The Effect of Feed Alley Space on the Agonistic and Spacing Behaviour of Dairy Cattle

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Abstract

The objectives of this study were first, to determine the difference in inter-cow distances of animals present at the feed alley with varying feed alley space, and second, to determine if providing more feed alley space would affect the display of aggressive behaviour. Feed alley space of 0.5 m per cow and 1.0 m per cow was provided for twenty-four lactating Holstein cows used in a two by two cross over design replicated over time. Time-lapse video surveillance was used to quantify the inter-cow distance and aggressive displacements. Observations took place twice a day for 90 min following the provision of fresh feed and were averaged for each treatment for twenty-four cows. The mean inter-cow distance increased by approximately 60% as feed alley space increased from 0.5 m to 1.0 m per cow. Cows typically showed preference in their spacing, and spaced themselves in relation to the other cows in the group. However, uniform spacing was noted at high social densities, when six animals were feeding with 0.5 m of alley space provided per cow. The number of displacements performed at the feed alley increased by over 120% with less feeding space available. Therefore, increasing the available feed alley space for lactating dairy cows was advantageous to the cows' welfare by enabling them to better maintain their individual space and by reducing the display of aggressive behaviour.

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1.0 INTRODUCTION

A primary criticism of intensive animal agriculture is that the welfare of the animal is adversely affected by insufficient space (Keeling and Duncan, 1989). Traditionally, the spacing of animals was influenced by environmental factors: weather, risk of predation, and the distribution of resources. However, for domesticated animals housed in intensive farming systems, social factors have a greater impact on spacing than environmental factors (Keeling and Duncan, 1991). The spatial needs of animals can be quantified in relation to, territory, physical space, and individual space (Fraser, 1980). Territory refers to a static area that is habitually used and defended by an animal. This type of spacing is commonly used when studying animals in natural environments (Fraser and Broom, 1998). When observing animals in intensively housed environments, researchers often refer to the animal's physical and individual space. Each animal has a physical space requirement, which is the actual amount of space the animal occupies (Freeman, 1983). This space requirement varies according to the activity the animal is performing (Keeling, 1994). However, the spatial requirements for a group of animals is larger than the sum of the group's physical space requirements because animals will space themselves in relation to each other (Fraser and Broom, 1998). This additional requirement for space has been termed individual space. Individual space has been defined as the minimum distance between animals of the same species, below which an animal will retreat, or attack (Conder, 1949). More recently it has been suggested that individual space is the distance at which the sum of all attractive and repulsive social forces between conspecifics are in equilibrium (Sibbald, et al., 2000).

The concept of individual space has important practical significance in intensive animal agriculture. Higher social density makes it difficult for an animal to maintain spatial relationships resulting in increased aggressive behaviour (Syme and Syme, 1979; Keeling and Duncan, 1989; Kondo et al., 1989). Increasing aggressive behaviour creates social tension within the herd. Cattle that are in socially stressful environments may be less productive, more susceptible to disease, and are more likely to experience reproductive difficulties (Friend and Polan, 1974; Dobson. et al., 2001). Consequently, these animals are most likely to be subjected to premature culling (Rajala-Schulz and Grohn, 1999). Involuntary culling results in the premature shortening of the cow's life and loss of future profitability for the producer.

The role of spacing during feeding is important because it has implications for production, welfare, and housing design. Dairy cows in western Canada are primarily housed in intensive free stall settings where feed is provided to the cows by way of a common feed alley. Housing design typically allocates approximately 0.5 m of feed alley space per cow (Friend et al., 1977; Manson and Appleby, 1990). Limited feed alley space creates a competitive feeding environment (Friend and Polan, 1974), and may prevent cows from maintaining their individual space, both of which contribute to aggressive behaviour and increased social stress. Previous research has stated that the dominant animals in cattle herds have priority whenever there is a competitive situation at the feeding site (McPhee et al., 1964; Friend and Polan, 1974). At times when competition is elevated, such as, when fresh food is offered and when the cows return from milking, dominant cows demand priority and the subordinate cows may have limited access to feed. This results in the more dominant cows spending more total time eating than cows of lower social rank, resulting in a greater dry matter intake (DMI) by higher ranked cows than submissive cows (Friend and Polan, 1974; Manson and Appleby, 1990). Additionally, this may result in the subordinate cows doing the majority of their feeding at a later time in the day, including late at night (Forbes, 1995). This can be particularly problematic for the subordinate cows since sorting of the total mixed ration (TMR) can reduce the quality of the feed for those who do not have access at the time fresh food is provided (Shaver, 2002).

