Opinion on the welfare of cattle kept in different production systems

Animal Welfare Committee
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The Animal Welfare Committee is an expert committee of the Department for Environment, Food and Rural Affairs in England and the Devolved Administrations in Scotland and Wales. Information about the Committee may be found at: https://www.gov.uk/government/groups/animal-welfare-committee-awc

AWC Opinions are short reports to Government[1] on contemporary topics relating to farm animal welfare. They are based on evidence and consultation with interested parties. They may highlight particular concerns and indicate issues for further consideration.

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Evidence and the welfare of farmed animals – part 1: the evidence base, 2014
Farmed fish welfare, 2014
Welfare of farmed and park deer, 2013
Contingency planning for farm animal welfare in disasters and emergencies, 2012

[1] Where we refer to 'Government' we are addressing the Department for Environment, Food and Rural Affairs in England, the Scottish and the Welsh Governments, and other responsible Government Departments and Agencies.

Contents

1. Introduction

1. The Farm Animal Welfare Committee (FAWC) traditionally provided detailed expert advice to Ministers in Defra and the Scottish and Welsh Governments on the welfare of farm animals on farm, at markets, during transport and at slaughter. On 1 October 2019, FAWC was renamed the Animal Welfare Committee (AWC) and its remit was expanded to include companion animals and wild animals kept by people, as well as farm animals. This enables it to provide authoritative advice, based on scientific research and experience, on a wider range of animal welfare issues.

2. FAWC recently addressed beef production but has not considered dairy cattle welfare since 2009.[2] The issues considered in this Opinion intersect with some addressed in these previous Opinions.

3. AWC gathered evidence for this Opinion through reviewing peer-reviewed and other research, consulting stakeholders, visiting farms and informal interviews. Key sources are footnoted. These typically refer to legislation, other AWC publications or scientific papers that review or contribute to knowledge of the point in question, but do not represent the breadth of the evidence considered.

2. Scope

4. This Opinion considers the welfare of cattle across the dairy and beef industries in the UK, including beef animals that have been born into dairy systems, up to but not including slaughter.

5. The questions it addresses are:

- Can continuously housed production systems meet the health, welfare and ethological needs of dairy and beef cattle? Can such systems be considered 'higher' welfare and under what circumstances?

- Can pasture-fed production systems meet the health, welfare and ethological needs of dairy and beef cattle? Can such systems be considered 'higher' welfare and under what circumstances?

6. Conservation grazing and rewilding schemes use cattle for ecological management but may not prioritize agricultural production. Nevertheless, because the animals used are under human care and their meat and milk may be consumed by humans, they fall within AWC's remit and this Opinion therefore addresses relevant aspects of these schemes.

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[2] FAWC Opinion on the welfare of cattle kept for beef production (2019), at https://www.gov.uk/government/publications/fawc-opinion-on-the-welfare-of-cattle-kept-for-beef-production; FAWC Opinion on dairy cow welfare (2009), at https://www.gov.uk/government/publications/fawc-opinion-on-dairy-cow-welfare.

3. Climate change

7. Shifting weather patterns attributable to climate change, including high temperatures, rapid and unpredictable temperature fluctuations, high and low rainfall, strong winds, and increased sunlight and humidity, are affecting all farmed species. Future planning of buildings and grazing infrastructure will need to take these into account. Increased contingency planning will be required to safeguard welfare against extreme weather events such as drought or flooding.

8. For housed animals, the effects of climate change may be mitigated by improved building design, temperature-controlled buildings ventilation using fans and sprinklers, on-site water storage, increased artificial lighting and reduced use of transparent roof panelling. In hot weather an animal's higher water intake requirements need to be reliably met.

9. Animals reared outdoors are likely to require improved provision of shelter from direct sun, wind and rain. On some soil types, sustained intense rainfall increases the risk of deep mud, which accentuates the risks of disease and injury through slippage. If heavy rain is followed by a heatwave, poaching produces hard uneven ground that leads to further injury risk. Shorter stocking periods and lower stocking densities may mitigate these effects. Local microclimates may either reduce or intensify climate change impacts. These general welfare aspects of climate change, which apply to different species, are further addressed in the relevant sections of this Opinion.

4. Definitions and production systems

10. Technical terms are defined in the glossary but key classifications are laid out here.

Traditional seasonal housing

11. 'Seasonal housing' is the traditional and most common management system in the UK for both beef and dairy cattle. In this system, animals are housed during winter and turned out to pasture during the grass growing season. This method has prevailed for good reason: it makes good use of forage when this is available, protects the ground from the short- and long-term impacts of poaching, and can make herd management easier.

12. The length of the grazing period, the proportion of the herd with pasture access and the number of hours spent at pasture each day vary. Many of the determining factors are farm-specific. These include farm type (e.g. dairy, beef suckler, store or finishing), local climate, grazing conditions and individual bovine characteristics (e.g. breed, age, sex and lactation stage).

13. During the grass growing season most of the diet comes from freshly grazed grass, forbs and legumes, with a small amount of other feed sources filling any nutritional gaps depending on the season and climatic variation. While out at pasture, cattle are often 'set stocked', grazing a single area for a long period, even the entire

grazing season. In order to maintain pasture productivity, animal numbers need to be kept at a level where the pasture is neither grazed bare nor allowed to overgrow.

14. During the housed period, animals are fed conserved forage and/or a total or partial mixed ration with supplementary concentrates.

- Conserved forage may include silage (preserved pasture) and hay (dried pasture).
- Supplementary feeds can include grains and beans, co-products from feed manufacture (e.g. pressed sunflower seeds) and minerals. Such ingredients are typically blended, or ground and compounded into pellet form.
- A total mixed ration (TMR) is produced by weighing and blending all the feedstuffs (silage, supplementary feeds and minerals) into a complete nutritionally balanced ration.
- A partial mixed ration (PMR) is produced by weighting and blending some of the feedstuffs for feeding to the cows, while the rest are fed separately in another location, such as the milking parlour.

Continuously housed and zero-grazing systems

15. The terms 'zero-grazing' and 'continuous (year-round) housing' describe two different management systems.

16. Zero-grazing describes a system of pasture management. Cattle are fed indoors using some combination of freshly cut grass, conserved forage and a total or partial mixed ration. These systems typically have higher use of supplementary 'concentrate' feed.

17. Continuous (year-round) housing describes a housing system in which cattle are kept within an enclosed environment. They do not have access to grazing but are fed a forage and concentrate diet. The housing may either be indoors or within an uncovered corral system. Such systems are mostly used for dairy cattle and beef finishing.

18. Some dairy farmers have adopted indoor continuous housing to maintain a balanced thermal environment, monitor and control their stock's nutritional requirements and reduce some disease risk. The cattle in these systems often have access to outdoor loafing or paddock areas, including outdoor corrals and bull pens.

Pasture-fed and outwintered herds

19. 'Pasture-fed' and 'outwintered' are two different concepts that are often wrongly conflated. 'Pasture-fed' refers to diet whereas 'outwintered' indicates habitat. It is important to note that stock described as 'pasture-fed' can be seasonally housed. Similarly, some 'outwintered' herds may be fed additional supplementary concentrates and conserved forage.

20. Producers use several terms for marketing purposes to inform customers about their animals' diet. These include '100% grass-fed', 'grass-finished', 'Pasture Promise' and 'Pasture-Fed Livestock Association (PFLA) certified'. None of these is currently recognized by the English, Scottish or Welsh Governments. Several are regulated by

farm certification schemes (see Appendix 1), which often specify additional animal husbandry, health and welfare requirements.

21. In systems in which cattle are kept outside all year (‘outwintered’ herds), pasture may be supplemented with brassicas (e.g. stubble turnips and kale). Hay or silage are still needed for fibre.

22. There are broadly two different methods that are used to try to ensure that animals maintain condition and that ground does not become ‘poached’. These are ‘extensive grazing’ and ‘multi-paddock grazing’ (MPG). Extensive grazing systems are mostly used for beef cattle. In these, the animals are set-stocked on the land but at a much lower density than that used in the ‘traditional’ system. The nutritional value of these systems to livestock is highly variable, depending on the plant species present, soil type, season and animal performance. Where the habitat and winter weather conditions are harsh (e.g. in upland areas), this type of grazing may only be suited to specific cattle types and breeds (e.g. some native breeds).

23. Few dairy systems outwinter milking animals, due to the excessive poaching and land damage that usually occur when animals are grazing during this period. Extensive grazing and outwintering are inappropriate for high-yielding dairy breeds in lactation, although a rotational system may be suitable for heifers.

24. Some dairy cattle are farmed intensively outdoors. In multi-paddock grazing (MPG) or mob-grazing systems, the land is subdivided into smaller paddocks (often with electric fencing) to control grazing duration and location. The cattle are kept within each paddock for only a short time period before being moved on.

25. Variants on MPG are characterized by the number of cattle per unit area, the duration of time they stay in that area and how both are managed or regulated. They include adaptive multi-paddock grazing (AMPG), holistic planned grazing (HPG), management-intensive grazing (MIG), precision grazing, strip grazing, high-density grazing (HDG) and ultra-high-density grazing (UHDG). The time spent within a paddock depends on plant density and growth rate, soil type, microclimate and animal performance.

26. To cope with winter conditions and decrease the risk of poaching, farmers using MPG may house their cattle indoors during periods of very inclement weather. To decrease poaching from motor vehicles in wet winter weather, farmers outwintering animals may put out large hay or silage bales in checkerboard formation (pods) in fields during the late summer or early autumn, when the ground is still dry. Cattle are then given sequential access to a few pods at a time. These provide additional feed during the winter as well as shelter from inclement weather.

27. There is little research on the welfare implications of these grazing systems. The current scientific literature on the benefits of MPG and of low-density extensive grazing focuses on the productivity of the grass leys and the ecological advantages for soil heath and biodiversity.

Calves and post-calving

28. For the majority of UK herds, calf management differs between beef and dairy systems. In dairy production, calves are typically separated from the cow at birth or shortly after. These calves require significant care until weaning is completed. This includes appropriate shelter, which is often difficult to achieve outdoors in UK weather conditions. These animals are therefore usually housed, either in hutches or conventional buildings. In beef systems, and in a few dairy operations, the calf remains with the dam until it is weaned.

29. In Britain in 2019, over 81% of dairy farmers identified as all-year-round calvers.[3] However, in the national dairy herd the number of cows calving peaks in autumn and the number of non-dairy (dairy cross-beef and suckler beef) registrations peaks in spring.

