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The relationships between social behaviour of dairy cows and the occurrence of lameness in three herds

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SUMMARY

It is well known that lameness in cattle has a multifactorial causation, however it is still not clear why some individuals are more susceptible to foot lesions in the same environment. Behaviour is thought to play an important role. The aim of this study was to assess the relationships between social and individual behaviour and the incidence of lameness in three dairy herds. Low-ranking cows spent less time lying and more time standing still and standing half in the cubicles than middle- and high-ranking cows. As time spent standing half in the cubicle increased, the number of soft tissue lesions increased and as total time standing increased the number of cases of lameness increased. The survival rate to lameness for low-ranking cows was significantly lower than for middle- or high-ranking individuals. © Harcourt Publishers Ltd

MODERN housing systems for dairy cattle have been designed to make some management procedures easier to carry out. These intensive systems have important consequences for the social behaviour of the animals. Several studies (O'Connell et al 1989, Miller and Wood-Gush 1991, Krohn et al 1992, Krohn and Munksgaard 1993, Galindo and Broom 1993) have shown that aggression increases and the synchrony of behaviour is disrupted when the cows are housed at high density. Reduced space and constant regrouping of cows causes increased aggression, partly because cows have to compete more for eating and lying places (Wierenga 1983, Potter and Broom 1987, Wierenga 1991). Under these conditions some individuals will be more successful than others at gaining access to feeding or lying places. Those which are less successful will have to be active at less favoured times, avoid activity when certain dominant animals are active, or tolerate less preferred places.

Lameness in cattle is a major economic and welfare problem (Greenough et al 1997) and although many studies about causation and pathogenesis have been carried out, it is still not clear which individuals under the same environmental conditions are more likely to develop different types of foot lesions. Several authors have suggested that behaviour is a factor to consider in order to understand the epidemiological pattern of lameness (Bazeley and Pinsent 1984, Chesterton et al 1989, Colam-Ainsworth et al 1989, David 1990, Greenough and Vermunt 1991, Tranter and Morris 1991, Singh et al 1993). To date, however, no detailed studies have been carried out on the influence of social rank on individual time budgets of dairy cows and how these can be related to the occurrence of clinical lameness.

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METHODS

Animals, housing and management

Totals of 50, 70 and 90 dehorned Holstein-Friesian dairy cows, ranging from 2 to 12 years old and calving all year round, were observed in three different farms during the housing period. During the winter they were housed in loose cubicle buildings. The cubicle:cow ratio was 1:1 in the three groups. In the three farms, the housing period lasted from the 1st November to the end of March. While housed, all cows were fed ad libitum on a silage-based diet. In the three buildings, nine bales of wheat straw (20·4 kg each) were used weekly as bedding. The buildings had solid concrete passageways that were cleaned twice a day when the cows were being milked, except for farm 3 where they were cleaned with automatic scrapers 10 times a day. No footbath was used and a specialist foot trimmer trimmed the cows' hooves twice a year. All cows had their feet trimmed before the start of the behavioural observations.

Behavioural observations and measurements

Direct observations were carried out to record information on social interactions and individual time budgets. All cows selected for observation were individually identified with plastic collars. The timetable for observation consisted of observations at different times of each day such that, averaged across the study, each part of the day was equally represented. Three observation periods, during weeks 1, 9 and 17, each lasting 8 days, were carried out on each farm in order to have behavioural data from the beginning, middle and end of the housing period. Each observation day consisted of 4 hours and these were distributed in the following way: day 1, 10:00 am to 2:00 pm; day 2, 5:00 pm to 9:00 pm; day 3, 10:00 pm to 2:00 am; day 4, 2:00 am–6:00 am. The cycle was repeated for days 5 to 8. At the end of the 8 days, 32 hours of behavioural observations were recorded, so a

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total of 96 hours of observation were carried out in each farm. A combination of scan and behaviour sampling techniques was used (Martin and Bateson 1986). Scan sampling was used to obtain information on the total time lying, lying out of the cubicle, time feeding, standing still and standing half in the cubicles for each cow. Behaviour sampling was used to record agonistic interactions, including knocks, threats, chases and avoidance. During the first week of observation, none of the cows was lame. When carrying out the other two observation periods, data on the behaviour of the lame was not considered in order not to confound any effect of lameness on behaviour.