Competition and aggression dramatically increase when feeding space is reduced (Olofsson, 1999). Aggression in cows tends to be procedural, such that, most interactions occur in sequence of first, approach, then threat, and followed by physical contact (Syme and Syme 1979). Physical contact is typically displayed as pushing, butting or a forceful head swing, both of which are used for the purpose of displacing another cow (Syme and Syme, 1979; Fraser and Broom, 1998). The ability of a cow to displace another cow is a key factor when determining the social dominance hierarchy of cattle (Beilharz and Zeeb, 1982). There is a high correlation between social rank, body weight, and age (Beilharz et al., 1966; Syme and Syme, 1979). Cows' social dominance rank increases up to the age of 9 years after which it begins to decline. This parallels body weight because cows gain weight until age 9 and then start to lose it (Syme and Syme, 1979).

The effect of dominance relationships, as it pertains to time spent at the feeder, feed intake, access to food, and intensity of aggressive interactions at the feed alley, has been well studied (Friend and Polan, 1974; Friend et al., 1977; Olofsson, 1999). This research has typically focussed on reducing feeding space from the current industry standard of approximately 0.5 m per cow to a minimum level without impairing feed intake. However, little research has focused on spacing and social interactions when feed space is changed, especially when it is increased from industry standards. It could be hypothesized that with only 0.5 m of feeding space per animal some animals will be prevented from feeding at highly desired feeding times due to increased competition and social interactions. Alternatively, it could be hypothesized that increasing the amount of feed alley space will increase the spacing between animals feeding, therefore reducing competition. Thus, the objective of this study was first, to determine the difference in inter-cow distances of animals present at the feed alley with varying feed alley space, and second, to determine if providing more feed alley space would affect the display of aggressive behaviour.

2.0 MATERIALS AND METHODS

2.1 Animals

The study was conducted from October to November 2002 at The University of British Columbia Dairy Education and Research Centre in Agassiz, British Columbia. The inter-cow distances and number of aggressive displacements were collected using two primiparous and 22 multiparous (parity = 2.95 ± 1.25; mean ± SD) lactating Holstein dairy cows. The animals were 85.3 ± 7.0 (mean ± SD) days in milk (DIM) and had a projected 305 day milk production of 12645 ± 1486 kg at the beginning of data collection for each group. Each animal had access to a free stall that was deep bedded with sand. The cows were milked daily at approximately 6:30 a.m. and 4:30 p.m. and were fed a total mixed ration (50% forage, 50% concentrate) twice a day. Cows were fed from a feed alley with access via a neck rail. The animals were cared for according to the Canadian Council of Animal Care (1993) guidelines.

2.2 Experimental Treatments

The experimental treatments included exposing the animals to differing amounts of feed alley space. This was accomplished by housing the grouped animals in identical adjacent pens. One pen had 1.0 m of feed alley space available per cow and the other had 0.5 m of feed alley space per cow. The 0.5 m of feed alley space per cow was achieved by placing a concrete partition midway along the feed alley. When this partition was in place, feed was placed on only the half of the feed alley furthest away from the adjacent pen with 1.0 m of feeding space per cow. The TMR was evenly distributed along the available feed alley space.

2.3 Experimental Design

The twenty-four lactating cows were used in a two by two cross over design replicated over time. The animals were divided into four equal groups of six cows, which were balanced according to projected 305 day milk production, DIM (at the start of data collection for each group), and parity.

At the start of the first replication, one group of cows had access to feed with 0.5 m of feed alley space per cow and the adjacent group had 1.0 m of feed alley space per cow. In addition to a 2 day adjustment period the animals maintained this treatment for 7 days. After this time period, the feed alley space allowance was switched for the two groups by moving the concrete partition from the feed alley of the one pen to the feed alley of the other pen. Again the animals had a 2 day adjustment period followed by 7 days on the treatment. Immediately following this time period, the two remaining groups of cows were brought into the pens and the experiment was repeated.

2.4 Behavioural Recording

Following the 2 day adjustment period, the social and spatial relationships between cows at the feed alley were continuously monitored for 7 days using time-lapse video equipment. A Panasonic WV 330 camera was positioned approximately 6 m above the feed alley used by each experimental pen. These cameras were attached to a Panasonic video multiplexer (WV-FS216) and time-lapse video recorder (AG-6540p). Red lights (100W) were hung, approximately 6 m directly above the feed alley to facilitate video recording at night. Observations, from the video, were recorded twice a day for 90 min following the provision of fresh feed. The appearance of the first cow feeding on the fresh feed marked the beginning of the 90 min observation period. Feed was either provided when the cows were gone for milking or just prior to milking. In the latter case, observations began after the feed was initially provided and continued until milking. Observations halted during the milking period and resumed again once the first animal had returned from milking and started feeding until 90 min of observations had been collected. This 90 min post-feeding period was chosen because preliminary observations of the videos indicated that during this time period there was the largest concentration of cows at the feed alley. Two types of observations were recorded, first, the inter-cow distance, and second, the number of aggressive displacements from the feed alley.