30. Animals intended for the beef market are managed in different ways depending on factors including cattle type, microclimate, soil type, grass growth and market forces. They may broadly be classified into three categories: intensive (12–15 months finishing time), semi-intensive (15–20 months) and extensive (over 20 months).[4] In general, entire bulls from continental breeds are most suited to intensive systems (so-called 'barley beef' or 'barley bulls') and may be housed all their life, potentially in a concrete environment including slatted floors. In contrast, British traditional native breeds or heifers often better suit extensive rearing systems due to their longer maturation, even if they are intensively finished. Within semi-intensive systems, the number of months an animal spends inside partly depends on when it is born. For example, a spring-born calf is likely to spend the majority of its life outdoors as it will only be housed over a single winter period. However, an autumn-born calf may spend over two-thirds of its life indoors, with its first few months inside before being put out to grass during the spring and summer then being kept inside again until it is finished.

Ecological management schemes

31. A range of ecological management schemes utilize cattle. These include 'land sharing' production systems such as agroecology, regenerative agriculture conservation and sustainable agriculture. They also encompass land sparing systems such as conservation grazing and rewilding. In these, the primary aim is land and habitat management or restoration rather than food production. However, most of these terms lack a clear single definition and often have several subcategories, which can lead to confusion and misunderstanding. For example, in some rewilding schemes humans have controlled the number of animals on the land, while in others, humans have stood back and allowed the available vegetation to determine how many large herbivores graze the habitat. In the latter case, some animals are likely to become emaciated during the winter and be at increased risk of death from starvation. This is clearly a welfare issue.

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[3] AHDB GB Cattle Health & Welfare Group Fifth Report, at https://ahdb.org.uk/cattle-health-and-welfare-group-chawg (to be published November 2020).

[4] Hybu Cig Cymru. Beef finishing systems – Options for beef farms in Wales (2014), at https://meatpromotion.wales/en/industry-resources/beef-management.

Net-zero greenhouse gas (GHG) initiatives

32. Following the recommendation from the Committee on Climate Change[5], the UK and Welsh Governments are committed to net-zero greenhouse gas emissions by 2050, while the Scottish Government aims to achieve this by 2045. It is therefore inevitable that, in the next few years, cattle management and production strategies will need to adapt if they are to contribute to meeting this target. Measures could include altering diet and using breeding strategies to select for animals that emit lower levels of methane and/or develop faster (and therefore finish sooner). Some producers may be encouraged to intensify their operations and develop their use of smart technology and precision methods to raise productivity further. In contrast, other producers may decide to adopt 'nature-friendly' farming practices to offset cattle emissions. Although no single strategy will suit all farm enterprises, many have potential welfare implications.

5. Background

33. In recent years there has been an increase in the number of production systems that are, in the UK context, different or novel. This is especially true of the dairy industry. Changes have also been seen in the beef industry, where there has been an increase in the number of extensively reared, outwintered herds, particularly in upland areas.

34. According to AHDB Dairy's estimates on available industry data for 2018/19, only 6% of UK dairy herds are continuously housed. For comparison, across Europe this figure ranges from 0% in Sweden (where grazing is mandatory) up to 85% in Denmark.[6]

35. For the same period, AHDB Dairy also estimates that 95% of UK herds had access to grazed pasture at some point in the year. Elsewhere in Europe, the figure ranges from 100% in Sweden down to 15% in Denmark. Among the 95% of UK dairy herds that graze, approximately 7% do so for over 9 months a year, 65% for 6–9 months, 20% for 3–6 months and 3% for fewer than 3 months.

36. In the UK, continuously housed beef suckler herds are rare, primarily because the milking management advantages that this system brings to dairy production are absent. However, dairy-bred bull beef is typically continuously housed on grounds of safety. There are also several outdoor corral systems in the UK. These are often used to finish dairy beef animals and are intensive systems with high stocking densities and low inputs. In these, weather conditions can have big welfare impacts.

[5] Committee on Climate Change (2019). Reaching Net Zero in the UK, at https://www.theccc.org.uk/uk-action-on-climate-change/reaching-net-zero-in-the-uk/.
[6] Personal communications.

6. Legal context

37. The legislation referred to in this Opinion may include additional amendments that are not listed here. At the time of writing, the implications of the UK's departure from the EU on future legislation in the UK are not fully known, and Agriculture Bills are currently going through Parliaments.

38. All livestock keepers are legally obliged to ensure minimum standards of care for their animals under the Animal Welfare Act 2006 in England and Wales and the Animal Health and Welfare (Scotland) Act 2006. It is an offence to cause unnecessary suffering to any domesticated animal and all reasonable steps must be taken to ensure that the needs of animals under a farmer's care are met.

39. In addition, all farmed animals are protected by the Welfare of Farmed Animals Regulations for England and Wales (both 2007) and Scotland (2010). These regulations transposed EU directives that set down minimum standards for the protection of farmed livestock. Those relevant to beef animals are 98/58/EC (all farmed livestock) and 2008/119/EC (calves). These include minimum requirements relating to inspections, record keeping, appropriate treatment, freedom of movement and appropriate environments, buildings and equipment, feeding and watering and breeding (schedule 1), and detailed requirements for calves that are artificially reared (i.e. all calves destined for veal or beef that are not suckled by the dam).

40. The Mutilations (Permitted Procedures) Regulations for England and Wales (both 2007) and The Prohibited Procedures on Protected Animals (Exemptions) (Scotland) Regulations (2010) permit specified procedures to be carried out, including ear-tagging, disbudding, dehorning and castration, provided specific requirements are adhered to. Tail-docking cattle of any age is illegal.

41. The Welfare of Animals (Transport) Orders for England and Wales and Regulations for Scotland and Northern Ireland (all 2006) make it an offence to transport any animal in a way which causes, or is likely to cause, injury or unnecessary suffering to that animal. They also provide the implementing legislation for European Regulation EC/1/2005, which protects animals during transport and related operations, when these are carried out for a commercial purpose.

42. The Welfare of Animals at Markets Order 1990 (WAMO) contains rules covering the treatment of animals in markets across Great Britain to ensure they are not caused injury or unnecessary suffering. It also sets out detailed arrangements in respect of:

- handling, penning, bedding, food and water provision
- the care of young animals, e.g. time limits on exposure for sale in markets and removal
- limits on how frequently calves pass through markets

Responsibility for enforcing WAMO rests with local authorities.

43. The Codes of Recommendations for the Welfare of Livestock: Cattle for England (2003), Wales (2010) and Scotland (2012), and in Northern Ireland the Codes of Practice for Beef Cattle (2012) and Dairy Cattle (2013), detail the statutory

requirements associated with domestic regulations, provide guidance on compliance and include elements of good practice. Livestock farmers and employers are legally required to ensure that all those with any responsibility for livestock care are familiar with, and have access to, the relevant Codes. Government and industry have produced guidance, such as on beef cattle body condition scoring, lameness and injuries, to assist in welfare assessments.

44. Artificial insemination in cattle is covered by the Artificial Insemination of Cattle (Animal Health) Regulations for England and Wales, and for Scotland (both 1985) and their amendments. The Veterinary Surgery (Artificial Insemination) Order 2010 permits people who are not veterinary surgeons to carry out artificial insemination, provided certain conditions are met. Embryo transfer is covered by the Bovine Embryo (Collection, Production and Transfer) Regulations 1995, under which a veterinary surgeon must be satisfied that a cow receiving an embryo is suitable to bring it to term and calve naturally before the technique can be used, and by the Veterinary Surgery (Epidural Anaesthesia of Bovines) Order 2010, under which people who are not veterinary surgeons are permitted to administer epidural anaesthesia to bovines for the purpose of embryo collection or transfer.

45. The European Convention for the Protection of Animals Kept for Farming Purposes (Council of Europe, 1976), and its recommendations on welfare, set out conditions to avoid any unnecessary suffering or injury, and require that physiological and behavioural needs be taken into account. The associated specific recommendations are now over 40 years old for all farmed livestock (1976) and almost 30 years old for cattle and calves (1993).

46. Organic systems (Commission Regulation 889/2008 EC) require that dairy cows have access to pasture grazing during the grass growing season and that at least 60% (dry matter) of their ration is from roughage (either fresh or dried fodder or silage). The minimum areas per cow are 6m^2 indoors and 4.5m^2 outdoors (excluding pasturage), with a limit of 2 cows per hectare of pasturage to comply with nitrogen input limits on the land. The individual penning of organic dairy calves is prohibited after one week of age.

7. Stockmanship

47. In every cattle rearing system, good stockmanship with an appropriately positive attitude is paramount to ensuring positive animal welfare. However, good stockmanship becomes difficult if staff are overworked or a farm is understaffed. In addition, a decline in a stockperson's physical or mental health may adversely affect their ability to perform their role successfully.[7]

48. The stockperson's role varies greatly between systems: from a highly trained generalist required to engage in all aspects of husbandry, to someone who undertakes a discrete repetitive task, e.g. udder preparation prior to milking cluster attachment.

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[7] FAWC Report on Stockmanship and Farm Animal Welfare (2007), at https://www.gov.uk/government/publications/fawc-report-on-stockmanship-and-farm-animal-welfare.

49. Stock behaviour and herd dynamics vary according to weather, hunger, presence of dogs, unusual sounds, and the introduction or removal of conspecifics. The stockperson needs sufficient knowledge, experience and skills to assess whether apparently unusual behaviour indicates a welfare issue or is a normal response to an unusual, but temporary, stressful situation.

50. Many animals are being cared for by a single person. Larger farms often divide labour so that individuals focus on specific tasks. Where there is a manager with others working under them, the attitude of the manager towards the animals is likely to have a significant impact on welfare.

51. The other class of stock that requires additional supervision is the calving cow. It is desirable to select genetically for easy calving, which requires little stockperson intervention, of animals that then grow efficiently to produce an acceptable carcase value or good quality future breeding. This is especially true of cattle at pasture, but regular checking is still essential, which is easier when cattle are housed. If a cow has problems giving birth while out at pasture it may be difficult for the stockperson to catch, or even to move her to where she may be caught, and assist. Many farms successfully calve outside and ensure that appropriate paddocks and handling facilities are available to assist cows without housing them. Where cattle are calved indoors, it is important that handling facilities are present within the calving area, because walking a calving cow over soiled concrete to access handling facilities represents a significant welfare risk due to the increased risk of slipping and falling.

52. Fetching in dairy cattle from their grazing areas for milking may take a long time. Cows can adjust to different milking regimes and will often be waiting at the gate ready to come in. On some farms, technology may open field gates automatically. Some farms have made significant investments to ease cattle flow, e.g. constructing an underpass beneath a public road.

