Behaviour of lame cows: a review

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ABSTRACT: Claw horn disorders, infectious diseases of hooves and leg injuries cause lameness in dairy cows. However, such diseases as sole haemorrhages, sole ulcers or white line diseases, cause clinical lameness. Lameness reduces milk production, the fertility of cows and also causes earlier culling of cows, as well resultings in a deterioration of their welfare. In this review we focus on the impact of lameness on bovine behaviour. The time spent lying down is an important behaviour of dairy cows. As an increased locomotion score is associated with an increased percentage of cows lying down, also the position of cows within the milking parlour is associated with lameness. Lame cows are more likely to present toward the end of milking. Clinical lameness is a chronic stressor, reducing progesterone concentrations prior to oestrus, and resulting in reduced sexual behaviour; however, lame cows have the same potential period of oestrus when compared with non-lame cows. Hoof diseases, particularly those which are a source of pain, also reduce animal welfare. A high standard of cow welfare may be achieved by improving the lives of animals and the people who work with them. A lack of comfort while lying presents a significant risk for lameness. Improvements in comfort on more than 75% of farms (32 out of a total number of 53 farms) reduced the incidence of *mastitis*, while on 42 farms it reduced the prevalence of lameness. The keeping of cows on the straw bed of stalls does not only improve animal welfare, mainly through the greater comfort of the floor, but has also been showed to increase eating and ruminating behaviour. Cows also prefer straw to sand bedding and lay down longer on straw than on sand; however, cleanliness and hoof health have been shown to be better on sand. Apart from comfort, the main factors which promote improvements in bovine welfare and health, include good management of dairy farms, keeping cows in free stalls with accompanying regular exercise, and a long time spent at pasture. The prevalence of clinical lameness was demonstrated to be higher on farms using mattresses when compared with farms using deep-bedded stalls. No differences were found in behaviour among cows with different degrees of lameness housed in mattress stalls. Hence, measures of laying behaviour are not good indicators of lameness.

Keywords: cow; behaviour; welfare; lameness; gait score; comfort of stalls

Contents

1. Introduction

Claw horn disorders (disruptions of the horn), infectious diseases such as digital dermatitis, and leg injuries, cause lameness in dairy cows. There are significant differences between farms in the incidence of lameness and such factors such as concrete flooring, a lack of grazing and uncomfortable stalls contribute to the occurrence of lameness (Cook and Nordlund, 2009). Lameness

in cows considerably deteriorates their welfare and is defined as a deviation in gait resulting from pain or discomfort from hoof or leg injuries (prevalence of up to 55%; Clarkson et al., 1996). Lameness reduces milk production and fertility in cows, as well as causing premature culling (Enting et al., 1997; Dobson and Smithy, 2000; Warnick et al., 2001; Green et al., 2002; Hernandez et al., 2005). This reduction in the productivity of cows constitutes a serious economic problem (Enting et al., 1997). It is difficult for producers to identify cows in the early stages of lameness (Whay et al., 2003), and producers identify only one in every four cases of hoof injuries or diseases in dairy cows. Many evaluation systems of locomotion in cows lack elements which measure the specific changes that occur in the gait of cows becoming lame (Sprecher et al., 1997; Channon et al., 2009; Tadich et al., 2010). In the development of good gait scoring systems we face a lack of good scientific descriptions of gait in healthy cows (von Keyserlingk et al., 2009). Better scoring systems concerning the gait of cows can be derived from computer-assisted kinematic techniques, which would precisely register changes in the gait of cows with different types of hoof injuries (Flower et al., 2005). Some scoring systems of bovine gait take into account several specific gait features such as asymmetric steps and tracking up; however, they are not identified as occurring when cows develop hoof lesions (von Keyserlingk et al., 2009). Only these scoring systems will make possible the early identification of cows with sole ulcers and allow the reduction of pain with the administration of local anaesthetics (Flower and Weary, 2009). The problem associated with early lameness detection may partly stem from the fact that average herd size is increasing and producers are pressed for time to spend with their animals. In the future identification of hoof lesions, such as changes in gait, time standing and lying or walking time, automated measures may be most suitable (Pastell and Kujala, 2007; Borderas et al., 2008; Weary et al., 2009; Tadich et al., 2010).