Calculation of behavioural indices

For each animal the time spent in non-interactive behaviours during the study was expressed as proportion of time calculated as follows: number of observations of a behaviour divided by total number of scan samplings. The term time budget was defined as the summed proportions (total 100 per cent) of these behaviours. For the data collected on interactive behaviours, indices of displacements were calculated to reflect social status of each cow according to her experiences in agonistic interactions. The index of each cow could therefore range from 0 to 1.

$$\text{Index of displacements} = \frac{\text{No. of times she displaces other individuals}}{\text{No. of times she displaces another cow} + \text{No. times she is displaced}}$$

Cows with an index of displacements between 0·4 and 0·6 were considered middle-ranking cows, those with an index of displacements above 0·6 were considered high-ranking animals and those with an index below 0·4 were classified as low-ranking cows.

Epidemiological study of lameness

Starting on the day the cows were housed, weekly visits were made to each farm. At each visit, a locomotion score was assigned to each cow as it entered the milking parlour. The scoring system used was adapted from that described by Manson and Leaver (1988), which includes five scores according to abduction or adduction and unevenness of gait in the cow. Scores from 3 to 5 are considered clinically lame. In this study, the scoring was always carried out by the same person and all lame cows had a score of 3. The site of the lesion was identified according to the zones of the sole and heels described by Mills et al (1986). Sole lesions were classified apart from soft tissue lesions, which included the interdigital space and the heel. All cows identified as clinically lame at each visit were separated from the herd and had their feet examined. This method of quantifying hoof disorders allowed for the calculation of the incidence rate of lameness and gave information on how many times each cow presented a new case of lameness throughout the period of the study. A new case of lameness in this study was defined as the first time a cow was identified as lame or when the same cow was lame on a different limb or on the same limb and had fully recovered before becoming lame again (Clarkson 1993). Clinical diagnosis of the hoof lesions was carried out according to Greenough et al (1981) and Toussaint Raven (1985). All necrotic tissue was pared away and free drainage was provided. In severe and painful cases affecting the corium, a wooden shoe was glued with a resin to the non-affected claw, allowing relief from weight bearing on the affected digit. Topical antibiotics were applied, and in cases of deep-seated infections under the sole or heel, a full course of systemic antibiotics was given.

Statistical procedures

A Kruskal–Wallis test was performed to compare mean time budgets between cows of different social rank. For the comparisons of the types of lesions observed in relation to time budgets, chi-square was used. Survival analysis was used to look at the association between the social rank of the cows and the occurrence of lameness. This analysis consists of statistical methods for analysis waiting times, which are the times from an initial event (that is, introduction to housing), to a final event (onset of clinical lameness). It has proved to be a useful statistical method when measuring waiting times to the onset of lameness in dairy cows under grazing conditions (Tranter and Morris, 1991). In this study, the technique was used to estimate rates of occurrence for the final event (lameness) and to compare two or more groups of cows according to their social rank (using the Lee–Desu statistic) with respect to waiting times (Shott 1991).

