that performed jumping and bucking (Miller, Wood-Gush & Martin, 1986). Dellmeier, Friend & Gbur (1985; 1990) found an increase in the locomotor play behaviour and trotting showed by calves during an open-field test with increasing degree of restraint prior to the testing. When testing calves and heifers in an open-field test, Jensen (1999; 2001) found an effect of time of confinement on the amount of galloping and bucking performed and interpreted the increase in galloping and bucking as a build-up of internal motivation for movement.

To the best of my knowledge no similar studies have been performed on cows to investigate whether the locomotion performed upon release into an open area increases with increasing time of confinement. Since locomotor play behaviour in cattle decreases with an increase in age (Wood-Gush *et al.*, 1984) we may not find a difference in this type of movement in adult cows although there may be a difference in slower types of locomotion such as trotting and walking.

In previous preference tests cattle were tested for their feed preference (Manda *et al.*, 1994; Atwood *et al.*, 2001; Lindström, 2000; Ginane, Petit & D'Hour, 2003) and for their preference of different types of lying surfaces (Herlin, 1997; Manninen *et al.*, 2002) and different types of handling (Pajor, Rushen & De Passillé, 2003). Calves have been shown to prefer a large room over a small room; however, this preference was reversed when food was placed in the small room (Jensen, 1999). In EU regulations on organic farming to take effect in 2011 it is stated that cows on small farms will be allowed to be tied provided they will have access to pasture or exercise paddocks outdoors at least twice a week (EC directive 1804/1999). This regulation implies that being outdoors has a value for the cows. Since one of the main difficulties with providing regular exercise, experienced by the farmers, is the effect of the poor weather (Loberg & Lidfors, 2002) I wanted to test whether cows also prefer to be outdoors when exercised during the winter.

Factors influencing locomotion in cattle

"Locomotion" is defined as voluntary movements that involve the whole body, and in cattle it includes walking, trotting, galloping, jumping, swimming and cantering (Phillips, 1993). The distance walked by cattle on pasture is around 3 km per day (Albright & Arave, 1997) and in cubicle housing they have been observed to walk 2-4 km per day (Schofield, Phillips & Owens, 1991). In a study performed in Denmark, dairy cows walked 2.5 km per day during summer and 0.8 km per day during winter (Krohn, Munksgaard & Jonasen, 1992). External factors affecting locomotion in cattle include space and food availability; when grazing in a large area where the food is scarce the cows walk longer distances to search for food than when kept on a well-managed pasture (Hafez & Bouissou, 1975; Phillips, 1993). External parasites can make cows increase their movement in search of open windy areas in order to avoid the parasites (Hafez & Bouissou, 1975; Phillips, 1993). In loose housing, too few cubicles for lying may increase locomotion, especially in subdominant cows (Phillips, 1993).

Floor properties have a big impact on the locomotion of cows. Slippery floors have been shown to reduce the cows' walking and stepping rate (Phillips &

Morris, 2000). Most of the locomotion in cattle occurs during daylight, especially around dusk and dawn when the cows are grazing (Phillips, 1993). Animal characteristics such as age, sex, breed and oestrous state also influence locomotion (Phillips, 1993).

The influence of weather on the behaviour of cattle

Cattle are relatively tolerant to low temperatures and can be kept outdoors during wintertime. It has been reported that the lower critical temperature for lactating dairy cows is -45^{0}C (Christopherson, 1985). In two previous studies performed during the winter in Sweden it was found that steers and heifers of dairy breeds were more passive during low temperatures and they were more active with increasing wind speed (Redbo *et al.*, 1996; Redbo, Ehrlemark & Redbo-Torstensson, 2001). Houseal & Olson (1995) found that beef cattle kept outdoors during winter in Montana tended to seek protection at higher wind speed and colder temperatures. In Sweden there is a legal requirement for wind and precipitation protection for farm animals kept outdoors 24 h a day during the winter. In an enquiry to organic farmers in Sweden who let their cows out during winter one of the main reasons for keeping cows indoors was poor weather such as rain, high wind speed and low temperatures (Loberg & Lidfors, 2001). Based on results like these it is important to consider the influence of weather on the behaviour and preferences of tied dairy cows when they are exercised during the winter in Sweden.