The aim of this paper is to review the literature on the impact of lameness on the behaviour of cows, particularly the social and individual behaviour of lame cows, and the assessment of bovine welfare.

2. Impact of lameness on the behaviour of cows

Causes of lameness include infectious diseases, such as digital dermatitis and foot rot, or claw horn lesions, such as ulcers, haemorrhages and white line disease. In the literature, only a few studies have accurately documented the behaviour of lame cows (Cook and Nordlund, 2009).

2.1. Lameness detection

Many of the lameness scoring systems use a 5-point ordinal scale (Sprecher et al., 1997; Wincler and Willen, 2001; Flower and Weary, 2006) and many of the scoring systems are modifications of previous systems (Haskell et al., 2006; Rajkondawar et al., 2006; Flower and Weary, 2009). Rajkondawar et al. (2002) developed a walk-through system for lameness detection by measuring the ground reaction forces, while Tasch and Rajkondawar (2004) further developed the SoftSeparator algorithm to separate measurements of a group of cows that walked through the system. Rajkondawar et al. (2006) also further developed models to identify lame cows. Pastell and Kujala (2007) used a four-balance system for automatic lameness detection, where each of the legs is weighed when a cow is in a milking robot. The data showed that the weight distribution between limbs changes when a cow becomes lame. The model was able to detect all leg problems using the validation data, with only 1.1% of false alarms given. This system can be used as a tool for lameness identification in herds milked with an automatic milking system (AMS), as well as for following disease development and the effect of treatment on pain and healing. In a subsequent study Pastell et al. (2008) introduced a new system to automatically detect leg problems in cows. The system consists of a mat made of an electromechanical film, which can detect only dynamic forces. The advantage of this system stems from the fact that its use is not limited to the milking robot, but can be set up in any corridor along which the cows walk. Pastell and Madsen (2008) suggested CUSUM charts for automatically detecting lameness in a milking robot based on the measurements. CUSUM charts are based on the statistical theory for sequential tests. Automated methods for detecting lameness and measuring analgesia in dairy cows were used by Chapinal et al. (2010). The measures of weight shifting between legs while cows are standing, their lying behaviour and walking speed show great potential as automated methods of detecting lameness and evaluating lameness therapies. Ketoprofen reduced the effect of lameness on weight shift-

ing, but did not have any influence on other behavioural characteristics of lameness.

2.2. Time spent lying down

Lying down is an important behaviour of dairy cows. Such factors as the type of housing, the bedding, oestrus and lactation, can affect the time spent lying down by cows (Wechsler et al., 2000; Regula et al., 2004; Norring et al., 2008). The time spend lying down has a significant effect on the occurrence of sole ulcers (Singh et al., 1994). Lame cows spent more time lying and less time standing and walking during oestrus (Walker et al., 2008b). In one study, on average cows during the three periods of observation spent 13.6 hours in the straw yard and lay down for 9.7 hours. The time spent standing was 6.1 hours and in feeding 5.4 hours, respectively. Straw yards are better than some cubicles in terms of encouraging cows to lie down and in providing a soft and dry surface for standing, and straw yards may be helpful in the prevention of lameness (Singh et al., 1994). An increased locomotion score was associated with an increased percentage of cows lying down (Juarez et al., 2003). Lame cows lay down for longer, grazed for a shorter time, had a lower bite rate and lay down for a greater proportion of the time they spent ruminating (Hassall et al., 1993; Walker et al., 2008b). The high lying times, long bouts of lying, and variability in the duration of lying bouts were associated with lameness (Ito et al., 2010). The stall surface influenced the behavioural responses of lame cows.

