BURLEIGH DODDS SERIES IN AGRICULTURAL SCIENCE

Understanding the behaviour and improving the welfare of dairy cattle

Edited by Professor Marcia Endres, University of Minnesota, USA

burleigh dodds SCIENCE PUBLISHING

Contents

Introduction

The welfare of farmed animals such as cattle is an increasing concern for consumers and regulatory agencies. This collection summarises and reviews the wealth of recent research on understanding dairy cow behaviour and improving their welfare.

Part 1 of this collection reviews advances in understanding aspects of dairy cattle behaviour such as cognition and learning and pain and stress. Part 2 assesses developments in welfare indicators and advances in monitoring such as sensors, acoustic and video techniques. It also examines effective training and certification schemes for improving on-farm dairy cattle welfare. Part 3 summarises recent research on improving welfare practices at different stages in production, including calves, heifers and transition cows, as well as areas such as housing. It also covers optimizing welfare in transport and slaughter of cattle.

Chapter 1 sets the scene by providing the author's overview of factors influencing the sustainability of the dairy sector. Welfare and other aspects of sustainability are becoming increasingly important in consumer purchasing decisions. The chapter introduces several key welfare issues affecting the dairy industry that need some improvement, including lameness, mastitis and aspects of calf management. Other topics mentioned in Chapter 1 that might relate to the sustainability of dairy production include minimising grain use, feeding high protein leaves of shrubs and trees, reducing greenhouse gas emissions such as by changing diet to reduce methane output, and improving labelling and traceability.

Part 1 Understanding behaviour

The first chapter of Part 1 reviews advances in understanding cognition and learning in cattle. Understanding the cognitive capacities of cattle is central when designing husbandry environments and developing handling and management practices. Chapter 2 outlines the current knowledge on cattle learning and cognition, with special emphasis on their socio-cognitive capacities. The chapter begins by discussing learning and memory in cattle, focusing specifically on feature cue learning and memory and spatial learning and memory. It then goes on to discuss the importance of understanding the physical environment, which is followed by a review of social cognition in the cattle group. Sections on human–cow interactions and cognitive research in an applied setting are also provided. The chapter concludes by highlighting the importance of using dairy cattle cognitive capacities in the conceptualisation

of handling regimes to ensure a safer working environment for handlers whilst also safeguarding the welfare of the animals.

Chapter 3 focuses on advances in understanding pain and stress in cows. The chapter provides definitions of pain and stress, particularly focusing on the issue that 'stress' as a stand-alone generic term may not be helpful in terms of advancing our understanding of the impact of animal management on animal welfare. For cattle, as for other animals managed by humans, it is necessary to consider the source of 'stress' and the general and specific animal responses to different contexts and events. The chapter also outlines the standard methods of assessing pain and stress, then presents a number of new methods that are being used to assess the experiential aspects. It explains the theoretical background of these methods and how they allow us to gain a better understanding of the experience of pain and stress in cattle than previous methods. Finally, the chapter provides a case study describing a situation where these approaches have led to clear recent improvements in practice that are having real benefits for animals under commercial management.

Part 2 Welfare indicators and monitoring

Part 2 of the book opens with a chapter focused on developing effective welfare measures for cattle. Chapter 4 concentrates on the performance characteristics a welfare measure should possess in order to be considered valid for the assessment of animal welfare. It presents a choice of validation measures that can be used to assess the welfare of cattle and discusses ways they can be collected in practice. The chapter also presents the various definitions of animal welfare and how these definitions can affect the measures that are chosen.

The next chapter provides an overview of advances in precision livestock farming (PLF) techniques for monitoring dairy cattle welfare. Chapter 5 begins by describing the potential of PLF technology linked to the Five Domains framework, then goes into more detail by focusing on the use of PLF techniques for each of the five domains. Finally, the chapter reviews the need for data processing algorithms.