53. In some pasture-fed dairy systems the practice has been adopted of not separating calves from their dam, with the milk shared between the calf and human consumption. In these systems, the dairy calf, like the beef calf, stays with their dam at pasture. Calves are also pastured with their dams in other European countries, where the practice is often more common. Calves could also be kept with their dams in continuously housed herds.

54. On beef farms, and on farms that raise replacement cows for dairy herds, fields that are non-contiguous with the main holding may be used. These may not be owned by the farmer who owns the cattle and may have no permanent handling facilities for stock. Although it is possible to check herd dynamics and individual animals in an open field, close inspection or treatment mean that animals have to be gathered. This often requires the stockperson to bring portable crushes and hurdles onto the site. These are heavy and often require additional labour, as well as taking considerable time and effort to install. In an open field, it is usually not possible to separate a single animal from the rest of the herd safely without such equipment. Instead, the whole herd needs to be rounded up and penned before an individual can be separated off for treatment.

55. Rewilding and conservation grazing schemes are becoming more widespread across the UK. Although the cattle used in them represent a very small percentage of

our total herd, the numbers and potential welfare issues are both significant. Stockpersons may be stationed a long distance from their animals. Schemes are often run by staff with ecological expertise rather than animal husbandry skills, who may lack the stock-keeping experience needed to recognize the early stages of a welfare problem. Inexperience in low-stress animal handling techniques (often combined with inadequate handling facilities on site) may discourage early intervention.

56. Welfare problems may result when cattle are moved between systems. For example, cattle accustomed to a total mixed ration (TMR) are likely to lose body condition when put onto pasture, either because of low grazing efficiency, or because the pasture is of insufficiently high quality to meet their nutritional requirements. There is also a gut-lag phase, during which the rumen settles into the new diet while its microflora adjust. Moreover, behavioural indicators of distress such as milling, in which frightened animals circle around each other, may be observed when extensively grazed cattle are brought into a handling system, especially if they are unaccustomed to confinement.

Electronic monitoring technologies

57. New technologies are increasingly being used to help manage stock. This appears to be motivated both by a belief that technological development will improve welfare, and by a wish to reduce reliance on labour and the cost of labour. Technology has the potential to raise welfare standards but this depends on what it is, how it is used and the presence and competence of human supervision of it.

58. The technologies in use can broadly be divided into three groups: those that assist with basic husbandry (e.g. cleaning floors, putting out bedding); those that inform stockperson decisions (e.g. data gathering from farm sensors, activity monitors, production records, pedigree and genomics data); and those that potentially replace stockperson decisions and actions (e.g. automated covering of a feed trough in a milking robot to encourage a cow to exit at the end of milking).

59. Electronic data is increasingly being used to aid decision making, potentially facilitating a higher standard of care and enabling more animals to be kept on a unit or holding. Data sources now include movement, medicine and production records, health status indicators and physiological measurements, pedigree and genomics data and data gathered by sensors.

60. The use of sensors is most common in dairy herds, particularly those that are housed for much of the year. Several types of activity monitor have been widely adopted. Most milking parlours and all milking robots automatically record milk yields. CCTV is increasingly being adopted throughout the sector to aid stock supervision. Other data able to be captured by sensors include animal weight, milk conductivity and composition, progesterone levels, body temperature, rumen pH, heart rate, environmental temperature, humidity and airflow, light levels, mass of feed offered and refused, feed quality, volume of milk consumed by calves, tail position and spatial positioning.

61. Such electronic monitoring systems require training for all involved in animal care. The richness of data collected by on-farm sensors has driven further

development of algorithm-based decision-making tools. Most of these produce recommendations for the stockperson. However, the most recent iterations of these tools may make decisions independently of human oversight, using predefined hard-coded logic. A variety of sensors are now used to facilitate stockmanship in different production systems.

- *Activity monitors*. Several types are now in use. An accelerometer incorporated into an ear tag, collar, bracelet or tail attachment is used to detect activities such as mating behaviour, lameness, rumination or impending calving. These devices alert stockpersons to animals requiring attention and should be used as an ‘extra pair of eyes’, rather than replacing the stockperson. They are particularly useful in housed dairy systems. However, portable radio masts and mobile data networks mean they are now also usable in pasture systems to improve the supervision of cattle that may be a long distance from the stockperson.

- *Milk measurements*. When cows are milked by a person, current hygiene regulations require that the udder and milk be inspected for signs of mastitis prior to cluster attachment. Because a human is not directly involved in most robotic milkings, alternative mastitis detection methods are required. The most common is milk conductivity. Whilst this technology is available for conventional parlours, it is predominantly used in robotic milking to detect changes in the milk, alert the stockperson and divert the milk from bulk collection. These changes are often identified before the milk is visibly abnormal and so lead to faster detection of udder infections than in conventional milking. These systems still rely on the stockperson responding to an alert from the robot and then manually inspecting and treating the infected cow. Most parlours and all robots record milk yields. A nutritionist then calculates the ration to be fed to cows based on energy and protein requirements. Some devices now permit the automatic measurement of progesterone and certain metabolites in milk. These allow the reproductive status of cows (and associated diseases) to be identified without more invasive procedures; detection of clinically inapparent metabolic disease (subclinical ketosis) for individual treatment and group nutritional management; and early identification of udder infections. These devices are not yet widely used.

- *Environmental sensors*. Although not yet widely adopted, these offer the potential to significantly improve the comfort of housed cattle. Some stockpersons manually adjust building ventilation in response to changing weather, but the continuous monitoring of temperature, humidity and windspeed can be used to automatically control the position of gale breakers, fans and roof vents to avoid animals becoming cold or heat stressed.

- *Locator devices*. Working with stock on pasture can be extremely time consuming and in very extensive grazing systems, locating animals can be challenging. Attaching radio or GPS tracking collars to one or two individuals in a herd can make this easier.

- *Devices promoting animal choice.* Some decision-making tools have been applied to allow both housed cattle and cattle at pasture to exercise preference.

For example, gates may be programmed to permit access to a milking robot, feed and/or pasture, allowing cattle to choose when they are milked or access pasture. System design is critical. If access to facilities or resources is limited, subordinate animals are vulnerable to bullying by being left waiting for a long time for access to milking or food. In both continually housed and pasture systems, there are well-founded concerns over how some decision-making tools are now being used.

Electronic goads, ticklers/trainers, gates and collars

62. Many assurance schemes prohibit the use[8] of electronic goads or even their presence[9] on farm. The cattle welfare Codes state that their use must be avoided as far as possible and that there must always be space for an animal to move forward.[10] The Codes of Practice for Beef Cattle (2012) and Dairy Cattle (2013) for Northern Ireland state that goads must never be used on calves. Although the Codes permit electric goads, they are rightly reserved for use as a last resort. Moreover, the Codes imply they are applied by a human using discretion and do not envisage automation.

63. Some milking robots include an electronic 'tickler', which applies a mild electric shock to induce cows to leave the robot if they have not departed after a specified time period following milking. However, an animal may be unable to exit if its path is blocked by a more dominant animal. An electronic tickler is similar to an electronic cow 'trainer', which is an electrified rod running above the animal's back that also applies an electric shock. In some European countries, trainers are used to discourage cows from arching their backs and passing urine or faeces in the cubicle without first stepping backwards so that their waste falls onto the floor or channel behind, and to stop them passing urine or faeces in the milking parlour. This practice probably spread from the past use of trainers in tie stalls for the same purpose. In a study of over 10,000 dairy cattle, cow exposure to trainers was associated with significantly increased incidence risk of silent heat, clinical mastitis and ketosis, reduced reproductive performance and higher culling rates.[11]

64. Motorised backing gates are common in collecting yards outside the milking parlour entrance and some are designed to administer an electric shock if an animal touches them. They discourage animals from pushing, damaging or crawling under the gate while it moves them towards the parlour by gradually reducing the size of the waiting area.

65. Electronic collars, which are now commercially available, may be fitted to cattle as part of a 'virtual fencing' system to control where an animal may move or graze. They emit a warning sound then, if necessary to prevent movement outside of a designated area, apply an electric shock to an animal. Early systems that were triggered when a sensor line dug under the ground was crossed are now being

[8] Red Tractor assurance beef & lamb standards (2018), 11; Dairy standards (2019), 18.
[9] RSPCA welfare standards for dairy cattle (2018), M 4.7; RSPCA welfare standards for beef cattle (2020), M 4.7.
[10] Codes of Recommendations for the Welfare of Livestock: Cattle for England (2003), 14; Wales (2010), 16; and Scotland (2012), 14.
[11] PA Oltenacu, J Hultgren and B Algers. Associations between use of electric cow-trainers and clinical diseases, reproductive performance and culling in Swedish dairy cattle. Preventive Veterinary Medicine 37 (1998), 77–90.

superseded by GPS technology. This is useful in some very large-scale extensive grazing contexts, including environmental stewardship projects, where erecting physical fencing may be financially unviable, environmentally undesirable or not legally permissible (e.g. on common land). Whereas a physical electric fence is visible to an animal and may be moved away from, an electronic collar, with no failsafe mechanism could malfunction, applying repeated shocks until its battery expires. Stockpersons are not required to record of the number of times collars activate, whether correctly or otherwise. This raises questions about oversight and record keeping requirements.

66. Legislative and regulatory approaches to electric shock collars and virtual fencing for cattle may be compared with those to electric shock collars and virtual boundary fencing for cats and dogs. The use of electric shock collars to contain (or train) dogs and cats is banned under The Animal Welfare (Electronic Collars) (Wales) Regulations 2010. Virtual fencing for cattle management, including technology that uses electric shock collars, could be regarded as equivalent. The Scottish Government has issued guidance suggesting that using such collars on dogs may contravene the Animal Health and Welfare (Scotland) Act 2006.[12] In 2018 a ban on training collars for dogs and cats was announced for England but has not yet been enacted. Virtual boundary fencing was expected to be exempted from the ban on the grounds that it is used to keep domesticated animals away from roads, and that animals typically quickly learn to respect geographical boundaries without receiving a shock. However, members of the public are highly unlikely to be aware of any invisible fence that is separating an animal or animals from them.

67. Electrical collars are also beginning to be used in MPG systems to control pasture access without a stockperson needing to be present. In some of these systems the stock need moving several times a day in order to maintain good health and welfare. This can be especially important in wet weather, when frequent moves are needed to stop the ground becoming poached. Virtual fencing uses GPS technology and collars, which emit an audible warning signal or signals (e.g. of increasing volume) when an animal approaches the virtual fence line and then apply an electric shock if the animal does not move away. The system is remotely controlled, with the boundary being moved to new coordinates by the reprogramming of the collars. It removes the significant time and labour required to access and move electric fence wire. (However, water troughs are still likely to require physical movement by a stockperson.) Because the fence-line is regularly moved, this automation relies on animals learning to respond to the audible signal rather than to any visual cue. Scientific research has so far focused on implementation rather than welfare. However, individual cattle appear to learn how to respond at different speeds and there are conflicting views about whether this has welfare implications. If sufficiently reliable, virtual fencing would enable a farmer to move their animals remotely. This is likely to reduce the frequency of stockperson checking of animals and interaction with them.