2.4.1 Spatial observations. To facilitate individual animal identification, each animal's hair coat was dyed with a unique symbol. To ensure a common reference point when inter-cow distance was measured a reflective cross was glued onto the third thoracic vertebra that was identified by palpation from the left lateral side of each cow. The neck rail of both pens was marked with a permanent vertical line every 0.3 m on centre. The cow's position was recorded by matching the reflective cross on the animal with the reference points on the neck rail.

Spatial observations were made of each cow's position along the feed alley every 5 min for the 90 min post-feeding period for each day of data collection. The number of animals feeding at the feed alley was also recorded at each of these 5 min intervals. The inter-cow distance was measured by counting the number of marked spaces between two cows. Measurements were taken to the precision of 0.15 m, which was half a space on the neck rail.

2.4.2 Aggressive displacements. Displacements from the feed alley within the 90 min post-feeding time period were also recorded. For each interaction, both cows involved were identified as either the cow provoking the interactions (actor) or the cow subjected to the provocation (reactor). A displacement was noted when a butt or a push from the actor resulted in the complete withdrawal of the reactor's head from beneath the neck rail.

2.5 Data Collection and Analysis

For the analysis of the inter-cow distances and displacements from the feed alley the individual cow was considered as the experimental unit. During the course of the experiment, data was collected from 28, 90 min observation periods for each of the four groups. However, four periods from the first replication and seven from the second replication were excluded for one or more of the following reasons: 1) not all animals returned from the milking parlor at the same time, 2) cows were returned to the wrong pens and had access to feed prior to being returned to the experimental pens, 3) a portion of the feed alley was obstructed by a gate, and 4) video equipment malfunction.

The inter-cow distances and number of times each cow displaced another cow were averaged for each cow for each treatment. The differences between the inter-cow distances and average number of displacements per cow per post-feeding period on each treatment were then calculated. The differences for the number of displacements were

$\log_{10}$-transformed in order to normalize their distribution. Treatment effects on the inter-cow distances and the number of displacements were detected by testing if the average difference was significantly different from zero. The uniformity of spacing for each treatment was detected by testing if the difference between the observed inter-cow distance and the expected inter-cow distance was significantly different from zero. The expected inter-cow distance was defined as the distance between animals if they had spaced themselves uniformly along the provided feed alley space.

3.0 RESULTS

3.1 Inter-cow Distance

The average distance between neighbouring cows was calculated for each treatment and took into consideration the variation in animal density at the feed alley (Figure 1). The average distance between cows increased ($P < 0.001$) by approximately 60% when the feed alley space increased from 0.5 m per cow to 1.0 m per cow. This was irrespective of animal density. Additionally, there was a significant interaction ($P < 0.001$) between the number of animals present at the feed alley and the average distance between animals; namely as the number of animals in attendance at the feed alley increased, the distance between animals decreased. This was observed when both 0.5 m and 1.0 m of feed alley space was provided. When 1.0 m of feed alley space per cow was provided the variability of inter-cow distances was greater with fewer animals present at the feed alley.

The observed and expected distances, for each treatment, were compared to test the uniformity of inter-cow spacing. When 0.5 m (Figure 2) and 1.0 m (Figure 3) of feed alley space per cow were provided the difference between the observed and expected distances was reduced when more animals were present at the feed alley. With five or less animals at the feed alley, when 0.5 m of feed alley space was available per animal (Figure 2), the cows spaced themselves significantly closer ($P < 0.01$) than if uniformly spaced. However, when six cows were present at the feed alley the cows spaced themselves close to the expected distance. Furthermore, when 1.0 m of feed alley space was available per animal (Figure 3), the average distance between cows was significantly less ($P < 0.02$) than expected, regardless of the animal density at the feed alley.

3.2 Aggressive Displacements

The aggressive behaviour of the cows, which was measured by the number of times a cow physically displaced another cow from feeding, was compared between treatments. There was a clear relationship between the amount of space available and the display of aggressive behaviour. Increasing the feed alley space, from 0.5 m per cow to 1.0 m per cow, reduced ($P < 0.002$) the incidence of aggressive interactions, during each 90 min post-feeding period, by over 120% (Figure 4).