The final chapter of Part 2 discusses developing effective training and certification schemes for improving on-farm dairy cattle welfare. Chapter 6 begins by reviewing the selection of measures that can be used for assessing animal welfare, focusing firstly on animal-based measures, then moves on to review resource and management based measures. The chapter also discusses the four welfare quality principles – feeding, housing, health and behaviour – and how dairy cattle welfare can be affected by the quality of these four principles. Training of assessors is also discussed, before a summary of why using a combination of resource-based, management-based and animal-based measures is the best way to ensure good welfare in animals such as dairy cattle.

Part 3 Improving welfare practices

Part 3 begins with a chapter on developments in housing of cattle to promote health and welfare. Chapter 7 summarises the adaptations and improvements that have been made to freestall housing of adult dairy cattle to enhance health and welfare. The chapter starts by reviewing the impact of housing on natural behaviours of dairy cattle, such as grazing. It then moves on to examine housing adaptations to feeding behaviour which is then followed by a discussion on group management of dairy cattle. A section on promoting optimal resting behaviour is also provided, followed by a review of behaviour responses to extreme climate. The chapter also addresses enhancements to natural behaviour before concluding with a section that emphasises the importance of using well-designed housing facilities to enhance the health and welfare of the animals using them.

The next chapter focuses on advances in understanding behavioural needs and improving the welfare of calves and heifers. Management factors affecting dairy calves have broad impacts on behavioral development and implications for long-term welfare. Chapter 8 summarises recent research addressing behavioral needs of pre-weaned calves and post-weaned heifers, encompassing aspects of social interactions and feeding, rest and comfort, and opportunities for other behavioral expression. In general, evidence suggests welfare and performance benefits of accommodating more natural behavioral expression, including social contact, higher milk intakes fed via a teat, dietary variety, and space and resources to accommodate preferred activities, such as grooming and play. Consequences of restricting these behaviours include development of abnormal oral behaviours. Emerging themes of this area of research include consideration of individual differences and implications and approaches to accommodate broader behavioral expression through increasing environmental complexity.

Moving on from Chapter 8, Chapter 9 addresses advances in understanding the needs and improving the welfare of transition cows. One of the most challenging time periods in a dairy cow's life is when she gives birth and transitions into lactation (the 'transition' period). The chapter begins by focusing on the biological health of dairy cows before and after giving birth, as cows are at high risk of disease post-calving. It then goes on to discuss the affective states of transition dairy cows, including pain associated with labour and disease. Finally, the chapter concludes by assessing the natural maternal behavior of cows before calving through a case study.

The final chapter of the book assesses optimising welfare in transport and slaughter of cattle. Transport represents one of the most stressful events an animal may experience. Its impact on the welfare of beef and dairy cattle is frequently underestimated, as are the effects of transport on carcass quality

issues such as bruises and dark cutting beef. Chapter 10 breaks the process down into three phases: pre-transport, transport and arrival at slaughter. The chapter begins by reviewing culling and permanent herd removal, focusing specifically on voluntary versus involuntary culling, surplus replacements and bull sales, culling based upon performance and removal rates for dairy and beef herds. It then discusses transport of cattle to markets and slaughter facilities and the trends in transport of dairy and beef cattle. This is then followed by a review of muscling and the body condition cull cows arriving at slaughter plants. A section on hide and carcass bruising evaluation is also provided, before concluding with a review of optimising welfare during the pre-transport, transport and slaughter stages.

Chapter 1

Dairy cattle welfare and other aspects of sustainability

Donald M. Broom, University of Cambridge, UK

1 Introduction

Future animal production, indeed all kinds of production, will have to be sustainable. A system or procedure is sustainable if it is acceptable now and if its expected future effects are acceptable, particularly in relation to resource availability, consequences of functioning and morality of action (Broom 2014, modified after Broom 2001, 2010). The development of new, sustainable systems is urgently needed because some current livestock production practices are not acceptable to consumers, many of whom now include the ethics of food production in their evaluation of product quality (Broom 2010). The opinion of the public is based on a range of components of sustainability, including welfare (Table 1).