[12] Dog training aids: guidance (2018), at https://www.gov.scot/publications/guidance-dog-training-aids/.

8. Feeding

68. Housed cattle normally spend around 4–6 hours per day feeding, spread over 7–12 meals. When at grass, grazing takes place over a longer period of 6–11 hours and around 7 bouts, with time increasing across the grazing season.

69. The food intake of grazing cattle largely follows the diurnal cycle, with peak grazing periods after sunrise and prior to sunset. After milking and return to a paddock, dairy animals usually graze, especially if they are on fresh pasture. Among housed animals, peak intake usually follows the arrival of fresh feed, and in dairy cattle, milking.

70. Oral manipulation of feed is a strong behavioural need in cattle regardless of their ruminal fill. Depriving animals of the opportunity to express feeding behaviour or forcing them to choose between other less variable needs (e.g. lying) due to daily time constraints will negatively impact welfare.

71. Controlling what is fed to an animal is easier when it is housed, but its ability to access feed depends on the human or machine allowing access, and on feeding facility design. In barrier systems, to ensure continual access feed must be pushed up so cows can reach it. A nutritionally balanced ration can be formulated for each individual cow and supplied through feeding stations that electronically identify each animal when it enters the feeding point, whether this is in the milking parlour, the milking robot, or outside the milking parlour. Milking robots and automatic feeding stations can allow or deny access to individual animals depending on their needs or herd management practices. Such systems remove some animal choice.

72. To maintain health and welfare, the facilities used to feed housed animals should be appropriate to stock type and nutritional needs. For cows in early lactation, this means almost continuous access to fresh, palatable feed, with space for all animals to feed simultaneously and multiple access points to prevent dominant cows controlling access by subordinate animals. Housed cattle may develop acidosis if the diet is imbalanced, e.g. excessive in concentrates and insufficient in long fibre in the form of pasture, hay or silage.[13] In continuously housed systems there is usually a strong economic motivation to develop suitable feeding facilities, as they promote or help stabilize production.

73. Most cattle are housed for some part of the year and are fed a diet centred around conserved forages (normally through drying, as hay, or acid-anaerobic preservation, as silage). Housed feeding facilities are therefore required in almost all production systems, and their quality or otherwise will strongly influence herd health and welfare. However, feeding facilities for seasonally housed herds may not be prioritized as highly as in systems that continuously house stock, because the benefits may be perceived as lower.

74. High-performing dairy cows require specialized feeding systems. The ability to provide very complex, nutritionally balanced diets through technologically advanced feeding systems has incentivized the selective breeding of animals with high

[13] J Hernández. Ruminal acidosis in feedlot: from aetiology to prevention. The Scientific World Journal (2014), 702572.

production potential. Where suitable feeding facilities exist, these animals can perform well and maintain good levels of nutritional and metabolic health. However, if such animals are introduced to more basic facilities possibly geared towards lower production goals, they may fail to thrive (e.g. lose weight, become more vulnerable to disease). High-production animals should not be turned out to graze low-quality pasture.

75. Conversely, if animals of lower production potential are introduced into a high production feeding system they may become overweight, with resultant health risks. To maintain health and welfare, the production potential of the animal should be matched to the feeding system.

76. In a landscape with diverse forages, pasture-fed animals may choose what they wish to eat (e.g. particular plants) based on experience and learning from their dam and conspecifics. However, such animals are more vulnerable to changes in food availability and nutritional quality, which can be influenced by the weather. For example, snow, waterlogging or floods may impede physical access; low or high temperatures may reduce grass growth and availability; physical damage to wet fields may poach or impact the ground, with resultant weed ingress and reduced nutritional quality. Adverse weather may also reduce grazing motivation and so pasture intake.

77. Animals grazing in a diverse habitat may browse trees. This can contribute as much as 12% of total diet.[14] Alternatively, the additional nutritional needs of grazed stock receiving little or no other food can be met by sophisticated liquid mineral feeding systems, but these are currently rare. Slow release boluses can be very effective in targeting trace element deficiencies. More basic methods of supplementation (e.g. voluntary access molassed mineral buckets), or no provision at all, brings increased risk of micronutrient deficiency diseases. Whenever routine supplementation is practiced, it is important to monitor animals to ensure the level is appropriate.

78. In a set-stocked grazing system, where animals are not regularly moved onto fresh pasture, the quality and quantity of forage often decreases through late autumn and winter. Native breeds tend to be able to convert this less nutritious fodder efficiently and usually have lower energy requirements. However, larger, continental breeds or those raised primarily on commercial TMR may be less able to find and utilize the limited forage. This may lead to increased discomfort and hunger in these breeds with subsequent loss of body condition.

79. In MPG systems, the frequent regular moves into fresh paddocks means that there may be minimal loss of pasture quality and quantity. Furthermore, the animals seem to relish these regular moves onto fresh grazing and grazing efficiency tends to be higher, with resultant improved nutrition. However, as in set-stocked systems, if animals are to thrive they need appropriate genetics and familiarity with grazing.

80. Effective grazing management requires a high level of competence and practical experience. Some skilled farmers set up multiple small paddocks on which animals are grazed for around 24 hours, before being moved onto the next. Grass

[14] Forestry Commission. Domestic stock grazing to enhance woodland biodiversity (1999), at https://www.forestresearch.gov.uk/research/archive-domestic-stock-grazing-to-enhance-woodland-biodiversity/.

growth and cover measurements are regularly made using rising plate meters, which may aid decisions about whether to ensile excess grass, or buffer-feed or expand the number of fields in use. However, farmers who find rising plate meter readings for very long plants and mixed sward pastures difficult to interpret or use may determine grazing rotation by observing the pasture and drawing on their experience of recovery periods. Advisory services and farmer-led grazing groups provide training to those starting out with such techniques.

81. For many farmers who have built their production systems specifically around grass utilisation (e.g. spring-calving dairy producers), uptake of grass management technologies and techniques is relatively common. However, technology usage is generally lower in traditional year-round-calving grazing units.

82. Climate, microclimate and soil structure vary hugely between farms. Moreover, pasture nutritional quality alters through the year. Not all pastures are equally durable if there are rainfall changes. Some rapidly 'burn off' in hot weather. Others suffer from poor drainage and easy poaching. Depending on these factors, systems that heavily rely on grazing may risk poor welfare unless carefully monitored and managed.

83. Climate change will inevitably alter the nature of grazing by bringing about long-term changes to average temperature and rainfall, and typical seasonal maxima and minima, on individual farms. Recent flooding has shown the vulnerability of some grassland, with cattle access made impossible, potential contamination of feed by floodwater detritus and subsequent long-term damage to sward structure. For herds highly reliant on grazing for nutrition, a late spring, a very dry summer or a wet autumn can deplete forage reserves, with animals either underfed forage (potentially to the detriment of their health) or sold. Multiple successive difficult years can compound these issues. In such circumstances, continuously housed herds will also suffer from a lack of forage but are usually given alternative feeds and by-products to compensate.

84. When kept with their dam, pre-weaned calves normally suckle milk several times per day. Among artificially fed calves, computerized or ad lib systems allow this feeding behaviour to be maintained. In traditional artificial feeding systems, however, calves are usually only fed twice a day. Low feeding frequency can increase the risk of abomasal disorders, such as abomasal ulceration, and calves should therefore be fed at least twice per day until weaning. During the first four weeks of life, some keepers minimally meet the legal minimum of two feeds in a day[15] by offering the second milk feed almost immediately following the first milk feed. From four weeks of age, calves may be legally milk fed only once per day, if they are also consuming and converting solid food and therefore feeding at least two times per day in total.[16]

[15] Schedule 6, paragraph 12(1) of The Welfare of Farmed Animals Regulations 2007 (both England and Wales) and 2010 (Scotland). This applies to all calves. EU Council Directive 2008/119/EC article 2.1 defines a calf as a bovine animal up to six months old.

[16] Guda van der Burgt and Sophia Hepple. Legal position on 'once a day' feeding of artificial milk to calves. Veterinary Record 172 (2013), 371–2.

9. Water

85. Cattle consume far more water than any other farmed animal, ranging from about 10 litres for a calf up to 150 litres for a high-yielding dairy cow. The volume of water an animal requires depends on how dry the feed is that it is given to consume, the ambient temperature and its physiological status (e.g. whether a cow is lactating). Insufficient water access can affect welfare not only through dehydration, but also by reducing feed intake and threatening rumen efficiency and health.

86. For housed stock, water provision is invariably via artificial sources, including mains, borehole, spring water or rainwater, and is fed via pipes, header tanks and troughs. For grazed stock these sources are also used. Natural sources including streams and ponds are occasionally also utilized, although the requirements of the Environment Agency, Natural Resources Wales or the Scottish Environment Protection Agency to avoid contaminating water sources with animal waste may limit their use. Some disease control programmes also require that access to natural water sources be blocked. Care must be taken to ensure a continual reliable water supply: for example, in winter, water pipes and troughs will require regular checking and possible de-icing, and during a hot period if a source dries up an alternative will be immediately needed.

87. Although mains water quality is largely assured, ground water or natural sources carry risks of microbial or chemical contamination, which can cause ill health. The risk of contaminating natural surface water sources is significant and there is a real possibility of infectious disease being transferred between farms by this medium. Testing water quality can significantly reduce these risks by identifying the need for ultraviolet, chemical (e.g. silver nitrate) or biological treatment of spring, borehole or stored water.

88. Sufficient space is needed for animals to drink. It is good practice to provide at least two troughs/drinkers per group, in order to prevent socially dominant animals controlling access. Given the high levels of consumption by some classes of stock, it is important to ensure that water pressure and flow rate are sufficient to meet demand. This is potentially more easily managed in housed systems, where header tanks can be sited, although these benefits may be offset by smaller trough size and greater risk of contamination by feed or bedding.

89. In grazed systems, increasing trough size (and thus water reservoir volume) may raise water pressure but potentially increases the contamination risk (e.g. dunging) from cattle and other species. In grazed systems, siting water troughs to ensure that cattle do not have to walk excessive distances (more than about 400m) to access water is likely to benefit welfare. Moveable troughs, which are the norm in MPG systems, should be sufficiently large, or otherwise maintain sufficient water pressure, to ensure a short refill time, so that all animals may drink as much as they wish without needing to wait.