4.0 DISCUSSION

4.1 Inter-cow Distance

There has been much research indicating that the distance between neighbouring animals is dependent on the amount of space they are provided (Keeling and Duncan, 1989; Kondo et al., 1989; Sibbald et al., 2000). However, there has been limited research in this area involving the spacing of dairy cattle. Studies focusing on dairy cattle in this area found that the distance to the nearest neighbour tends to increase with increased space allowance (Kondo et al., 1989). Similarly, the current study found that increasing the amount of feeding space available to dairy cows increased the distance between animals present at the feed alley. When more space was available the variability of the average inter-cow distance was greater with fewer animals present at the feed alley. This result is similar to work by Sibbald, et al. (2000), who found increased variability in nearest neighbour distances between grazing sheep with increased space allowance and decreased group size.

In addition to comparing the difference between average inter-cow distances with varying amounts of feed alley space, we also analysed the type of spacing that occurred within each treatment by comparing the observed and expected distances for each treatment. The mean observed inter-cow distances were consistently lower than expected distances, indicating that cows did not distribute themselves uniformly at the feed alley. Rather, the cows actively sought to be closer than expected to each other when 1.0 m of feed alley space per cow was provided for all animal densities present at the feed alley. This was also observed when five or fewer animals were present at the feed alley when the space provided equalled 0.5 m per cow. The observed huddling behaviour suggests that the individual space desired by each individual cow would have been exceeded if they had distributed themselves uniformly at the feed alley. An animal's individual space is the distance at which the sum of all attractive and repulsive social forces between the animals is in equilibrium (Sibbald, et al., 2000). Therefore, when individual space is exceeded, an attractive force component of individual space is no longer being considered. Factors contributing to the attractive force include important biological survival strategies such as predator protection and energy efficiency (Gueron et al., 1996). Thus, when individual space is not in equilibrium the animal enters a "stress zone", in which the animal feels vulnerable and as a result will move closer to another animal (Gueron et al., 1996). This idea is echoed by a study conducted by Pollard and Littlejohn (1995) who showed that animals isolated from the group displayed acute signs of stress. Thus, our results indicate that inter-cow space at the feed alley is affected by the number of animals present at the feed alley as well as their individual position along the feed alley and that individual animals will show preference towards maintaining their individual space if given the opportunity.

When 0.5 m of feed alley space was available per cow and six animals were present at the feed alley, the observed inter-cow distance was not significantly different from the expected distance. This suggests that in situations where the density of animals at the feed alley is high, they are less able to show preference in their positioning at the feed alley, forcing them to uniformly distribute themselves along the feed alley. This may be related, in part, to the physical space required to accommodate the width of a Holstein cow. When six animals are present with only 0.5 m of feed alley space available per cow the physical space per animal is limited to 0.5 m. In comparison, the hip width of a

Holstein dairy cow has been reported to be 0.57 m (Enevoldsen and Kristensen, 1997). Since the body of a cow can be even wider than this, there was clearly insufficient space available for the animals to show preference, thus, they were unable to maintain individual space when only 0.5 m of feeding space per cow was made available. McBride (1971) stated that crowding occurs when cows are forced into the personal space of their neighbours. Therefore, in the present study cows were crowded when six animals were present at the feed alley with only 0.5 m of feed alley space per cow. Crowding has been shown to have an adverse effect on production and welfare (Friend et al., 1977). When assessing the impact of crowding on the welfare of animals it is very important to consider resource distribution (Stokols, 1972). When there is a high animal density and only a single food source available, crowding can occur, which may limit availability of food for some of the animals. Thus, to ensure that all cows attain proper intake levels, feed availability cannot be limited during any particular time (Grant and Albright, 1995). Furthermore, competition at the feed alley is elevated during certain periods throughout the day such as, when cows return from milking and when fresh food is offered (Friend and Polan, 1974). Therefore, crowding may occur at times when competition is high and may further limit the feed availability of some animals.

4.2 Aggressive Displacements

The effect of feeding and housing space on social behaviour has been well documented (Friend and Poland, 1974; Friend et al., 1977; Kondo et al., 1989; Manson and Appleby, 1990; Keeling, 1994). Social competition may have serious effects on feed availability, and therefore, may have serious production and welfare implications. In the present study the effect of feeding space on social competition was measured by averaging the number of times a cow physically displaced another cow from feeding during the 90 min post-feeding period. This method of measuring social competition was chosen because competition for food, in cattle, is controlled by aggressive interactions (Metz, 1983). Additionally, other researchers have used a similar method and indicated that using displacements to gauge social behaviour within a group is a useful tool (Arave et al., 1974; Wierenga 1990; Galindo et al., 2000). It has been suggested that simply counting displacements does not give a full picture of the agonistic behaviour of the herd and may produce arbitrary results (Miller and Wood-Gush, 1991; Galindo et al., 2000). However, this study did not simply count displacements, rather it compared how the individual animal changed the average number of times it would displace another cow with increased feed alley space. This, within cow test, provided a sensitive way of detecting changes in behaviour in response to the different treatments.