2.3. Time spent standing

In dairy cows a reduction was observed in the lying time of 3 h/day across the range (from 63.6 to 72.5) of the temperature-humidity index (THI) during the summer. The behavioural change was additionally associated with changes in the locomotion score of cows that typically occur over the late summer months. The development of claw horn lesions in this period may be associated with an increase in total standing time per day (Cook et al., 2007). Cows diagnosed with lesions such as sole haemorrhages and sole ulcers, when compared with cows without lesions in mid lactation, spend more time standing during the two weeks before calving. Standing cows are perched with their two front feet in the lying stall. In this period cows with lesions ate faster than cows without lesions. During the first 24 hours after calving cows with lesions consumed more feed and ate more frequent meals than cows without lesions. Changes in the behaviour of cows can be an early indicator of sole haemorrhages and sole ulcers that become visible several weeks after calving (Proudfoot et al., 2010).

2.4. Behavioural changes in the milking parlour

It was demonstrated that lame cows entered the parlour later and were more restless when in the parlour when compared with non-lame cows. An increased locomotion score was associated with an increase in the return time of cows from the milking parlour (Juarez et al., 2003). Similarly, poor stall designs with obstructions were associated with behavioural changes in the transition period, heat stress and prolonged milking times (Cook and Nordlund, 2009). Such behaviours of cows result in a decrease of milk yield or weight loss (Hassall et al., 1993). The position of a cow within the milking order was also associated with lameness. Lame cows are more likely to present toward the end of milking (Main et al., 2010).

2.5. Oestrus intensity in lame cows

The effect of lameness on ovarian postpartum activity is controversial. Some studies have shown that clinical lameness postpones by up to 18 days the beginning of ovarian cyclicity and by 24 days the onset to oestrus when compared to non-lame cows (Garbarino et al., 2004; Petersson et al., 2006). Similar effects were observed in cases of subclinical lameness (Walker et al., 2008a). Lameness in dairy cows has also been associated with a higher risk of ovarian cysts due to a delay or inhibition of the LH surge (Hamilton et al., 1995; Melendez et al., 2003; Morris et al., 2009). However, recently it has been shown that in lame cows the dominant follicle grew at the same rate, to the same maximum diameter and ovulated at the same time as in healthy cows (Morris et al., 2009).

Lameness is classically associated with a reduction in oestrus intensity in dairy cows (Collick et al., 1989; Walker et al., 2008b). A chronic stressor, such as clinical lameness, contributes to a reduction in

progesterone concentrations prior to oestrus, accompanied by a reduction in sexual behaviour (Walker et al., 2008a). The reduction in oestrus may be caused by physical limitations of lameness itself, inducing a reduced frequency of primary and secondary oestrus behaviours. Using a weighted scoring system to quantify oestrus behaviour it has been determined that lameness can induce an overall reduction of approximately 37% in oestrus intensity (Walker et al., 2010). It is very interesting that subclinical claw disorders have no influence on the intensity of oestrus (Gomez and de Boer, 2003). The overall duration of oestrus was non-significantly shorter in crossbred lame cows (Holstein Friesian and local cattle kept under the loose housing system in tropical India) than in non-lame cows (17.2 vs. 18.7 h); however, a considerable proportion of lame cows (29.7%) had a shorter oestrus duration (from 8.5 to13 h) than normal cows. Altered oestrus behaviour can be caused by a mild degree of lameness (Sood and Nanda, 2006). Stress is associated with lameness in dairy cows, causes a reduction in the period in which cows are mounted, but do not stand, as well as reduces oestrus intensity through low progesterone concentrations prior to oestrus. Lame cows have the same potential oestrus time as non-lame cows (Walker et al., 2010).

2.6. The environment as an important component in lesion development

Cow gait has been scored using a 1 to 5 numerical rating system (NRS), where 1 = perfect gait and 5 = severely lame). NRS is based on the seven specific gait attributes, which were described by Flower and Weary (2009). Multiparous cows with sole ulcers scored higher than cows without sole ulcers (3.3 vs. 2.8). Cows with sole ulcers did not walk more slowly than cows without sole ulcers (1.4 m/s); however, they spent more time lying down (827.8 vs. 738.2 min/day; Chapinal et al., 2009). According to those authors, NRS appeared to be a more consistent predictor of sole ulcers when compared with specific gait attributes and compared with the time spent lying down or walking speed. Behavioural differences between cows with and without hoof lesions in their early lactation suggest that the challenge of early lactation has an effect over and above that of the physical stressors associated with housing; however, the increased prevalence of hoof lesions in heifers in the pregnancy period indicates that the environment is an important component in lesion development (Chaplin et al., 2000).