After an era when negative effects on consumer health have been a major factor in attitudes to some foods, poor welfare of animals is now a substantial factor in consumer purchase decisions, which affect the sustainability of animal production systems (Bennett et al. 2002; Broom 2014, 2017a). Recently, production practices negatively affecting the world's climate and biodiversity have also become more important. In the long run, inefficient use of world resources is likely to influence the public greatly but any of these factors can result in a product being avoided by consumers. It is therefore very important for producers to consider all aspects of sustainability, including welfare, if they are to hold on to their markets. The dairy industry is particularly vulnerable because some of its production practices have come under sustained criticism

http://dx.doi.org/10.19103/AS.2020.0084.01

Table 1 Some factors which might make a food production system unsustainable

Inefficient usage of world food resources	
Adverse effects on human welfare, including health	
Poor welfare of animals	
Harmful environmental effects	a too much greenhouse gas production b low biodiversity c insufficient conservation
Unacceptable genetic modification	
Production systems not 'fair trade', producers in poor countries not properly rewarded	
Damage to rural communities	

in recent years. What can it do to meet changing consumer expectations? Since there are many facets of welfare and other aspects of sustainability, many kinds of measurement are needed (Von Keyserlingk et al. 2013).

2 Animal welfare and the dairy industry

Major welfare problems of dairy cows include lameness, mastitis, impaired reproduction, inability to show normal behavioural and physiological responses, infectious diseases and injury (see review by EFSA 2009). Efforts are being made to address these problems but the first three can still be considered a major issue in high-producing dairy cows (Schukken et al. 2005; Oltenacu and Broom 2010; Webster et al. 2017). It would seem that many dairy cows could be at or beyond a production level that is metabolically damaging to them (Knaus 2009). Since some of the major welfare problems of dairy cows are a consequence of genetic selection for high production, there is a need to balance production and functional traits in dairy breeding programmes in order to protect the future of the industry (Van der Werf and Pryce 2019). It is also recommended that cows should not be fed a diet that exacerbates the metabolic disorders leading to lameness, mastitis and reproductive problems (Blümmel et al. 2017). Bovine somatotrophin can further increase milk yield, metabolic pressure and poor welfare resulting from lameness, mastitis and reproductive disorders (EU SCAHAW 1999). This has been known for many years and consumers are increasingly aware of it but its use is still permitted in some countries.

Welfare issues affect both extensive and intensive production systems. None of the problems is necessarily worse in large dairy herds than in small ones but some aspects of welfare, such as outdoor access, may be more challenging to address in large herds (Broom 2013). On the other hand, large herds can have in-house specialised labour (e.g. hoof trimmer and veterinary care), which can improve other aspects of welfare such as animal health (Robbins et al. 2016).

2.1 Lameness

There are many methods for detecting lameness and, as a result, estimates of the prevalence of lameness vary widely. Cook et al. (2016) reported a lameness prevalence of 9.6% in high-performance dairy herds ranging in size from 203 to 2966 cows while others report prevalences of 39% or higher (Archer et al. 2010; Bell 2017). Barker et al. (2010) concluded that a lameness prevalence of 37% was typical of the milk production industry in much of the world and Bell (2017) suggested lameness may affect one-third of adult dairy cattle, with the majority of animals experiencing a lameness event in the course of a year. Lameness can be a significant problem in both intensive and extensive systems (Ranjbar et al. 2016).

Health is an important part of welfare and lameness is a clear example of this. Leg and foot disorders involve painful tissue damage and they are also frustrating because many of them prevent normal control of movement. They often cause animals to walk with a limp, reduce walking to a low level, or avoid walking whenever possible (Broom and Fraser 2015). The ability of lame cattle to carry out various preferred behaviours is generally impaired, and there may be adverse consequences for various other aspects of their normal biological functioning. Lameness reduces ability to obtain some resources, such as food, water and preferred lying places. Lameness always means some degree of poor welfare, and sometimes means that welfare is very poor indeed. EFSA (2009) concluded that no farms should continue to produce milk without urgent remedial action if more than 10% of cows are lame at any time. Lameness affects production as well as welfare: Archer et al. (2010) found that lame cows produced about 1 kg less milk per day. There is a wide range of clinical causes of lameness in dairy cows (Bran et al. 2019) and the clinical condition can be treated using appropriate analgesia (Stilwell et al. 2019).