The average number of times a cow displaced another from feeding during this period increased by over 120% when the feed alley space was decreased from 1.0 m to 0.5m per cow. These results are similar to other studies, which found that agonistic behaviour increased with reduced feeding space (Friend et al., 1977; Kondo et al., 1989; Olofsson, 1999). However, the findings of Friend et al. (1977) differed from this study in that they did not note a change of behaviour until 0.2 m or less of feed alley space was available per cow. This difference may be attributed to Friend et al. (1977) using different methods for collecting data and calculating agonistic behaviour.

An increase in competition and aggression at the feed alley creates a frustrating, stressful environment for the cows and is detrimental to the welfare of the animals (Metz, 1983). Therefore, the results of this study would indicate that increasing the amount of available feed space would create a less stressful environment and would be beneficial to the welfare of the cows.

5.0 CONCLUSIONS

When feed alley space was doubled, from 0.5 m to 1.0 m per cow, the inter-cow distance did not increase proportionately; however, the occurrence of aggressive interactions dramatically decreased. The study revealed that when the feed alley space was increased to 1.0 m, the inter-cow distances were less than the expected uniform distribution. This indicates that cows show social preference when positioning themselves along the feed alley and that cows chose to maintain group cohesion as part of their herding instinct. However, when six animals were feeding with only 0.5 m of alley space per cow they were unable to maintain their individual space and levels of inter-cow aggression increased. This clearly indicates that the cows were over crowded. Correspondingly, the number of displacements performed decreased considerably when the cows were provided 1.0 m of alley space per cow. Of particular interest, was the dramatic decrease in the total number of displacements despite the failure of the animals to utilize the entire space provided. This result highlights the importance of individual space and demonstrates that animals will react to defend it. Thus, this study emphasizes the importance of providing sufficient feed alley space for dairy cows and indicates that current industry standard of providing 0.5 m of feed alley space per cow is clearly insufficient. The current industry standard disables the cows' ability to maintain their individual space and facilitates the occurrence of aggressive behaviour.