Aims

The overall aim of this thesis was to investigate whether tied dairy cows have motivation to move *per se* when exercised during winter and whether they prefer to be outdoors or indoors when exercising.

Paper I: The main aim of this study was to compare the effect of exercise every day, twice a week and once a week on the amount of movements, exploration, grooming, ruminating and social interactions in tied dairy cows.

Paper II: The first aim of this study was to investigate whether tied dairy cows show a general preference for being indoors or outdoors when exercised during the winter and whether they perform certain behaviours more often when choosing to be indoors or outdoors. The second aim was to compare two different preference tests used for investigating the preference for indoor and outdoor exercise.

Summary of materials and methods

Paper I

This study was conducted at an organic dairy farm with 52 tied cows of Swedish Red and White breed. The cows were divided into four groups according to lactation number and milk production and whether or not they had been dehorned. The four groups were randomly assigned to one of the following treatments: (1) exercise for 1 h per day, 7 days a week (E7); (2) exercise for 1 h per day, 2 days a week (E2); (3) exercise for 1 h per day once a week (E1); and (4) no exercise during the period (NoE). The treatments started in November and continued until the end of April. During exercise the cows were released into one of two paddocks of approximately equal size (Fig. 1). The different treatment groups were never mixed. Behavioural observations were done on each group once a week, 2 weeks per month, during the 6 months of exercise. We observed the behaviour of the three exercised groups when they were outdoors. The activity of the control group (NoE) in the barn was observed during the same time of day as the other groups were exercised. The behaviours were recorded on a portable tape recorder with one-zero sampling using focal animal observations.

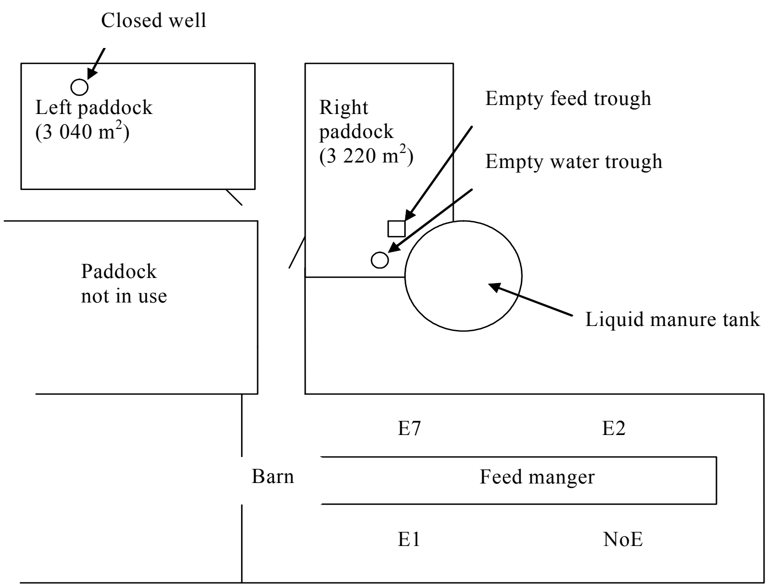

Fig. 1. Diagram of the barn and the two exercise paddocks used in Paper I. The places where cows in the different treatments were tied are indicated by the abbreviations E7 (= exercise for 1 h per day, 7 days a week), E2 (= exercise for 1 h per day, 2 days a week), E1 (= exercise for 1 h once a week) and NoE (= no exercise during the study period). The drawing is not to scale.