10. Comfort and mental state

90. Comfort has three elements: physical, thermal and mental. Thermal is sometimes regarded as a subset of physical. Experimental research is ongoing to investigate the trade-offs that cattle experience between these comforts. All three are, to a greater or lesser degree, impacted by the geographic location of the farm or holding, building design, land topography, field layout and the presence or absence of trees, hedges and shrubs.

Physical comfort

91. Many of the buildings still in use on farms are of an age and design that is unsuited to modern cattle breeds, size and shape. Some farmers adopting seasonal calving are therefore reverting to smaller breeds that better fit their facilities. Old cubicles are difficult to redesign to accommodate larger modern breeds. They can sometimes be replaced, or they can be removed, and the building converted to a straw-based yard system. However, either option requires capital investment, and neither may be permitted nor financially expedient for a farm in tenancy. Lack of light can also be a problem due to small and frequently dirty windows. In addition, difficulty in cleaning old barns out can lead to a build-up of litter, even to the extent of reducing the available head clearance for cattle. Ventilation in older sheds is often poor, meaning that air quality is often low (due to dust, bacterial load and noxious gases), particularly when there is little wind.

92. Tying or tethering cattle for extended periods is a traditional practice that remains in limited use, especially in some regions. In these, cattle are continually tethered by the neck. This may be inside in a stall, especially during winter, or outside, such as while at pasture. Whether inside or outside, an animal is unable to exercise unless released. An animal tied or tethered outdoors is unable to shelter from discomforting weather or to move away from humans, conspecifics or wild animals that it finds threatening.

93. In cubicles, physical comfort may be experimentally assessed by cattle lying duration, bouts and position. In comfortable cubicles, cows lie for 60% of the day and seldom perch (with hindfeet in the passageway) or stand idly (with all four feet in the passageway).[17] In contrast, in poorly-designed facilities, cattle will often show stereotypic behaviours (e.g. tongue rolling) indicative of stress.

94. When indoors, dairy cows have increased lameness risk if unable to lie down or if unwilling due to the lying surface being too wet, cold or hard. Various designs for cow stalls and lying surfaces and substrates (e.g. straw, deep sand bedding, recycled manure solids) are available and each has advocates. All need to balance ease of lying and rising for the cow with keeping the lying surface clean, so dung is not deposited into the bedding area.

95. The type and depth of cubicle bedding material has a significant impact on comfort. The lying area off the dung passageway must be low enough to prevent lameness induced by stepping up and down. Hocks and carpi damage indicate

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[17] N Anderson. Dairy cow comfort: cow behaviour to judge free-stall and tie-stall barns (2008).

pressure on the prominent aspects of joints when cattle are lying, rising or sitting. Similarly, evidence of damage to ribs, point of shoulder, withers or hips may indicate poor cubicle or passageway design, with cattle in concussive contact with solid protruding structures.

96. The FAWC Opinion on the welfare of cattle kept for beef production (February 2019) recommended that fully slatted systems for finishing beef cattle be phased out. Concrete slats provide poor lying comfort indicated by the absence of long lying bouts, caused by a reluctance to lie down and stand up. They rank low in preference testing and cause chronic and acute leg lesions and injuries. There is some evidence that rubberized or plastic-coated slats may be more comfortable than concrete slats, but indoor straw yards that are kept clean and supplied with a generous volume of clean dry straw are more comfortable than either. Sand yards and thick, soft and seamless rubber matting may also provide good physical comfort.

97. In housing, the design of any lying area must be appropriate to the size of stock, ensure good lying comfort through appropriate bed base material and bedding, be hygienic and prevent injury. In general, poor lying areas are likely to lead quickly to health and welfare problems. Buildings infrastructure and facilities should therefore deliver satisfactory welfare even if they are only used for short periods of time.

98. When walking to and from the milking parlour, grazed dairy cows require a surface capable of taking their weight of a cow and the anatomical shape of their hooves. When the surface on which cattle walk is slippery, they respond by standing for longer periods and/or exhibiting abnormal movement (i.e. there will be poor 'cow flow'). Grooving the underfoot surface is a popular measure to reduce slippage and injury and is especially important for concrete. Hard or uneven surfaces can bruise the soles. Surfaces with a loose hard grit cover increase the frequency of stone penetration and subsequent abscessation. In some pasture-fed systems, dairy cows are required to make long journeys to and from pasture twice a day, and good underfoot conditions are therefore extremely important to protect welfare. There is a limit to the distance a cow can walk given the time required to graze, ruminate and milk.

99. In extensive systems, or indoor systems with free access to pasture, animals may lie wherever they choose. In MPG systems, sufficient space needs to be provided for submissive animals to lie down, and to shelter, away from dominant animals. When outdoors, cattle should always be kept clean, because the 'lagging' of legs and bellies in mud and faeces reduces comfort.

100. Poaching of ground can be a significant problem for outdoor herds, especially those set-stocked. It occurs when there is heavy cattle traffic over a prolonged period and can be severe during extended wet periods. Poaching is often observed around watering points and feeding rings that are either not placed on hard standing or are not moved with sufficient frequency. In these situations, cattle have no option but to stand in deep, wet mud to access forage and/or water. Furthermore, as more ground becomes poached, the cattle have less well-drained dry ground for lying. Leg and belly 'lagging' often occur in these situations. In well-managed multi-paddock grazing (MPG) systems, regular rotation and leaving more residual grass mean that poaching is less of a problem. During periods of adverse weather and especially on heavy clay soils, these paddock moves may need to be twice a day or even more frequent.

101. Some farmers appear to struggle to balance stock welfare needs with environmental land management scheme requirements, especially in adverse weather conditions. Some farmers who outwinter cattle and also have land under 'higher tier' environmental management schemes withhold other areas of their farm in order to use it as 'sacrificial land'. These sacrificial areas enable land managers to keep stock at times of the year when scheme requirements might otherwise be challenging to meet. To be serviceable, this sacrificial ground will either be hard-standing or well-drained, fairly flat fields. However, if this is not the case, the sacrificial land can become heavily poached, especially if feeding rings and water troughs are not moved with sufficient frequency, if the area of sacrificial land is too small, or if water drainage is poor. In these situations, cattle can suffer the problems due to poaching described in the previous paragraph.

Thermal comfort

102. Even farms that are neighbouring or on opposite sides of a valley may have markedly disparate microclimates and so provide different thermal conditions.

103. Temperature and ventilation are closely linked. Slotted roofs can work well. With these, the panels are set slightly apart leaving a gap where any falling rain will be evaporated by the heat coming off the bodies of the cattle in the building. Well-designed roof vents can also have a positive effect, particularly when all the transparent or translucent roof panels are removed to prevent the ingress of heat from the sun, which can be considerable during hot summers. The modern higher-pitched roof can greatly assist air movement, increasing the speed at which warm air rises, is expelled from the barn and replaced by cooler air sucked in close to ground level, which in turn then rises during warming. The need for artificial lighting is reduced in a higher building, as more light may enter through the vertical sides and ends. In all cases, orientation needs to be determined with reference to factors including sun and prevailing wind direction. Planning permission for taller buildings may be harder to obtain.

104. In more advanced barn designs, side walls may be closed or opened using adjustable ventilation panels. Walls of a flexible net-based design and construction, with the net descending from the top or ascending from the bottom, may be linked to sensors and pre-set adjustable positions or to remote sensing and command control.[18] Such systems are costly and unlikely to be used anywhere but the largest and most productive dairy herds.

105. Forced fan ventilation may be used to assist air movement, especially in older buildings.

106. Plastic calf hutches are a common means of reducing respiratory and enteric disease transmission risk and improving management control by maintaining small groups, but typically have minimal and ineffective ventilation. They can become very hot when in direct sunlight and so require shade in hot sunny conditions.

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[18] Better Cattle Housing Design, at http://beefandlamb.ahdb.org.uk/wp/wp-content/uploads/2016/03/BRP-plus-Better-cattle-housing-design-080316.pdf.

107. The proximity, design and construction of buildings that neighbour those housing animals should also be considered. These can provide useful draughts or shelter from prevailing winds or conversely result in poor airflow or even static air in the building(s) in which cattle are housed.

108. When outdoors, cattle are at risk of heat stress[19], and potentially sunburn on unpigmented skin. Shelter may be provided by landscape features such as trees, hedges, drystone walls or just the varied topography of an undulating hillside. However, shade availability may vary through the day. Furthermore, the direction of prevailing winds, foliage loss in winter and the location of snowdrifts may also affect available shelter through the year. On land with limited shelter, herd dynamics may determine whether all individual cows can access shelter, as more submissive animals may not wish to stand or lie near more dominant herd members. In outdoor paddocks there may be no shelter, making these unsuitable for some cattle types depending on season, soil and wind.

109. In grazing herds, breed selection and individual adaptation generally mean that cold but dry weather can be tolerated. Animals that become covered in wet mud have a reduced thermoregulation capacity. Risks to thermal comfort include rain (especially when combined with strong winds), sudden temperature changes, and prolonged strong summer sunlight (when no shade is available) including ultraviolet light. Extreme weather events such as flooding or significant snowfall may cause distress or even death. However, if possible and when given advance warning of an approaching storm or flood, farmers will usually try to move their stock to a safe, less exposed area before the adverse weather arrives.

110. In a multi-paddock grazing system it may be impossible for cattle to access shelter or shade. Long grass grazing, which keeps the soil cool and provides a cool surface for animals to lie on, may mitigate this, but other measures may also be needed. When planning paddock rotation, the farmer should consider the weather forecast. Some farmers are now putting out large hay or silage bales in pods in fields during the late summer or early autumn when the ground is dry. As well as providing shelter, these offer additional winter feed.

Mental comfort

111. Cattle are social animals that instinctively seek comfort and protection by being with each other. There is also a dominance hierarchy within each herd, with some animals being submissive towards others. Much of an individual cow's mental well-being depends on genetics combined with previous experience and learning from conspecifics. Furthermore, because cattle are prey animals, a fear ('fight or flight') response is part of their survival instinct. Cattle can become distressed or even extremely agitated if they are suddenly exposed to a new experience (e.g. new feed, new environment, altered lighting, a new handling system, movement into a new herd) or if they are isolated or if herd size significantly decreases.