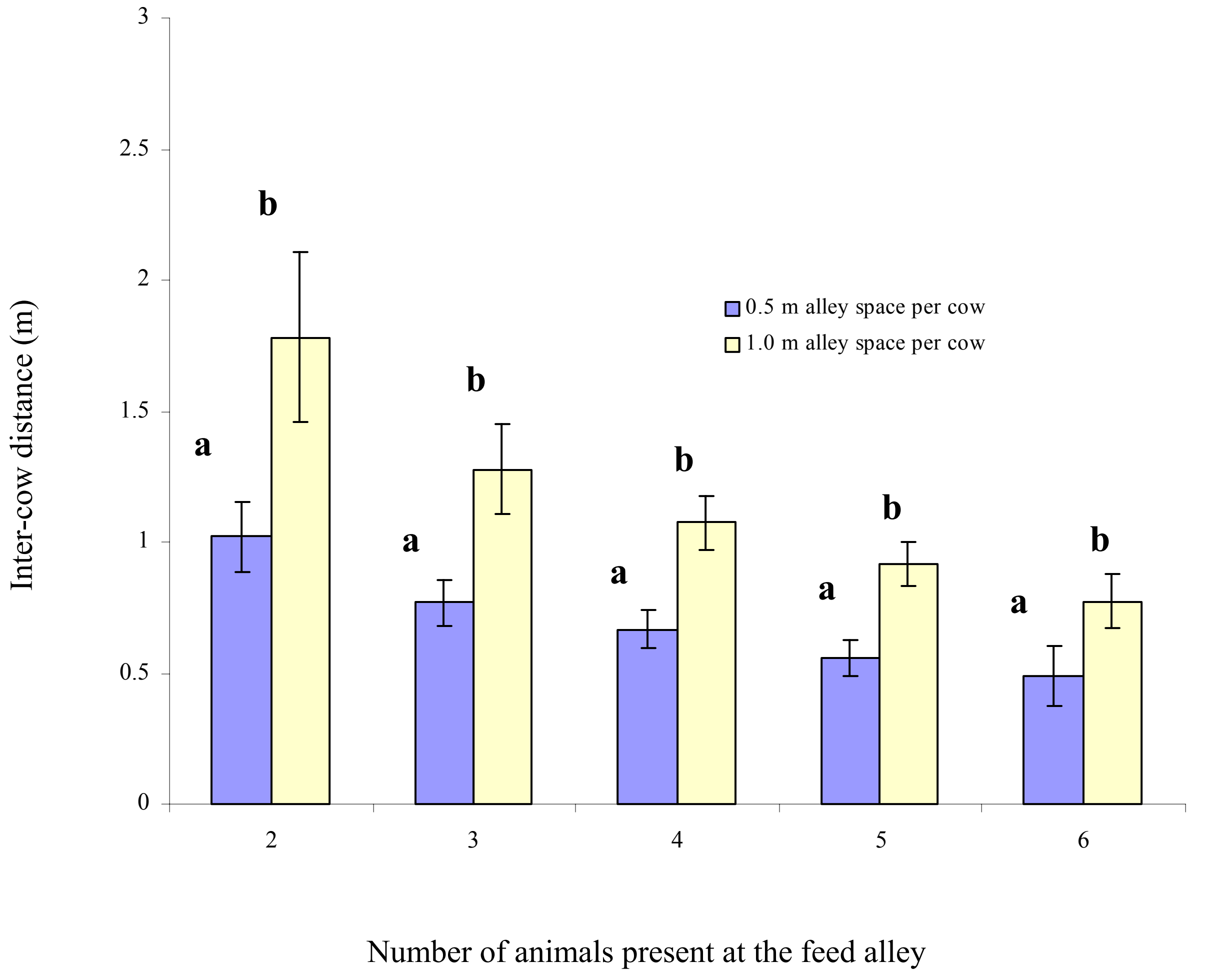

Figure 1. The average distance (± SD) between cows with 0.5 m and 1.0 m allocated feed alley space per cow with varying number of animals present at the feed alley. Distances were calculated from 5 min scan samples of 90 min post-feeding periods and were averaged for 24 cows, fed twice a day. a, b = different indices for each number of animals present at the feed alley indicate significant treatment differences at $P < 0.001$.