Paper II

This study was conducted at a conventional dairy farm with 100 cows in a tied-up system. Ninety per cent of the cows in the herd were of Swedish Holstein breed and 10% were crosses between Swedish Holstein and Swedish Red and White breed. The cows were out on pasture from April until mid-October. The study was conducted as two separate experiments with two different types of preference tests. In the first, an instantaneous choice test, we used 13 test cows and eight companion cows. The test started in November, 3 weeks after the end of the grazing period, and lasted for 10 days. In the second experiment, a time choice test, we used 22 test cows. This experiment started in February and lasted for 6 weeks. None of the cows in the barn was exercised between the two tests and only three cows were used in both tests.

In the instantaneous choice test we used a two-choice maze with an indoor and an outdoor area (see Fig. 1 in Paper II). The partitions were made of metal gates indoors and barbed wire fence outdoors. The floor indoors consisted of limestone covered with straw while outdoors it consisted of concrete and was covered with dirt and clay. The 13 test cows were randomly divided into two groups of six and seven, and trained twice each in the two-choice maze. In each test area a companion cow, visible from the start boxes, was tied during both training and testing. At testing, each cow was moved to one of the start boxes and left there for 30 s before the gate opened and she could make her choice. When the cow had entered one of the two test areas a gate was closed behind her and she remained there for 5 min. If the test cow did not enter either of the test areas within 5 min, she was returned to the stable and "no choice" was recorded. Each cow was given five choices (runs) with 1 day between each run. At testing we recorded the choice of each test cow and the time it took for the cow to move from the start box to one of the two test areas i.e. the latency time. Behaviours were recorded continuously on a portable tape recorder. We also measured rain, wind speed, temperature and relative humidity both indoors and outdoors before every second cow was tested.

In the time choice test we used a preference test arena, half of which was indoors and half of which was outdoors (see Fig. 2 in Paper II). The ground in the outdoor area was made of concrete while in the indoor area it was limestone. Both areas were covered with a thin layer of chopped straw before the training and testing began. During the 2 weeks of training and the first week of testing (run one) the outdoor area was covered with a layer of ice. To reduce the risk of cows slipping, sand was spread over the ice. The whole preference test arena was built with the same metal gates as used in the previous test.

The 22 test cows were randomly divided into three groups of six and one group of four. Each group was trained twice, with an interval of 1 week between the training sessions. The opening between the indoor and the outdoor area was closed with two chains. During training each cow was left in each area for 10 min. After training, the cow was tested four times (runs), with 1 week between runs. At testing, the cow had access to the whole arena and was it was left undisturbed for 20 min. Behaviours were continuously recorded on a portable tape recorder during the 20 min that the cow was in the test arena. The time the cow spent indoors and outdoors was recorded with a stop watch by an assisting person. Before each cow was trained or tested we measured the temperature, wind speed, light intensity and relative humidity both indoors and outdoors. Rain and snow were recorded on a three-grade scale.

Statistics

Behaviours in both studies and the time spent indoors and outdoors in the time choice test were analysed using analysis of variance (ANOVA) (Mixed Effect Model, SAS version 8.2, SAS Institute, Inc., Cary, NC, USA). Behaviours in Paper I that were not normally distributed were tested with a Kruskal-Wallis test (SAS). A chi-squared test (Siegel & Castellan, 1988) was used to analyse the behaviour play in Paper I and the difference in the number of choices in the instantaneous choice test. The latency to enter a test area in the instantaneous choice test was tested with a Friedman Two-Way Analysis of Variance by Ranks test (Siegel & Castellan, 1988). The effect of run on the cows' choices was tested using a Cochran Q test (Siegel & Castellan, 1988). The differences in the behaviours between the indoor and outdoor test area in the instantaneous choice test and the difference in play between indoors and outdoors in the time choice test were tested with Wilcoxon's signed-rank test (Siegel & Castellan, 1988).