112. Within confined spaces, including both indoor housing and corrals, some individuals may seek to maintain or extend personal space by bullying other cattle. A

[19] D Wolfenson and Z Roth. Impact of heat stress on cow reproduction and fertility. Animal Frontiers 9 (2019), 32–8.

submissive animal will try to avoid confrontation by moving away. Where this is not possible, they may suffer mental distress. In cubicle housing, submissive cows will often choose to stand rather than lie in a cubicle next to a dominant cow. Allowing more cubicles than cows (5% is often recommended) enables submissive cows to lie away from dominant cows. Other indoor stressors include poor ventilation, sudden or loud noise, shafts of bright light and difficulties accessing food or water.

113. Research has demonstrated that housing calves in pairs or groups, rather than individually, benefits their social and behavioural development, and their feed intake and growth rates across weaning.[20] The evidence for whether pairing or grouping achieves lower infectious disease incidence is equivocal. Although legislation requires that individually penned calves must have visual and tactile contact with another calf, at least through perforated walls, this limited social contact is very unlikely to offer the same benefits as full social contact. In the UK, there has been a recent move towards earlier grouping, with small groups facilitated by the emergence of group hutches and the adaptation of existing pens to allow pairing. Calves that aggressively navel-suck another calf, display infectious disease symptoms, or are markedly different in body size or age, should be individually housed. In all other instances, pair- or group-housing is likely to bring a net welfare benefit.

114. Bull pens are still based on a design from many years ago. There has been little research into their suitability or welfare implications. Cattle are herd species yet the separation of bulls from herds still commonly occurs on farms.

115. In set-stocked extensive grazing systems with a stable herd, animals can move around as a group, maintaining whatever distance they wish from each other. Although there may be some minor tussles, these tend to be quickly settled without significant injury.

116. In multi-paddock grazing systems, paddocks are often sufficiently large to provide grazing for at least 24 hours. This enables cattle to position themselves where they wish within the herd. However, the stock may sometimes be confined at very high density, such as when a herd effect (of trampling, urinating and dunging) is considered necessary to build soil structure. This aims to mimic the effect of predators surrounding the stock and makes inexperienced cattle mill and circle within the bunched herd, which is a sign of stress. Cattle thus managed need to be moved very frequently (perhaps every hour) and so ultra-high-density grazing is generally only used for a few hours at a time, with cattle given additional space overnight. Ultra-high-density grazing is not yet practiced in the UK, although is used on some farms in the United States and Australia.

117. In extensive grazing systems, cattle may be subjected to stressors including dogs, walkers, machinery, vehicles, aircraft, drones, gun noise, vandalism and fly-tipped rubbish.

[20] JHC Costa, MAG von Keyserlingk and DM Weary. Invited review: Effects of group housing of dairy calves on behavior, cognition, performance, and health. Journal of Dairy Science 99 (2016), 2453–67.

11. Injury

118. There are injury hazards in all types of production system. Because so much depends on individual circumstances, no generic risk assessments have been published allowing different systems to be compared. Indoor housing probably carries a greater risk of injury due to minor to moderate hazards, while animals outdoors have a lower risk of potentially more serious injury due to more serious hazards.

119. Within housed systems, many fixtures and fittings bring risk of injury, especially if poorly maintained. Minor to moderate injuries, such as hock/stifle rubs, bursitis and neck callouses, are relatively common. The most common cause of injury in housed cattle is probably foot bruising or damage by standing on concrete for long periods. This is particularly common where group milking times are protracted (over 1.5 hours) or lying surfaces are uncomfortable, difficult to access or too small. More serious injuries due to slips and falls on concrete, or the pinching of tails by equipment such as automatic scrapers, occur in small numbers on some farms.

120. Most injuries may be avoided by appropriate building design, regular maintenance and appropriate stocking densities. Many of the minor injuries in housed animals are the indirect result of changes in body size and conformation without appropriate modification of older buildings to meet modern standards. Farms are investing in rubber or similar matting in collecting yards, in the parlour, and by feed faces and other areas that cows stand on, but many more could benefit from this. Improving lying surfaces (e.g. deep sand bedding or recycled manure solids) and ensuring that stocking densities remain appropriate for the type of housing would also reduce the risk of foot injury.

121. The most common form of serious injury are slips and falls on concrete, which can be greatly reduced by several methods. These include appropriate grooving, sand either added or dragged in by cows from sand beds, appropriate slope inclines, and the wetting of ground made slippery by semi-dried slurry. Optimal groove design is an area of ongoing research. Smooth surfaces on which cattle walk should be kept dry and free of slurry.

122. In housed systems, injuries occur as a result of becoming stuck in feed troughs or ring feeders. On many farms, old tyres are still the means of weighing down silage clamp sheets because many alternatives are more expensive. This can result in contamination of the ration by loose tyre wire or other loose pieces of metal, leading to ‘hardware disease’ (penetration of the gastrointestinal tract).

123. When animals are outdoors, soft and dry ground may reduce lameness incidence and promote recovery.[21] However, the outdoor environment poses other injury hazards. These include foot bruising by stones and lameness due to poorly maintained tracks or slipping around watercourses[22]; poisoning as a result of consuming plants (e.g. St John’s Wort, Hemlock, Yew, Ragwort) that form part of the diverse or rewilded flora, or from other contaminants (e.g. fly-tipped lead batteries); or,

[21] O Hernandez-Mendo, MAG von Keyserlingk, DM Veira and DM Weary. Effects of pasture on lameness in dairy cows. Journal of Dairy Science 90 (2007), 1209–14.
[22] A Hund, JC Logroño, RD Ollhoff and K Kofler. Aspects of lameness in pasture based dairy systems. The Veterinary Journal 244 (2019), 83–90.

less commonly, stick injuries to eyes when forest-grazed cattle explore undergrowth, and there is always the risk of death from lightning strike. Old farm or construction equipment that has not been disposed of also poses a physical injury hazard.

124. In grazed dairy herds, the most likely cause of injury is from cattle walking long distances to and from the milking parlour, usually twice per day. If tracks and gateways are poorly maintained, there is a significant risk of bruising from stones, ‘white line’ lesions or physical injury, and often subsequent infection due to soil or stubble balling between the claws.

125. Well-designed cow tracks reduce the energy expended walking to and from the grazing area and lower the risk of lameness and locomotor disorders. There are good published resources on cow track design. The construction and maintenance costs for good tracks are significant, and while it may be possible to estimate the return-on-investment, the level of uncertainty and large capital outlay may deter some farmers. Many farms have excellent tracks in place, but a large number have no purpose-built tracks.

126. Among grazed cattle that are not milked or regularly brought back to the farm, there is generally a lower risk of foot injury because the ground has a chance to ‘rest’. However, points of high transit, such as feed and water points, may bring such risks.

127. Dairy assurance schemes now include a welfare outcome assessment.[23] Cows are observed by the auditors for lameness, injury (hair loss, lesions and swellings), cleanliness and body condition. This provides a critical third-party evaluation of how the cows’ interact with their environment. The inclusion of these welfare outcome measures has bought the welfare outcomes into the vocabulary of dairy farmers and their teams which in turn has aided the adoption of these measures on farm. A welfare outcome protocol for beef cattle has been produced[24] but has not yet been adopted by all farm assurance schemes.

128. Assurance assessments can be time-consuming to complete but allow critical third-party evaluation of the interaction between animals and their environment and facilitate conversations about how to reduce associated risks. Ongoing research on significant ‘iceberg indicators’ might in future provide grounds for reducing the scale or complexity of assessments.

[23] AssureWel Dairy Cattle Welfare Outcome Protocol, at http://www.assurewel.org/dairycows.html.
[24] AssureWel Beef Cattle Welfare Outcome Protocol, at http://www.assurewel.org/beefcattle.html.

12. Disease risk

129. Disease is of three broad types: infectious communicable disease (such as bovine viral diarrhoea), opportunistic infectious disease (such as mastitis from *E. coli*) and disease from metabolic, nutritional and other causes (e.g. toxicity, common injuries). Disease risks differ between outdoor and housed animals.

130. Many intrinsic disease risks can be reduced by good management practices and farm infrastructure. Farms that house herds for all or most of the year are more likely to invest in housing infrastructure (e.g. lying and feeding facilities), while those using outdoor accommodation are more likely to direct resources towards grazing infrastructure (e.g. cow tracks).

131. Most communicable infectious diseases are due to cattle-to-cattle transmission, either through purchasing carrier animals or by close contact with neighbouring stock. Disease risks may be significantly mitigated by good biosecurity and biocontainment practices. These include appropriate diagnostic screening, vaccination and isolation of incoming animals, and running a 'closed herd' in which replacements are bred from homebred bulls and/or artificial insemination. Nonetheless, infectious disease outbreaks are still common, and the cattle sector remains a long way behind pigs and poultry in terms of biosecurity and biocontainment.[25]

132. Individual outdoor-reared stock are probably at greater risk of novel communicable infectious disease than housed animals. Animals may break through fences and mix with neighbouring stock; have nose-to-nose contact with neighbouring animals; have greater opportunity for interactions with wildlife (which may carry infectious diseases such as Leptospirosis[26] and bovine tuberculosis); have access to fomites carried from other farms by wildlife; or share water sources (e.g. streams) with neighbouring stock. However, the rate of infection spread between animals is likely to be higher indoors due to the closer proximity of animals to each other, the far greater number of physical objects that might become contaminated and airborne transmission.

133. In general, parasitic disease risk is much higher in grazed systems, although its incidence is farm-dependent and will remain low with good conditions and stockmanship. Parasitic diseases including gut worm (*Ostertagia ostertagi* and *Cooperia oncophora*), lung worm (*Dictyocaulus viviparus*), liver fluke (*Fasciola hepatica*) and the protozoan *Neospora caninum* from dogs are transmitted through pasture, in which most of the parasites live for part of their lifecycle.[27] Research-based modelling has suggested that changing climate will result in significantly increased

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[25] ML Brennan and RM Christley. Biosecurity on cattle farms: a study in north-west England. PLoS One 7/1 (2012).

[26] JF Fávero, HL de Araújo, W Lilenbaum and G Machado. Bovine Leptospirosis: prevalence, associated risk factors for infection and their cause-effect relation. Microbial Pathogenesis 107 (2017), 149–54; S Adugna. A review of bovine Leptospirosis. European Journal of Applied Sciences 8 (2016), 347–55.

[27] JF Mee and LA Boyle. Assessing whether dairy cow welfare is 'better' in pasture-based than in confinement-based management systems. New Zealand Veterinary Journal 68 (2020), 168–77; PJ Skuce and RN Zadoks. Liver fluke – a growing threat to UK livestock production. Cattle Practice 21 (2013), 13–49.

parasitic disease risk in northern Europe[28] and the UK[29] including severe liver fluke epidemics in Wales by 2050.[30]

134. The role of pasture in bacterial disease transmission may previously have been underestimated with too much transmission attributed to close contact between animals.[31] For example, clostridial disease is spread from pathogenic bacterial spores in pasture.