RESULTS

The relationships between social rank and time budgets

Those behaviours thought to be relevant to the presentation of lameness were analysed and compared in the ranking groups, pooling data on social behaviour. The mean lying time, lying out of the cubicle, feeding time, time standing still, and time standing half in the cubicles were compared between the low-, middle- and high-ranking groups. There were significant differences in the amount of time the cows spent performing these behaviours over a 24-hour period. The mean lying time for the low-ranking group was lower than that of the middle- and high-ranking groups (H = 5·37, df = 2, $P < 0·05$; 31·8, 33·7 and 36·6 per cent of the day, respectively). Also, the mean time lying out of the cubicle was lower for the low-ranking group (H = 8·9, df = 2, $P < 0·05$; 16, 22 and 27 per cent of the day, respectively). From the analysis of feeding time in the three herds, no significant differences were found (H = 1·75, df = 2, $P = 0·41$; 18·2, 19·3 and 20·6 per cent of the day, respectively). The mean time spent standing still in the passageway of the building varied; low-ranking cows spent significantly longer standing still than cows in the other two groups (H = 61·08, df = 2, $P < 0·01$; 50·1, 47·4 and 39·7 per cent of the day, respectively). When the mean time spent standing half in the cubicles was compared in the three groups, the low-ranking cows were found to spend more time in that position than individuals from the middle- and high-ranking groups (H = 19·09, df = 2, $P < 0·01$; 7·3, 3·2, and 3·1 per cent of the day, respectively).

Epidemiology of foot lesions in the groups of cows observed

The number of sole lesions, interdigital/heel lesions, and incidence rate of lameness recorded in each group of cows

TABLE 1: The number of lame cows, lameness cases, sole lesions and interdigital and heel lesions observed during the housing period (25 weeks) and obtained from weekly records in the groups of cows observed in farms 1, 2 and 3

Number of cows observed	Number of lame cows	Number of lameness cases	Number of sole lesions	Number of interdigital and heel lesions	Incidence of lameness (cases per 100 cows)
Farm 1 (n = 50)	17	22	15	7	44
Farm 2 (n = 70)	9	11	6	5	15·7
Farm 3 (n = 90)	16	18	6	12	20

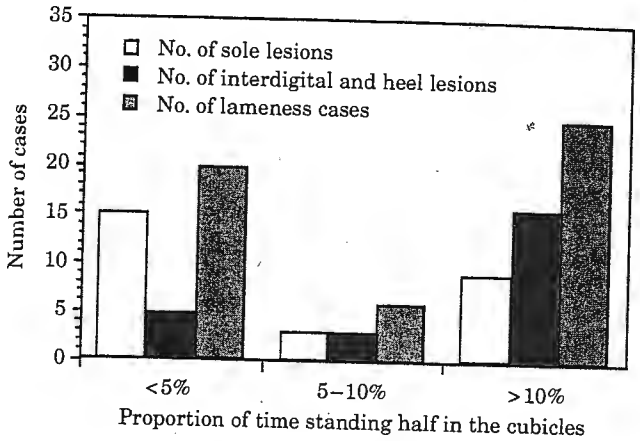

FIG 1: Number of sole lesions, interdigital and heel lesions, and lameness cases in relation to the time standing half in the cubicles.

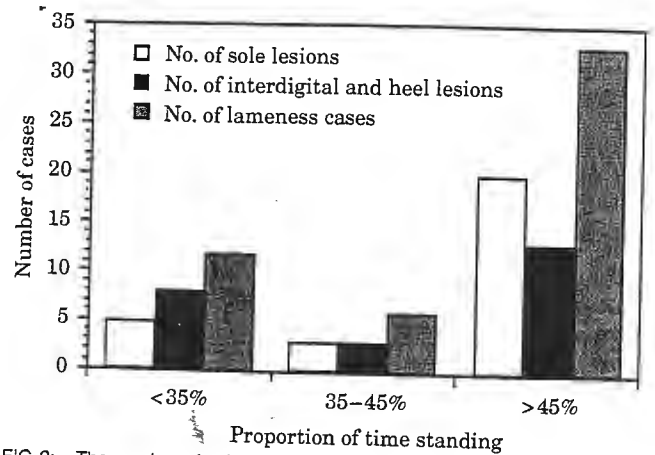

FIG 2: The number of sole lesions, interdigital and heel lesions, and lameness cases in relation to the total time standing.