The clear measurable welfare outcome of lameness is that the cow shows difficulty in walking and consequent alteration of gait. This can be identified by direct observation of the animal while walking or while attempting to move or walk. Those assessing lameness categorise walking ability using a scale ranging from no problem to scarcely able to walk for each individual. Cows that are lame walk less often to particular resources and walk less in total. Some automated measurement methods can be used, especially for the total amount of walking by the individual, but direct observation by a skilled observer is still the best measure. A criterion for lameness that is generally usable by inspectors is necessary as farmers often fail to identify lameness, especially milder cases. The extent of lameness in a herd can be assessed by an inspection visit to a farm, or to a slaughterhouse, during which every animal (or a representative sample) is checked.

2.2 Mastitis

Mastitis in mammals is a very painful condition. The teat and udder are very sensitive to touch and there is obvious diminution of normal function. Despite many advances in understanding and treatment, mastitis remains the most economically significant bacterial disease of dairy cattle (Moroni et al. 2017b). The incidence of clinical mastitis has been estimated to range from 14 to 40 cases/100 cows per year, and is worst in poorly managed herds and some high-yielding herds (EFSA 2009; Jamali et al. 2018). It has been argued that, as there have been major advances in veterinary science, the prevalence of this serious animal welfare problem might have declined more if there had been less pressure to keep increasing milk yield per cow. Information about mastitis, including sub-clinical mastitis, can be obtained by clinical examination of the cow and by other measures such as white cell count in the milk (Sant' Anna and Paranhos da Costa 2011; Moroni et al. 2017a). Herd records should be kept and be made available for evaluation as part of welfare assessment procedures. A threshold for identification of mastitis is required in order that current prevalence during an inspection visit or prevalence as assessed from herd records can be calculated. Every milking cow on a farm or other unit should be taken into account.

2.3 Reproductive disorders

Reproductive disorders are important indicators of poor welfare in dairy cows. Esslemont and Kossaibati (1997) reported that of cows that were culled, 36–44% of cows were culled because of failure to get in calf. This problem has continued to be important, especially in high-yielding cows that are metabolically stressed (Dobson et al. 2007; Berglund 2008; Friggens et al. 2010; Leroy et al. 2015; Diskin et al. 2016; Evans and Zeng 2017). Reproductive disorders, lameness and mastitis result in cows being culled earlier in life and hence having shorter lives than they did 20–30 years ago (Compton et al. 2017). Cloning of cattle has high risks of poor welfare (Broom 2014, 2018a), and so many countries do not permit it. The data required for assessing the extent of reproductive disorders on a dairy farm are those from clinical investigation during an inspection visit and those from records of veterinary treatment and from the culling of cows (von Keyserlingk et al. 2009).

2.4 Other cow welfare problems

One aspect of more intensive dairy herd management that has attracted concern is housing. Many modern housing systems for cattle involve keeping animals indoors, in a more restricted space, sometimes at high stocking density. This can increase the chance of injury, spread of disease and heat stress as

well as cause poor welfare by restricting behaviour (EFSA 2009; Polsky and von Keyserlingk 2017; Rushen 2017). While cows prefer an adequate to an inadequate food supply (which can be better controlled in intensive systems), they also show clear preferences for access to pasture rather than continuous housing (Spörndly and Wredle 2004; Legrand et al. 2009; Charlton et al. 2011, 2013; Von Keyserlingk et al. 2017). Recent research has confirmed the benefits of outdoor access to pasture in allowing the expression of grazing, lying, standing, walking and social behaviours (Smid et al. 2020).