135. Risks can be mitigated through herd management (e.g. vaccination and building natural immunity) and the selective use of drugs such as anthelmintics. Anthelmintic and anti-trematode drug resistance is increasing, however,[32] and disease incidence could rise in future if genetic selection for parasite resistance or improved management techniques are not adopted. Farmers using rotational grazing systems and long-grass grazing reportedly find that, following assessment by faecal egg count, they need to use anthelmintics less. This may be because their animals have less contact with worms. For example, if animals are allowed to graze dry grass only down to 10cm the infection risk is greatly lowered, because in dry conditions most parasites live in the bottom 5cm of vegetation.[33] Moreover, rotational systems encourage dung beetles, which quickly remove dung from the pasture surface.

136. The transmission risk of some communicable diseases (e.g. calf and adult respiratory viruses, infectious diarrhoea in calves) is greater in housed stock because the higher stocking density facilitates in-contact and airborne spread.[34] Parasites affecting housed stock include lice and mites, but serious infections are uncommon. Gut worms and fluke are very rare. It is possible that larvae or eggs found at pasture may survive ensiling and then be consumed by housed animals[35] although a recent study indicates that the fluke parasite does not survive anaerobic conditions and so this may only be an issue for poorly ensiled forage.[36] Opportunistic infection risks most

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[28] DN Logue and CS Mayne. Welfare-positive management and nutrition for the dairy herd: a European perspective. Veterinary Journal 199 (2014), 31–8.

[29] J van Dijk, ND Sargison, F Kenyon and PJ Skuce. Climate change and infectious disease: helminthological challenges to farmed ruminants in temperate regions. Animal 4 (2010), 377–92.

[30] NJ Fox, PCL White, CJ McClean, G Marion, A Evans and MR Hutchings. Predicting impacts of climate change on *Fasciola hepatica* risk. PLoS One 6/1 (2011).

[31] R Woodroffe, CA Donnelly, C Ham, SYB Jackson, K Moyes, K Chapman, NG Stratton and SJ Cartwright. Badgers prefer cattle pasture but avoid cattle: implications for bovine tuberculosis control. Ecology Letters 19 (2016), 1201–8.

[32] C McLeonard and J van Dijk. Controlling lungworm disease (husk) in dairy cattle. In Practice 39 (2017), 408–19.

[33] N Kumar, TKS Rao, A Varghese and VS Rathor. Internal parasite management in grazing livestock. Journal of Parasitic Diseases 37 (2013), 151–7.

[34] C Svensson, J Hultgren and PA Oltenacu. Morbidity in 3–7-month-old dairy calves in south-western Sweden, and risk factors for diarrhoea and respiratory disease. Preventive Veterinary Medicine 74 (2006), 162–79; GK Lundborg, EC Svensson and PA Oltenacu. Herd-level risk factors for infectious diseases in Swedish dairy calves aged 0–90 days. Preventive Veterinary Medicine 68 (2005), 123–43.

[35] BC John, DR Davies, DJL Williams and JE Hodgkinson. A review of our current understanding of parasite survival in silage and stored forages, with a focus on *Fasciola hepatica metacercariae*. Grass and Forage Science 74 (2019), 211–17.

[36] BC John, DR Davies, AK Howell, D Williams and JE Hodgkinson. Anaerobic fermentation results in loss of viability of *Fasciola hepatica metacercariae* in grass silage. Veterinary Parasitology 285 (2020), 109218.

commonly relate to infectious forms of lameness (e.g. interdigital necrobacillosis or digital dermatitis) and udder infections, including mastitis.

137. Among housed animals, most opportunistic infections stem from contact with slurry or manure and contaminated bedding. For example, contact with slurry can reduce skin integrity and allow bacteria like Treponemes to establish infections such as digital dermatitis. Equally, *Steptococcus uberis* may thrive in contaminated straw bedding and cause mastitis. Buildings and equipment that prevent slurry build-up and employ biologically inert bedding (e.g. sand) reduce such risks. For example, robotic dung scrapers or well-designed and frequently-run automatic passage scrapers can efficiently remove slurry.

138. Outdoor stock are at lower risk of infectious lameness, mastitis and uterine disease.[37] Even so, skin wetting due to rainfall and mud may lead to opportunistic infection, as well as decreased udder cleanliness and so mastitis risk.[38] In some weather conditions animals may gather at high densities (e.g. in shaded areas), with resultant contamination of areas and risk of udder infection through direct contact with dung or via flies spreading pathogens between animals. The bacterial disease New Forest eye is also a risk, especially among youngstock during summer grazing.

139. In broad terms, the inherent risk of metabolic diseases, such as hypocalcaemia and ketosis, increases with genetic propensity to milk production. However, in housed systems, which more commonly favour higher output, there is usually greater dietary control (e.g. through provision of a total mixed ration) and therefore these risks may be largely eliminated. Animals of higher genetic milk propensity kept at grass during critical periods of their production cycle (particularly around calving) are therefore particularly difficult to manage. Equally, housed high-production animals that are fed a very basic ration are likely to suffer metabolic problems.

140. The mineral content of grazed pasture is unlikely to meet the high requirements of dairy animals. Most productive stock require supplementary mineral nutrition, which is more easily given via supplementary feeds. Grazed cows are more vulnerable to ketosis than housed cows[39], especially after calving.[40] They exhibit twice as much post-partum weight loss[41] and may develop hypocalcaemia. They are also vulnerable to hypomagnesemia (grass staggers).

[37] GL Charlton and SM Rutter. The behaviour of housed dairy cattle with and without pasture access: a review. Applied Animal Behaviour Science 192 (2017), 2–9.
[38] MJ Green, AJ Bradley, GF Medley and WJ Browne. Cow, farm, and management factors during the dry period that determine the rate of clinical mastitis after calving. Journal of Dairy Science 90 (2007), 3764–76.
[39] GL Charlton and SM Rutter. The behaviour of housed dairy cattle with and without pasture access: a review. Applied Animal Behaviour Science 192 (2017), 2–9.
[40] AC Berge and G Vertenten, A field study to determine the prevalence, dairy herd management systems, and fresh cow clinical conditions associated with ketosis in western European dairy herds. Journal of Dairy Science 97 (2014), 2145–54; JR Roche, JK Kay, CVC Phyn, S Meier, JM Lee and CR Burke. Dietary structural to nonfiber carbohydrate concentration during the transition period in grazing dairy cows. Journal of Dairy Science 93 (2010), 3671–83.
[41] RS Fontaneli, LE Sollenberger, RC Littell and CR Staples. Performance of lactating dairy cows managed on pasture-based or in freestall barn-feeding systems. Journal of Dairy Science 88 (2005), 1264–76.

141. In some extensive systems, cattle are co-grazed with sheep. There is insufficient evidence to offer any assessment of the overall benefits and costs of this practice.

13. Behaviour

142. Bovine behaviour is, like that of other species, a product of instinct, experience, system, learning and individuality. Despite the number and range of breeds, many instinctive behaviours seem to have been retained from wild ancestors. However, others (e.g. docility when handled) have evolved or developed in response to domestication.

143. Selective breeding strategies that specifically focus on production traits such as leanness have been reported to lead to more excitable animals.[42] Similarly, studies have shown that there is a genetic component to calf reactivity to external stimuli (as determined by behaviour, heart rate and blood cortisol levels).[43] Conversely, calm mothers tend to produce calm calves. Although this genetic component is clearly important, stockperson behaviour and attitude and the frequency of contact also fundamentally shape stock behaviour. Harsh handling increases stress levels.

144. Other purely instinctive behaviours include mating, the desire to leave the herd when about to give birth, licking new-born calves and ruminating to aid forage digestion. However, most behaviours also have a learnt component. These include finding food, knowing what to eat and what to avoid, grazing grass, manipulating the tongue and mouth to eat other pasture plants or tree/hedge brash, knowing where to find appropriate shelter from rain or sun and walking into the milking parlour.

145. Feeding behaviour is influenced by both feed distribution and type. In housed systems, cows typically eat for 4–6 hours/day, while those at pasture often graze for 6–10 hours/day. In addition, to feeding, cattle also spend 6–8 hours/day ruminating, either standing or lying in bouts lasting about 45 minutes. Only healthy and unstressed cattle ruminate normally, and stockpersons often use this as an indicator of wellbeing.

146. Cattle are heavily influenced by previous experience, especially during early life.[44] If allowed to explore something new in their own time, they are naturally curious. However, they can become very agitated and distressed when forced to confront anything novel. They can become especially stressed if suddenly moved to an unfamiliar environment or placed into a different herd.

147. Signs of stress include a range of physical and behavioural changes in the individual that may include a ‘freeze, fight or flight’ response, increased respiratory and heart rates, excessive salivation, vocalization, defecation/urination, reduced immune response and milling (circling around each other in a circle). Chronic

[42] MJ Haskell, G Simm and SP Turner. Genetic selection of temperament traits in dairy and beef cattle. Frontiers in Genetics 5 (2014), 368.

[43] A Boissy and HW Erhard. How studying interactions between animal emotions, cognition, and personality can contribute to improve farm animal welfare. In Genetics and the Behavior of Domestic Animals, eds. T Grandin and MJ Deesing. London: Academic Press, 2nd edn, 2014, 81–113.

[44] A De Paula Vieira, AM de Passillé and DM Weary. Effects of the early social environment on behavioral responses of dairy calves to novel events. Journal of Dairy Science 95 (2012), 5149–55.

(longstanding) stress has been correlated with poor weight gain or even weight loss. Animals kept in an inadequate environment may also display stereotypic behaviours, e.g. tongue rolling, bar-biting and non-nutritive sucking. Stereotypies are rarely, if ever, seen in cattle at pasture, suggesting that it is easier to meet the behavioural needs of cattle at pasture than indoors.

148. Cattle are naturally social animals. On most farms, the herd composition (i.e. the number, gender and age of animals) is controlled by the keeper and is usually based on practical management considerations. An animal separated from the herd will often display signs of stress. Within any herd, cattle quickly establish a hierarchy. In free-ranging herds, there are additional hierarchies within the different subgroups, e.g. adult females, juveniles and adult males. This hierarchy is often more apparent during certain situations and especially when the herd is confined. For example, a lower-ranking animal will usually choose not to feed or lie next to a higher-ranking animal. Similarly, a subordinate animal may be unwilling to enter a handling pen or exit a milking station when a more dominant animal is obstructing her path. In addition to this hierarchical structure, individuals will often choose a few others within the herd with whom to groom, graze, lie down or be milked. In a closed herd, these animals are often closely related to each other.