Summary of results

Paper I

The longer the cows had been tied between exercise sessions the more they walked and trotted more during exercise (Table 1). They also walked and trotted more at the beginning of the test period than towards the end. Furthermore, there was higher frequency of explorative behaviours recorded for the cows exercised once and twice a week compared with cows exercised every day (Table 1). The cows that were being exercised once a week groomed themselves more during the hour of exercise than did the cows that were exercised twice a week or daily (Table 1). The cows that were being exercised every day were observed to ruminate more in the paddock than the cows that were exercised less frequently (Table 1).

Table 1. *Least square means (±SE), in per cent, of observations during outdoor exercise and p-values for the behaviours that were significantly different between treatments, calculated by analysis of variance (ANOVA), Mixed Effect Model, SAS version 8.2*

Behaviour	E7	E2	E1	p-value
Walking/trotting	24.9 (2.5)	41.5 (2.6)	49.2 (2.6)	<0.0001
Exploring	14.2 (2.5)	24.4 (2.6)	31.4 (2.5)	<0.0001
Self-grooming	23.5 (3.1)	19.9 (3.2)	34.0 (3.1)	<0.01
Ruminating	28.5 (2.6)	11.2 (2.7)	1.6 (2.7)	<0.001

E7 = exercise for 1 h per day, 7 days a week; E2 = exercise for 1 h per day, 2 days a week; E1 = exercise for 1 h once a week

Play behaviour and aggression was observed most often in the group exercised once a week. There was no difference in the non-agonistic social behaviours of the groups. Younger cows explored the paddocks more actively than did older cows, and older cows groomed themselves more than the younger cows did.

Paper II

We found no general preference for indoor or outdoor exercise in either of the two tests. However, in the time choice test the cows spent more time indoors than outdoors during the second run ($p<0.001$). During this run the wind speed was higher than during the other runs; also, the only day with rain occurred during this run.

In the instantaneous choice test the cows performed more explorative behaviours ($p<0.001$), were more active ($p<0.05$) and tended to play more indoors than outdoors. The weather did not have an effect on the cows' choices.

In the time choice test the cows sniffed the air more outdoors than indoors ($p<0.001$). All cows played and for this, they usually used both the indoor and the outdoor part of the arena. Even though they spent less time outdoors during the second run they were more active and explored the environment more intensely in the outdoor area during this run ($p<0.05$). The level of activity and exploration did not differ between indoors and outdoors during the other runs.

Discussion

A detailed discussion of the different results can be found in the two papers. In the following I will discuss the main results in relation to the theory of motivation and also, the methods used to measure motivation and preferences.

Motivation for movement in adult cattle

The main question we wanted to investigate in the first paper was whether motivation for movement in dairy cows builds up with length of confinement. In a natural context cattle move when grazing. They move to find new pastures, water and shelter and to escape from predators (Zeeb, 1983). Since we provide them with food, water and shelter and protect them from predators behaviours such as walking, trotting and galloping are not necessary for survival of the dairy cow. In my first study (Paper I) we found an increase in the amount of walking and trotting performed by the cows with an increase in time since last exercise. This is similar to Jensen's findings about play behaviours in calves and heifers (1999; 2001) and Dellmeier, Friend & Gbur's about playing in calves (1985; 1990). Jensen discusses this finding in the context of a rebound effect. The rebound effect is a common way of assessing level of motivation after a period of deprivation (Petherick & Rushen, 1997) since the behaviour is performed with increasing intensity after a period of deprivation. Behaviours that show the rebound effect are often thought to be partly motivated by internal factors. This result may be interpreted in the context of the model by Lorenz from 1950, in which action-specific energy builds up in the animal if it is not exposed to the relevant releasing stimuli and in which the performance of the behaviour itself lowers the motivation regardless of the consequences.