Husbandry practices that have caused concern include tail-docking (Broom and Fraser 2015), which most dairy cattle welfare programmes around the world have banned (e.g. FARM Programme in the United States), the need for caesarean section because of breed or impregnation by a bull that is large in relation to the size of the cow, and embryo loss when cloning is used. Dystocia and other abdominal pain cause poor welfare and the use of analgesia during all parturition can have beneficial effects (Stilwell et al. 2014). Hot conditions cause poor welfare in cattle and measures of heat stress in cows are described by Polsky and von Keyserlingk (2017).

2.5 Calf welfare problems

The process of parturition can be a stressful, traumatic and hazardous event for both cow and calf. It has been estimated that up to 10% of heifers, when stillbirths are included, may die before weaning in the United States with lower rates in Europe and elsewhere (Miller-Cushon et al. 2017). In the first few days after birth, the major calf welfare problems are enteric and respiratory diseases, identifiable by clinical signs. The calves of dairy cows may fail to obtain sufficient colostrum for a variety of reasons, and will then be more susceptible to disease, so checks on suckling or measurement of immunoglobulin concentration in the blood give information about welfare. The diet of the calf should have sufficient iron to prevent anaemia and, a little later in life, sufficient fibre to promote normal gut development (Phillips 2002; Broom and Fraser 2015). Both of these effects and immune system function can be used as welfare indicators.

Most dairy calves are separated from their mothers at an early age to be reared individually with potentially negative welfare consequences (Phillips 2017). In situations of inadequate management, signs of poor welfare in calves reared in individual crates or pens may include stereotypies; difficulties in standing, lying and grooming; excessive grooming of the front of the body with the ingestion of much hair and the formation of hairballs in the gut; and substantial adverse reactions to walking and to transport (Broom and Leaver 1978; Veissier et al. 1994; Broom 1996; Boe and Faerevik 2003; Gaillard et al. 2014; Broom and Fraser 2015). In contrast, group housing, if well managed, improves feeding, health, and development of behaviour and cognition

(Miller-Cushon et al. 2017). Calves may also be subjected to practices that cause pain including castration and horn-disbudding, resulting in measurable pain-related behaviours preventable by anaesthesia and analgesia (Stafford and Mellor 2005; Stilwell et al. 2008a,b, 2009, 2010, 2012).

An ethical problem for the dairy industry is the production of unwanted male calves. If these calves are removed from the cow and humanely killed, there is no welfare problem for the calf. However, if they are handled roughly, transported in inadequate ways or kept in conditions that do not provide for their needs, their welfare will be poor. These last points apply also to female calves. The solution to this problem may be the sexing of semen so that no unwanted calves are produced.

3 Dairy production, welfare and sustainability

As previously discussed, production methods can have negative welfare impacts which need to be properly understood and addressed. Different methods also have broader environmental impacts which themselves have welfare implications, such as the hotter and drier conditions resulting from climate change that livestock already encounter (Pryce and de Haas 2017). Consumers concerned about the effects of dairy products on their health can now access good information about how to manage cholesterol levels, avoid obesity and also take advantage of the nutritional benefits of dairy products. With well-controlled labelling and traceability, consumers can choose to buy products that are high welfare, have low greenhouse gas emission, are indicated as 'fair trade' and are otherwise sustainable. These issues have major consequences for the future survival and success of dairy farming.

It is well known that herbivorous animals such as cattle and sheep can consume material that humans cannot consume (e.g. grass) and convert it to an edible form (e.g. meat or milk). Many parts of the world are not suitable for arable crop production but can support pasture, suggesting that extensive, pasture-based dairy production, if properly managed, can be an efficient and sustainable use of available world resources (Marshall and Collins 2018).

However, while grasses continue to dominate feed resources for livestock production globally, feed from sources such as grain may represent around 30–40% of the diet of dairy cattle in some regions such as North America characterised by more intensive forms of production (Blümmel et al. 2017). The use of grain and other crops as feed has become controversial because of competition for land and other resources with crop production for food (Herrero et al. 2010; Broom 2018b; Balmford et al. 2018). Stoll-Kleemann and O'Riordan (2015) estimate that 45% of greenhouse gas production from cattle production comes from feed production and processing, with 39% from cow digestion and 10% from their faeces. Feeding energy-dense,

Index