3. Social and individual behaviour of lame cows

For each cow the time spent in non-interactive behaviours was calculated using behavioural indices as a proportion of time including the number of observations of a given behaviour divided by the total number of scan samplings. The index for every cow ranged from zero to one (Galindo and Broom, 2000). Cows with an index above 0.6 were considered high-ranking animals, between 0.4 and 0.6 were considered as middle-ranking cows, and those with an index below 0.4 were classified as low-ranking cows. The mean lying time, lying out of the cubicle, feeding time, time standing still, and time standing half in the cubicles were compared between ranking groups of cows. The mean lying time, as well as the mean time lying out of the cubicles, for the low-ranking cows was significantly shorter when compared with time spent lying and lying out of the cubicles for cows classified in the middle- and high-ranking groups. However, the mean time spent standing still for the low-ranking cows was longer than for cows in the two other groups. No significant differences were found between the social rank of cows and the occurrence of lameness; however, when using pair-wise comparisons the high-ranking cows showed a significantly lower rate of lameness during the housing period than low-ranking cows. In another study by the same authors it was suggested that lameness in cows influences their social and individual behaviour (Galindo and Broom, 2002). Lameness is a behaviour associated with pain, which cows experience on slippery floors. For this reason the prevention of lameness should be a high priority, similarly to the improvement in management systems, in order to improve the welfare of lame cows. No differences were found in the mean time spent standing between the groups of low-, middle- and high-ranking cows (Galindo et al., 2000). However, when comparing the mean time spent standing still and standing half in the cubicles, differences were found between the groups. Cows with a lower index spent a longer time standing still, and also a longer time standing half in the cubicles, than cows from the other groups. A prolonged standing time could be a behaviour predisposing to sole and soft tissue lesions.

The mean time standing, standing still in passageways, and standing half in the cubicles during the observation period (from October 1st to April 2nd of the next year) were compared between lame and non-lame cows. No differences were found between the groups of cows in terms of the mean time standing and mean time standing still. However, clinically lame cows spent a longer time standing half in their cubicles. When comparing the index of displacements between the groups of cows a significantly lower index of displacements was found in lame cows than in non-lame cows.

4. Assessment of bovine welfare

Many studies investigating animal welfare pay insufficient attention to disease as a welfare problem. The health of animals is an important part of their welfare (Broom and Corke, 2002; O'Callaghan, 2002; Whay et al., 2003; Weary et al., 2006), and for this reason several studies search for relationships between welfare and health and between different diseases and stress (Fregonesi and Leaver, 2001; Cook et al., 2007; von Keyserlingk et al., 2009). Diseases of animals, particularly those, which are the source of pain, as a rule cause a deterioration in welfare (Hassall et al., 1993; Whay et al., 1997; O'Callaghan, 2002; Weary et al., 2009). The best solution to achieve high standards of animal welfare is to improve the lives of cattle and the people who work with them. Apart from that, these solutions need to address several issues, such as lack of pasture access or whether or not cows are exposed to heat stress (von Keyserlingk et al., 2009).

The welfare of cows was assessed in England in many herds and on a large number of cows in consultation with international experts on the welfare of cattle (Whay et al., 2003). Fifty-three dairy farms were visited once during the winter of 2000/01. The protocol of this assessment consisted of three parts. The first part collated information on the herd during the previous 12 months. These data concerned production (average milk yield and conception rate to first service), disease incidence (*mastitis*, lameness, milk fever and other diseases) and sudden death or slaughter out of necessity. The second part started with observations of undisturbed behaviour, indicating the number of cows not engaged in any activities (idling). An increased rate of idling behaviour was used by Chaplin et al. (2000) as an indicator of a reluctance to lie down in cubicles, probably on account of discomfort in lying. In each herd special attention was given to rising behaviour. The third part analysed the records of treatment and medicine use. The opinion of experts was consistent in the fact that intervention is essential to improve the welfare of cows. They all agreed that the most serious problems were lameness, hock injuries and injuries caused by the environment. Finally, more than 75% of farms (32 of the 53 farms) had a reduced incidence of *mastitis* and on at least 42 farms the prevalence of lameness was reduced.