An alternative explanation has been presented by McFarland (Petherick & Rushen, 1997). He suggests that if a stimulus is present all the time the animal is habituated to it, but if the stimulus is removed for a long time the animal will lose the habituation and will react with an exaggerated response when the stimulus is reintroduced. This means, in relation to our results, that during the time when the cows cannot perform locomotion, the motivation does not necessarily increase; however, once the possibility of movement is reintroduced the animals react with a heightened response.

The increase in movement after different lengths of confinement observed in the present study fits both these explanations. However, the implications for the animals are different with the different explanations. If we explain the response as a rebound effect we expect the animals to perceive some kind of suffering during the period of deprivation since we believe that during that time there is a build-up of motivation in the animals. If we adopt McFarland's' theory, however, we do not expect the animals to suffer during the period of deprivation since this theory does not involve on an increase in motivation during the period of deprivation.

In the discussion about behavioural needs a central issue is whether an animal suffers or is frustrated when it is prevented from performing a specific behaviour (Petherick & Rushen, 1997). If we want to investigate whether the prevention of locomotor behaviour imposes suffering on the animal we need to find out which of the above models best explains how the cow perceives her situation. One way of doing this is to investigate whether the cow suffers when being tied for long periods of time. This suffering can be either physical, meaning that the animal feels pain during a long period of confinement, or mental. There is evidence that long confinement impairs the ability of a cow to lie down (Krohn & Munksgaard, 1993; Gustafson & Lund-Magnussen, 1995) and earlier studies have shown that forced exercise in the late gestation period increases the ease of calving as well as reducing the time between calving and release of the placenta (Lamb *et al.*, 1979).

Abnormal behaviour is often used as an indicator of stress in farm animals. In a study comparing the behaviour of tied cows with that of loose-housed cows Krohn (1994) observed more leaning behaviour in the tied cows. This was interpreted as meaning that the cows had problems in lying down in the tie stall and as indicating that cows suffer when lying-down behaviour is difficult. There appears to be some evidence that tied cows suffer both physically and mentally; however, this may not necessarily be related to the fact that they cannot move *per se*.

To further investigate this question; in a future study operant conditioning might be used to establish how hard a tied dairy cow is willing to work to be released from the stall. One could measure the number of muzzle presses on a panel each cow would be willing to make to gain access to movement after a longer time of confinement. This could be used as the maximum workload when comparing how much cows are willing to work after shorter periods of confinement. In a study of this nature both the length of deprivation and the time the cows are allowed to move after being released have an effect on the maximum workload (Jensen *et al.*, 2004). How much an animal is prepared to work to end the deprivation after various lengths of time of confinement can show us whether the motivation builds up with time or not. According to Dawkins (1983; 1988), this test can be used in interpreting the amount of suffering the animal is experiencing during the deprivation.

Motivation for explorative behaviour

The motivation to explore the environment is influenced by the external stimulus in the context of an animal's expectations of the environment (Toates, 1986). In the first study (Paper I) the cows that were being exercised once a week explored the paddock more actively than did the other groups. Also, during the preference test the indoor area in the instantaneous choice test elicited more explorative behaviours than did the outdoor area which was fenced with already existing fences. All cows in the barn had previous experience of the already existing fences in the outdoor area. In both these cases the novelty of the environment could have been the cause of the higher level of explorative behaviours observed. During the time choice test the gates in both the indoor and the outdoor areas were equally new to the animals and in this test there was no difference in explorative behaviour between the two areas.

Explorative behaviour is sometimes divided into inspective behaviours, in which the animal explores a present object, and inquisitive behaviour, during which the animal looks for new objects (Berlyne, 1960; Toates, 1986). When an animal patrols its environment regularly to find out whether there have been any changes since the last time it was there, this can be argued to constitute inquisitive exploration (Toates, 1986). This can also explain the higher frequency of exploration seen in the group exercised least often. They may have patrolled the paddock more than the other groups since they only came outside once a week. If they did more patrolling of their environment than the other groups this could be an alternative explanation for the increase in movement we found: the more explorative behaviours performed the more movement in the paddock. Patrolling may explain part of the increase in movement we found but is not likely to be the only explanation. If explorative behaviour would have been the only factor influencing the amount of movement in this study I would have expected to see an increase in explorative behaviours in the same way as we had an increase in movement with time of confinement. However, this was not the case.