observed are shown in Table 1. A total of 22 cases of lameness were recorded on farm 1, 15 of which appeared in the sole and seven in the interdigital space. One cow developed interdigital necrobacillosis on four occasions, another developed sole ulcer twice and one cow had a case of sole ulcer and a case of white line disease. On farm 2, 11 cases were recorded from nine cows during the housing period. Six cases occurred in the sole, two in the interdigital space and three in the heel. One cow presented with a case of sole ulcer and one of interdigital granuloma, and another cow developed heel horn erosion twice. On farm 3, 18 cases of clinical lameness were recorded. Of these, six cases affected the sole and 12 the interdigital space. One cow had a sole ulcer and a lesion caused by a foreign body and two cows presented with interdigital necrobacillosis twice. All 51 cases of lameness were pooled and compared with the individual time budgets of the cows on the three farms.

Time budgets and their relationships with the number of sole lesions, number of interdigital and heel lesions, and total number of lameness cases

The time budgets for individual behaviour were divided into three time intervals according to the range of times recorded of each behavioural category: feeding (<15 per cent, 15 to 20 per cent, >20 per cent); standing still (<30 per cent, 30 to 40 per cent, >40 per cent); standing half in cubicle (<5 per cent, 5 to 10 per cent, >10 per cent); total time standing, as opposed to lying, (<35 per cent, 35 to 45 per cent, >45 per cent). The distribution of sole, interdigital and heel lesions, and lameness cases for each time interval or behaviour was analysed. There were no significant differences in the distribution of lameness in relation to the proportion of time spent feeding and standing still. The numbers of sole lesions, interdigital and heel lesions, and lameness cases did not increase as the time feeding or standing still increased. When the distribution of foot lesions was analysed in relation to the proportion of time standing half in the cubicle, significant differences were revealed. The number of sole lesions did not increase as time standing half in the cubicles increased, but the number of interdigital and heel lesions did. Cows standing more than 10 per cent of the time in that position presented more cases of interdigital and heel lesions than other cows ($\chi^2 = 14{\cdot}09$, df = 2, $P < 0{\cdot}01$). Also, the total number of lameness cases was higher in those cows standing for more than 10 per cent of the time half in the cubicles ($\chi^2 = 39{\cdot}21$, df = 2, $P < 0{\cdot}01$; Fig 1). When the distribution of clinical cases was analysed in relation to the total time standing, significant differences were found. The number of sole lesions increased with an increase in the total time standing ($\chi^2 = 17{\cdot}033$, df = 2, $P < 0{\cdot}001$), as did the number of interdigital and heel lesions ($\chi^2 = 13{\cdot}208$, df = 2, $P < 0{\cdot}01$), and the total number of lameness cases ($\chi^2 = 40{\cdot}023$, df = 2, $P < 0{\cdot}001$; Fig 2).

The relationships between social rank and the occurrence of foot lesions

Survival analysis was used to determine the association between the social rank of the cows and the occurrence of lameness, using the first case of lameness as an end point. Overall, the survival rate to lameness of the three ranking groups was not significantly different ($D = 3{\cdot}352$, df = 2, $P > 0{\cdot}05$). However, using pair-wise comparisons, the high-ranking cows showed a significantly higher survival rate to lameness during the housing period than the low-ranking

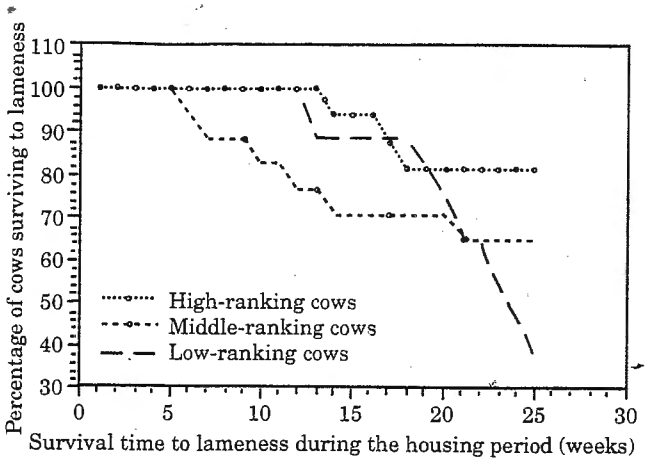

FIG 3: The survival rate to lameness during the housing period for high-, middle- and low-ranking cows.