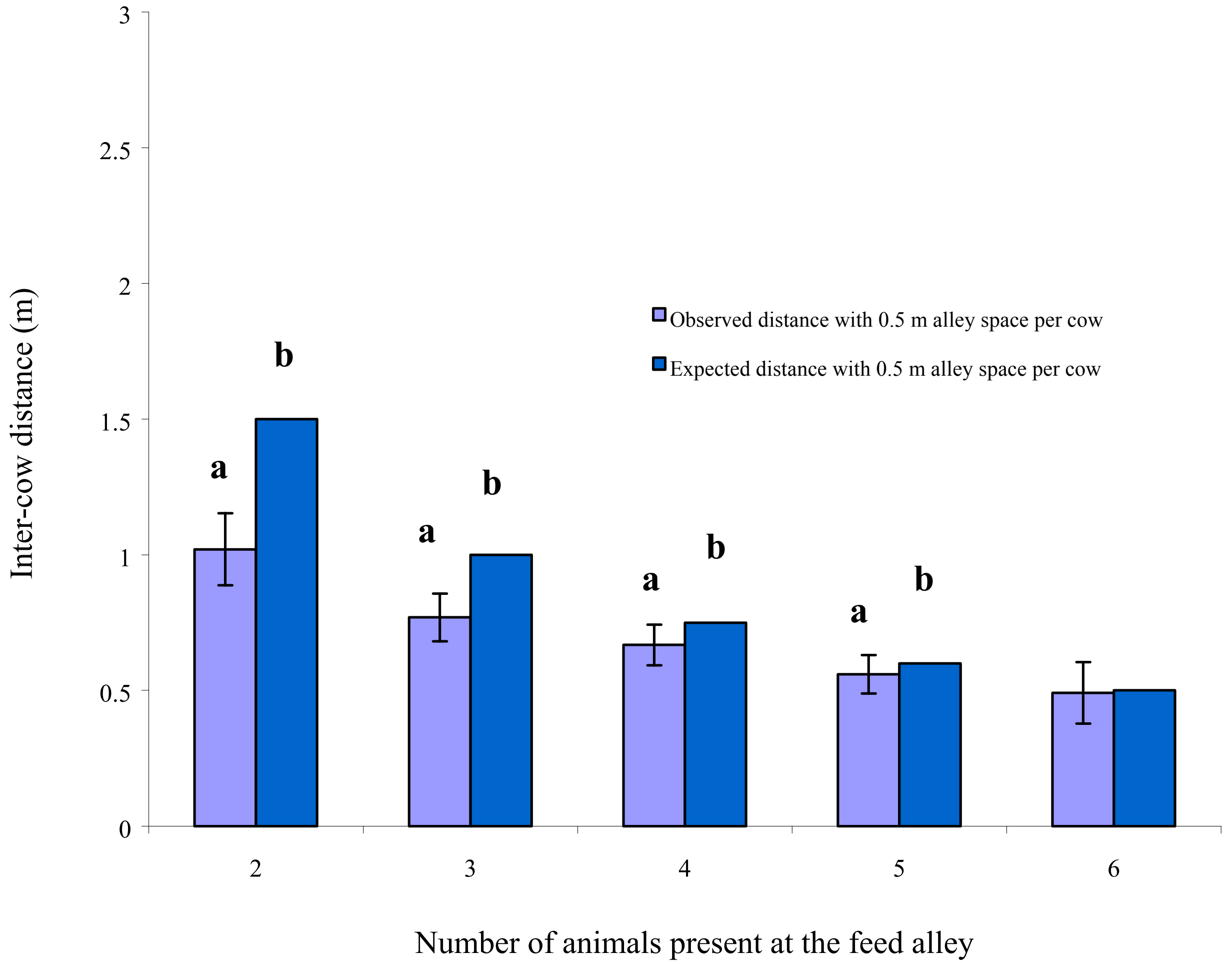

Figure 2. The observed distances (± SD) and expected uniform distances between neighbouring cows with 0.5 m of feed alley space per cow with varying number of animals present at the feed alley. Observed distances were calculated from 5 min scan samples of 90 min post-feeding periods and were averaged for 24 cows fed twice a day. a, b = different indices for each number of animals present at the feed alley indicate significant differences between observed and expected distances at $P < 0.01$.

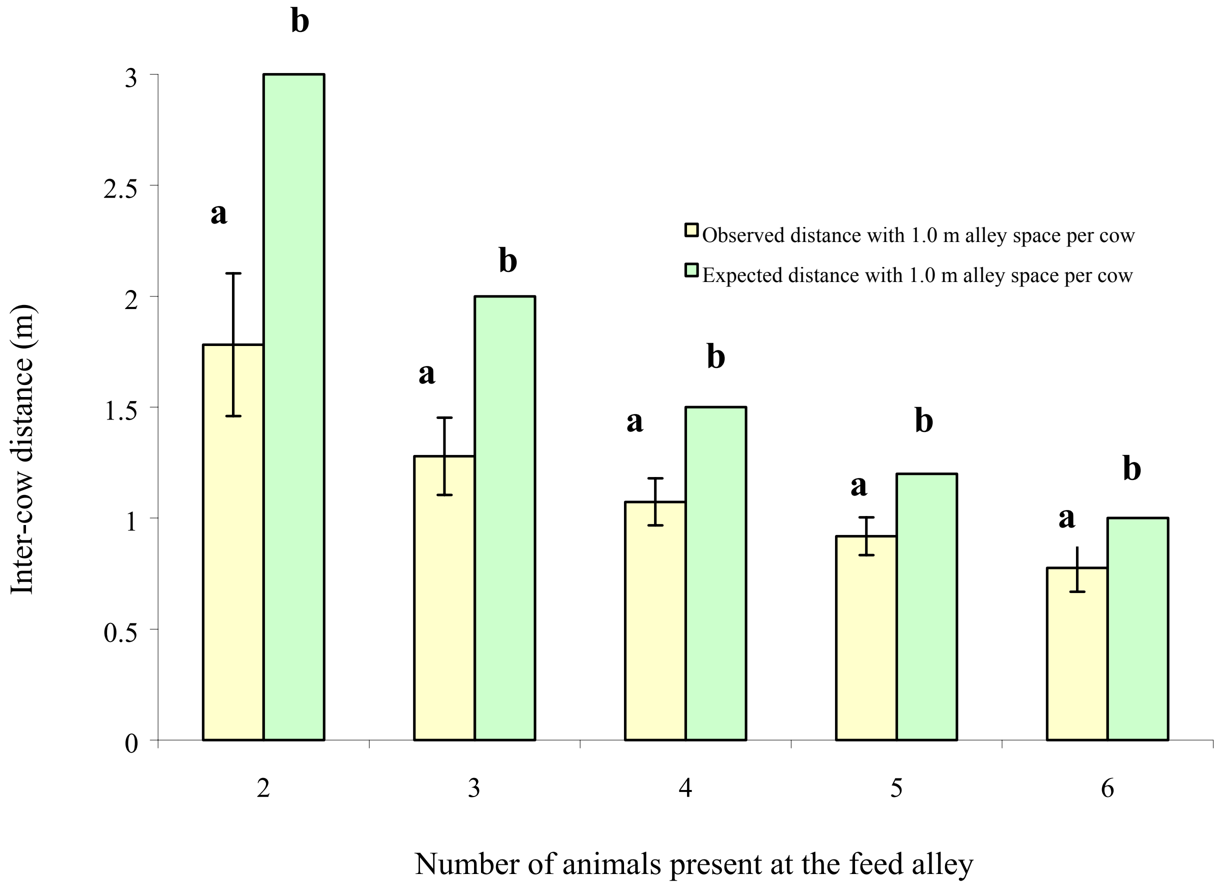

Figure 3. The observed (± SD) and expected distances between neighbouring cows with 1.0 m of feed alley space per cow with varying number of animals present at the feed alley. Observed distances were calculated from 5 min scan samples of 90 min post-feeding periods and were averaged for 24 cows fed twice a day. a, b = different indices for each number of animals present at the feed alley indicate significant differences between observed and expected distances at $P < 0.02$.