Methodological considerations on the preference tests

With regard to the question whether tied dairy cows have a preference for being indoors or outdoors when exercised during the winter, the weather probably has an impact on the choice made by the individual cow. During the instantaneous choice test we started to question whether the cows could actually make an informed choice related to the weather on the test day. From one of the start boxes the cows did not have a good view of the outdoor area. The design also stopped them from changing their mind once they had made their choice. Had we wanted the instantaneous choice test to give us a more reliable result of the cows' preference of being indoors or outdoors, we would probably have to train them more and test them during the same well-defined weather conditions. One way to achieve this would have been to train and test them during the same day.

In the time choice test we gave the cows the opportunity to investigate both the indoor and the outdoor area, in terms of climate conditions, and they still did not show any general preference. In many preference tests only the position and the time the animal spends with the different resources are recorded, which may lead the researcher to draw wrong conclusions about the animal's preference. By studying the behaviour of an animal during the test we gain more knowledge about how the animal uses the resources given. During the time choice test, play behaviour was observed in all cows and they used the whole test arena to perform play (i.e. gallop and jump). This left us with the impression that only one of the areas was too small to express the high motivation for movement.

The decision to test the cows once a week was based on the results in Paper I, in which cows that were exercised once a week performed more movements than did the other cows. We wanted to achieve high motivation for movement during the test and investigate where the cows preferred to move, indoors or outdoors. Possibly the motivation for movement was so high that it got priority over the preference of being indoors or outdoors. If this was the case, the preference to be indoors or outdoors may only have shown when the motivation for movement had decreased. On the other hand, perhaps the cows' preference for being indoors or outdoors had nothing to do with where they wanted to move. It may have been based on fresh air, for example, and more light, or on a more complex and novel environment. If this is the case, testing cows with a high motivation for locomotion is not suitable when trying to investigate their preference for indoor v. outdoor exercise.

If we want to create the right conditions for testing the preference of tied dairy cows for being indoors or outdoors when exercised during the winter we need to make sure that the motivation for movement is low when the animals are released from the tie stall. And if we want to use the time choice test we have to control the motivation for movement by either testing the cows more often, possibly once a day, or exercising them before the test.

Implications for the regulations on organic farming

Regular exercise can be a good way of giving tied dairy cows the possibility to have more social contact and to show their heat behaviour. It makes it easier for them to groom themselves and gives them new environments to explore and perform locomotion behaviours in. Since the animals in the present study performed the most movement after 1 week of confinement and we cannot rule out the possibility that they did not suffer while being tied, I would recommend exercise at shorter intervals. Whether this needs to be done outdoors or the cows can be released indoors in an open area depends on what we want to give them in terms of a complex environment. An indoor area will always be the same while allowing them to go out will give them a more varied environment which changes with the weather. An exercise area with possibilities to be both indoors and outdoors depending on the weather can be a good alternative if we want to provide the cows with both an outdoor environment and the possibility to avoid a wet or slippery surface outdoors or getting wet or chilled by the wind.

Conclusions

In conclusion,

- When released in an outdoor paddock for 1 h during winter, tied dairy cows increased their amount of movement (rebound) with increase in length of previous indoor confinement.

- Cows that were exercised once and twice a week explored the environment more actively than did cows that were exercised daily.

- Cows exercised once a week groomed themselves more during exercise than cows exercised more often.

- The cows in our study did not show a preference for being indoors or outdoors when exercised during the winter.

- A modified time choice test is superior to the instantaneous choice test in assessing cows' preference for being indoors or outdoors when exercised during the winter.