ones ($D = 3{\cdot}456$, df = 1, $P < 0{\cdot}05$). Less than 40% of low-ranking cows avoided lameness during the housing period compared with the survival rates of 67 per cent and 82 per cent of the middle- and high-ranking cows respectively (Fig 3).

DISCUSSION

When sudden changes in the environment take place, for example confining the cows, mixing groups, or introducing new members into the herd, dominance relationships are more difficult to maintain and agonistic interactions increase (Wierenga 1991). From the results presented here, it is seen that under these conditions, those cows which are more successful in competitive interactions will adapt more easily to their environment. Cows that were more successful in displacing other individuals spent less time standing still in passageways and less time standing half in the cubicles. Both behaviours are related to low-ranking cows that spend more time waiting in passageways for an available space and that use cubicles to hide from dominant individuals, spending more time standing in those places (Wierenga and Metz 1986, Potter and Broom 1987).

Although the aetiology and development of sole lesions in cattle is not clearly understood, it has been suggested that prolonged standing can have a predisposing effect both on sole and soft-tissue lesions. Singh et al (1993) found that cows that stood for longer presented more haemorrhages in the sole horn, which could predispose them to lameness. Phillips and Schofield (1994) observed that cows in cubicles had a reduction in heel depth compared with those kept on straw yards. The results presented here support this, as the occurrence of lameness caused by either sole lesions or soft-tissue lesions increases as the total time the cows spend standing on concrete floors increases. In this study, standing half in the cubicle was also related to lesions affecting the soft tissues of the hoof. It is possible that cows that stand half in the cubicles for longer, have a greater reduction in heel depth of the hind digits, predisposing them to infection in the interdigital tissue and heel. It is important to note that as social status in cows is stable over a long period of time (Wierenga 1991), it is possible to explain the occurrence of lameness as an effect of behaviour. This is confirmed by the differences found between rank groups in the survival times to lameness, particularly the fact that the lower the social rank of a cow, the higher her likelihood to become lame. However, as it is possible that lame cows lose their social position while they suffer from the lesion, it is necessary to consider in the future, whether those changes happen and whether they are permanent.

This methodology could be used to study the relationships between behaviour and individual susceptibility to other health problems such as mastitis and reproductive disorders. Other risk factors affecting individual susceptibility, apart from behaviour, should be considered, particularly those factors influencing changes in weight distribution of the lateral digit of the hind feet during locomotion and stance, such as conformation traits of the udder, hind legs and claws (Galindo 1994).

The information presented in this study could usefully lead to modifications to housing systems for dairy cows, to reduce the incidence of lameness. All possible modifications to encourage and allow lying behaviour should be made, including a high-quality floor and proper bedding and design of cubicles. The cubicle to cow ratio generally recommended is 1:1. However, this does not mean that all cows in a group will have a lying place guaranteed and that they will be able to lie for the length of time they want. It is advisable, therefore, that the farmers always have a spare number of cubicles to provide options for lying to those cows reluctant to use specific cubicles or that are displaced more frequently from some areas. It is suggested that all cows entering the herd should be put in a separate area of the building with deep-strawed cubicles where they can learn or readapt to use cubicles. In most cubicle houses, the cubicles are not evenly distributed in relation to the distance that the cow has to walk to the feeders, drinkers or open areas. Therefore, a suitable distribution of the cubicles allowing a one-way flow of cattle has been suggested that uses curved passageways and adequate lighting to help the cows avoid confrontations as much as possible (Potter and Broom 1987).

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