5. A relationship between comfort of stalls, behaviour and occurrence of lameness

Lying comfort is a factor, which influences lameness in dairy cows to a considerable degree. A lack of comfort while lying is a good predictor of lameness risk, and is of great help in the identification of risk factors found on dairy farms (Dippel et al., 2009). Preparing bed for cows with the straw from stalls provides multiple benefits, such as improved welfare, mainly through the greater comfort of the floor. The keeping of cows under such conditions has been shown to increase eating and ruminating behaviour. Straw also reduces oral stereotypies by reducing feeding motivation (Fregonesi and Leaver, 2001; Tuyttens, 2005). Cows were shown to prefer straw to sand bedding and lay down longer on straw; however, cleanliness and hoof health were better on sand, suggesting an improvement in overall welfare. Calculated coefficients of correlation between the time of lying and the health of hooves were difficult to interpret (Norring et al., 2008). Keeping dairy cows in loose-housing systems connected with regular exercise outdoors was associated with better health and welfare of cows. Regular exercise was also beneficial for cows kept in tie stalls in terms of the occurrence of lameness and teat injuries. Good management in dairy farms is also an important factor influencing the health and welfare of dairy cows (Regula et al., 2004). Also the period on pasture of cows provides multiple benefits; even a relatively short time at pasture improved hoof health of cows (Hernandez-Mendo et al., 2007). Lame cows, at the end of a four-week period at pasture had an average numerical rating system (NRS) close to two, but those in free stalls scored more than three (a score of three or more indicates clinical lameness). In a study by Ito et al. (2010) the lameness of cows was scored

also according to this system and data were analyzed from farms applying deep-bedded stalls (DB; n = 11 farms and 526 cows) as well as farms using mattresses (MAT; n = 17 farms and 793 cows). Lameness was dichotomized twice: LAME (NRS ≥ 3) and SEVLAME (NRS = 4). The prevalence of SEVLAME was higher on farms using MAT stalls when compared with farms using DB stalls. The SEVLAME cows housed in DB stalls spent more time lying down compared with cows that were not SEVLAME. Differences in behaviour were not revealed among cows with different degrees of lameness housed in MAT stalls. Measures of lying behaviour are not a good indicator for lameness. Similarly, no relationship was found between the cow comfort index (CCI) and the stall use index (SUI), hence, the daily lying time, the number of lying bouts, or the duration of individual bouts cannot be recommended as methods for assessing this behaviour (Ito et al., 2009). Improving free stalls by fitting the stalls with mattresses did not improve the stall use behaviour of lame cows. However, such improved stalls led to longer standing times in stalls being recorded for non-lame cows (of 12 h/day) (Cook et al., 2008). The behaviour of cows kept on the soft lying mats and on the straw bedding was similar; however, the lying of cows on soft mats, when compared with straw bedding, did not promote hoof health (Wechsler et al., 2000).

In conclusion, the lameness of cows is associated with their behaviour, particularly with a longer time spend lying down and a shorter time spent grazing, while lame cows have a lower bite rate and lay down for the greater proportion of the time they spend ruminating. However, lame cows were shown to spend more time standing during the two weeks before calving. An increased locomotion score was associated with an increased percentage of cows lying down and with an increase in the return time of cows from the milking parlour. Lame cows showed reduced oestrus intensity due to low progesterone concentrations; however, lame cows have the same potential period of oestrus time as non-lame cows. In the assessment of the welfare of cows kept in straw yards it was found that straw gives multiple benefits such as a greater comfort of the floor, and increased eating and ruminating behaviour, better performance and health. Also, regular exercise and pasture were demonstrated to be beneficial for cows kept in free stalls and tie stalls in terms of the occurrence of lameness and teat injuries. One should add that good management in dairy farms is an important factor influencing the health and welfare of dairy cows.

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