Svensk sammanfattning

Motivation är ett begrepp som används för att beskriva vad som styr ett djurs beteende vid varje tillfälle. Det finns många olika modeller för hur motivationen för olika beteenden kontrolleras och vilka faktorer som påverkar motivationen. Djur kan sägas ha ett beteendebehov för att utföra rörelsemönstren i ett beteende trots att målet med beteendet redan är uppfyllt. För att undersöka om ett djur är motiverat för att utföra ett visst beteende kan man hindra det från att utföra beteendet under en viss tid och sedan observera djuret när det får möjlighet att utföra beteendet. En annan typ av test som också används för att ta reda på hur viktigt en viss resurs eller ett beteende är för ett djur är preferenstest. I ett sådant test erbjuds djuret flera alternativ och visar med sitt beteende vilket alternativ som föredras. I tidigare studier har det visats att ju längre tid kalvar och kvigor varit instängda/bundna desto mer hoppade och galopperade de när de gavs möjlighet. Detta skulle tyda på att motivationen för rörelse hos kalvar och kvigor ökar med tiden sedan de senast kunde springa fritt i en större box. Något liknande försök har inte gjorts för kor. Vi vet inte heller om bundna kor skulle föredra att vara ute eller inne under rastningen på vintern om de fick välja själva.

I den först studien undersökte jag om kor rörde sig mer ju längre tid de hade varit bundna. Kor i ett uppbundet system rastades i en paddock under vintern med olika intervall: varje dag, två gånger i veckan eller en gång i veckan. Kornas beteende under rastningen registrerades. I den andra studien undersöktes om bundna kor fördrog att vara inne eller ute vid rastning vintertid. Detta gjordes med två olika typer av preferenstest. I det första testet fick korna en möjlighet att välja ute eller inne och hade ingen möjlighet att gå tillbaka. I det andra testet fick kon vistas i en arena där halva ytan var inomhus och halva ytan var utomhus, och tiden som kon spenderade inne respektive ute mättes.

I den först studien gick och travade korna mer under rastningen ju längre de hade varit bundna mellan två rastningstillfällen. Detta kan indikera att kor har ett behov av att röra sig som byggs upp med tiden, men det kan också förklaras av att korna reagerade på den nya omgivningen som paddocken var och att detta orsakade den ökade mängden rörelse. Från välfärdssynpunkt är det viktigt att ta reda på vilket av ovanstående förklaringar som bäst stämmer med verkligheten då man kan anta att korna lider om motivationen byggs upp med tiden medan de inte antas lida om beteendet utlöses när korna släpps ut. Genom att använda operant teknik där kon får arbeta för att släppas loss kan vi ta reda på om rörelsen är viktig för kon när hon står bunden.

I den andra studien visade korna ingen preferens för att vara ute eller inne i något av de två testen vi använde. Det vi såg var dock att de i det andra testet använde hela arenan för att gå, trava och galoppera. Det som kan ha inträffat är att motivationen för rörelse under testtillfället var för hög så att de inte visade preferens för att vara inne eller ute. För att få ett säkrare resultat från preferenstestet bör vi kontrollera motivationen för rörelse. Det kan göras antingen genom att testa korna med tätare intervall så att motivationen för rörelse är lägre under testet eller att låta korna röra sig innan de testas.

Följande slutsatser dras av dessa försök: 1) uppbundna mjölkkor rörde sig mer när de släpptes ut för rastning i en paddock under vintern ju längre tid de varit bundna, 2) de kor som rastades en och två gånger i veckan undersökte paddocken mer vid rastning än de kor som rastades varje dag, 3) kor som rastades en gång i veckan slickade sig mer än kor som rastades oftare, 4) korna visade ingen preferens för att vara inne eller ute när de rastades på vintern och 5) en modifierad typ av test i vilket kon får röra sig fritt mellan inne och ute är bättre än ett test där kon endast kan gör ett val för att undersöka kors preferens för att rastas inne eller ute under vintern.

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