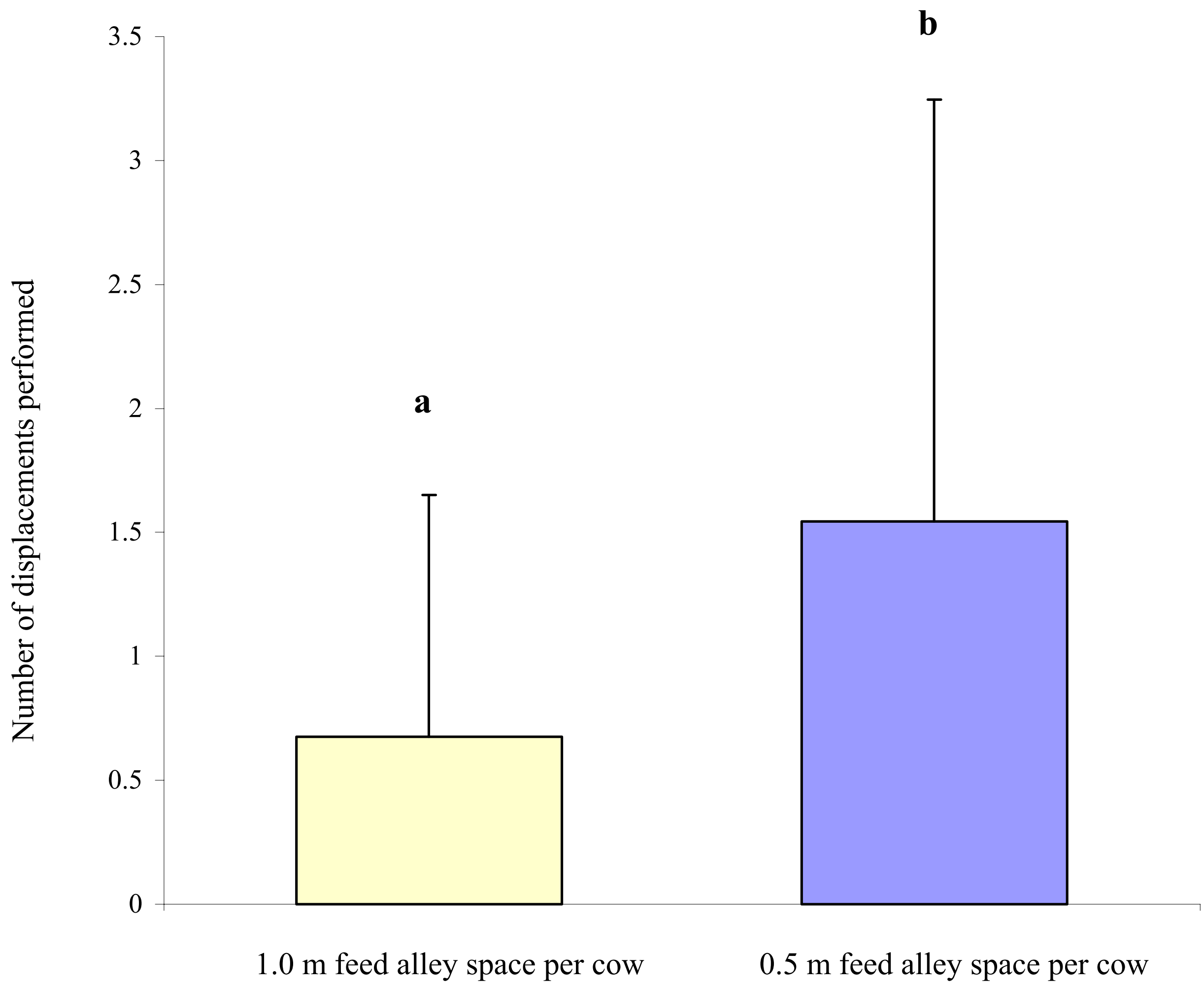

Figure 4. Number of displacements (+ mean SD) performed by each cow. Observed displacements were calculated for 90 min post-feeding periods and were averaged for 24 cows, fed twice a day, for 7 days per treatment. a, b = different indices indicate significant treatment differences at $P < 0.002$.

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