Choice

149. Cattle, like other domesticated species, have a wide range of personalities and preferences. Characterizing what they ‘want’ or ’need’ at an aggregated herd level overlooks the individual. Selective breeding has conferred genetic traits that confer advantages in certain environments and production systems (e.g. a thicker coat for cold, outdoor environments), and there is good evidence this extends to personality. Such traits are often recognized within different breeds, but there is usually at least as much variation within breeds as between breeds.

150. Animals also adapt non-genetically to new environments. This probably includes both physical and mental adaptation. It is highly likely that early life experiences greatly influence this via genetic expression (epigenetics), mental development (including behavioural adaptation) and physical development (e.g. thickening of coats).

151. Within an individual system, one of the ways in which the needs of individual animals may be addressed is by providing choice. Some existing farms allow cows to choose whether to go outside to graze or to come inside to shelter and access resources such as prepared ration. In these systems, some animals will choose to spend all their time either inside or outside, but the majority will divide their time between indoors and outdoors depending on preferences (e.g. for weather) and perceived physical and mental needs. On many farms, offering such choice may be difficult, and animals, like humans, do not always appear to choose their own long-term interests. Nevertheless, consideration should be given to introducing choice where possible to cater for individual as well as herd preferences.

The impact of change on cattle behaviour

152. If they are given sufficient adjustment opportunity, cattle are often able to adapt their behaviour to new situations. However, they can find a sudden alteration in either

social grouping or habitat very stressful. Transitions of this kind are considered a greater source of stress than large herd size, which may be inconsequential. The impact of any transition on both normal behaviour and welfare should therefore always be considered.

153. Younger animals reportedly tend to adapt more readily to new environments than older ones. Similarly, animals often appear less stressed if they are kept within a known group. Despite this proviso, transition is often aided if new animals are mixed with at least one 'trainer' animal who knows what to eat and where to go. However, if two groups are assimilated, the new group may segregate itself.[45] In these situations, the stockperson should ensure that all the animals remain mixed as this generally ensures that the newcomers will settle faster into their novel surroundings. It can also help to manage the change in stages, such as by introducing animals to foods they will encounter in their new location prior to their move, or providing familiar feed (e.g. conserved forage produced in their original habitat) in their new location, or combining smaller herds into a single larger herd prior to moving them to a new location or system.

154. In some systems, individuals are frequently moved between groups for management purposes. For example, dry cows and lactating cows have differing feed requirements. These changes inevitably affect group hierarchy. Although dominant animals reassert themselves within a few hours of joining a new group, repeated changes in group membership probably result in multiple stress incidents as the social status of each individual is established.

Behaviour of cattle in housed systems

155. Within indoor systems, cattle may be kept on a variety of substrates, which will affect their ability to express normal behaviour. These may be broadly divided into open cubicles and loose yards. In the former, rows of cubicles are arranged along a concrete passageway, with cows trained to lie in the cubicle with their tail hanging over the back of the cubicle and into the passageway. Adjacent cubicles are separated by dividers, while the substrate is either deep-bedded sand or a mattress or mat on a concrete base that has been dressed with a thin layer of bedding such as sawdust. This system was developed to increase stocking density, reduce substrate utilization, improve udder hygiene and ease waste management. In contrast, in loose yards, cattle may lie where they choose. Substrates vary greatly. Straw is traditional and most common but concrete slats, rubber matting and mill waste are also all used.

156. The European Food Standards Agency (EFSA) has examined behavioural problems in cattle kept in different housing systems and found that the risk estimates for behavioural problems were highest in cubicle housing.[46] In a cubicle, an animal should rise as if it were in an open space, smoothly and comfortably and without side lunging or reduced lunging speed. Historically, many cubicles have provided

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[45] KE Bøe and G Færevik. Grouping and social preferences in calves, heifers and cows. Applied Animal Behaviour Science 80 (2003), 175–90.
[46] The EFSA Journal 1139 (2009), 1–68.

insufficient space for rising, especially by large modern dairy breeds.[47] This need is recognized by some assurance schemes. For instance, RSPCA Assured standards require 0.7m space for forward lunging and bobbing.[48] However, BS5502 specifies minima of just 0.25–0.3m depending on cow size.[49] The material of the cubicle separators may also be important to allow the expression of normal rising and lying behaviour, with flexible rubberized separators now available that may permit rubbing and maximal movement while reducing the incidence of injury due to an animal becoming trapped, knocked or scraped. The exact shape and slope angle of the separator is an important factor in minimizing these risks.

157. There is some emerging evidence regarding preference for different bedding substrates in cubicle versus loose yard configurations. This suggests that cattle prefer larger open spaces, such as straw yards and pasture, to cubicles, even if this means choosing a lower-preference substrate to lie on. Cubicles provide bullying opportunities for dominant animals, which may hinder a subservient animal's entry and/or exit.

158. Loafing spaces are areas within housing that can be used for social interaction, expression of mating behaviour and limited exercise. However, there is still disagreement over what should be defined as loafing space, with many units considering busy feed areas and passageways as potential loafing, even though they do not provide opportunities for these normal and social behaviours. Exercise in housed areas is rarely considered for cattle, yet both young and adult cattle demonstrate running and bucking behaviours when provided with sufficient space and opportunity.

159. The expression of mating and exercise behaviour is also affected by the loafing area design, with slippery surfaces and low rooves impeding full expression.[50] Loafing areas are required by most assurance schemes, but are often permitted to include narrow feed areas and passageways, and may be difficult to audit. There has been a recent attempt to better characterize areas for the expression of normal behaviours. This acknowledges that wide, open feed areas and sometimes cubicle passageways can fulfil animal needs and may therefore be defined as 'living space'.[51]

160. Fully slatted systems for finishing beef cattle usually have high stocking rates, which are necessary to ensure that manure is trodden through the slats. While all animals are theoretically able to lie down at the same time and feed access is typically good, there are severe limitations on the expression of normal behaviour. These include difficulties in standing and lying transitions (due to low lunging space, slippery conditions underfoot and hard surfaces), lack of freedom to explore or exercise and inability to withdraw from dominant or aggressive conspecifics.

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[47] MJ Haskell, LJ Rennie, VA Bowell, MJ Bell and AB Lawrence. Housing system, milk production, and zero-grazing effects on lameness and leg injury in dairy cows. Journal of Dairy Science 89 (2006), 4259–66.
[48] RSPCA welfare standards for dairy cattle E5.9.1.
[49] BS5502, Part 40 (1990) on Building and Structures for Agriculture: Code of Practice for Design and Construction of Cattle Buildings.
[50] MG Diskin and JM Sreenan. Expression and detection of oestrus in cattle. Reproduction Nutrition Development 40 (2000), 281–91.
[51] JS Thompson, JN Huxley, CD Hudson, J Kaler, J Gibbons and MJ Green. Field survey to evaluate space allowances for dairy cows in Great Britain. Journal of Dairy Science 103 (2019), 3745–59.

161. For housed cattle, disbudding and dehorning are frequently employed to reduce injury risk to conspecifics, stockpersons and the animal itself, which may become trapped by its horns in cubicle separators or other barriers.

162. Where housed cattle are fed from raised troughs, they are unlikely to be able to adopt a natural grazing position (i.e. one foot placed forward to facilitate downward reach). Feeding housed cows at floor height may increase the weight on the front feet and predispose to lameness. Slightly raising the feed height (to 15cm above the floor) can compensate to some extent for these positional differences. However, it is not uncommon to see cattle fed from a significantly higher trough or feed table, especially as this has been recommended to reduce potential interaction with badgers as part of a bovine TB biosecurity programme. Cattle fed from close to ground level produce more saliva, making it easier to eat, and also demonstrate fewer abnormal behaviours, such as tossing feed.

163. In many highly productive dairy cow herds, feed constituent selection is actively discouraged. This is achieved by chopping forages, typically to 0.5–5 cm in length, to prevent animals sorting through feed. To reduce wastage, housed cattle are usually separated from feed by a barrier. Head yolks or dividers may be installed at the barrier to reduce fighting at the feed face. Insufficient barrier space for the number of animals in a group and/or poor cow flow around a building will increase aggression, with cows fighting to move around the building and access food.

164. Housed cattle have more non-feeding time and fewer behavioural choices compared with those kept outdoors. Environmental enrichment is therefore extremely important for the welfare of housed animals. The most widely used forms of physical enrichment are brushes, which cattle may rub on or stand against if automated. Brush points should be sufficiently widely spaced to allow use by submissive animals. Fresh straw is also an enrichment, as indicated by positive animal responses on delivery including investigation and interaction. A review has identified other forms of enrichment including wood logs, a scratching/rubbing walkway, hanging manila ropes, classical music, playback of natural sounds, indoor trees or plants, and building siting and design to allow views of surrounding fields.[52]

165. Cattle preferences are heavily influenced by prior experience. Adults that have never been outside demonstrate a preference for an indoor environment when first offered the choice. Moreover, grazing is also a learnt behaviour and can take several weeks to become fully established when cattle are first offered the opportunity. In cattle that are experienced in both indoor and outdoor environments, factors influencing choice between the two include the time of day, season and the location in which feed is normally provided.[53] During rainfall, preference for indoor housing increases.[54] When cattle display a preference for indoor housing during daytime, but for an outdoor

[52] R Mandel, HR Whay, E Klement and CJ Nicol. Environmental enrichment of dairy cows and calves in indoor housing. Journal of Dairy Science 99 (2015), 1695–1715.
[53] GL Charlton and SM Rutter. The behaviour of housed dairy cattle with and without pasture access: a review. Applied Animal Behaviour Science 192 (2017), 2–9.
[54] GL Charlton, SM Rutter, M East and LA Sinclair. Preference of dairy cows: indoor cubicle housing with access to a total mixed ration vs. access to pasture. Applied Animal Behaviour Science 130 (2011), 1–9.

environment at night, this may be because feed is provided during daytime indoors[55] and/or because cattle that have previously been housed are likely to display a learned preference for this system. Studies that have controlled for food availability and past experience suggest that cattle may prefer to be outdoors.[56] This is acknowledged by some farm assurance schemes, such as RSPCA Assured, which does not permit the year-round housing of dairy cattle.[57] For dairy cows, the distance from milking to pasture is an additional factor influencing preference.[58] When outdoors, cows probably prefer good-quality pasture over sand pack, partly due to the greater extent of pasture.[59]

166. Some retailer and industry assurance schemes have mandatory minimum grazing requirements (usually for a set number of hours per day and days per year) and do not permit the continuous housing of dairy cattle. Although these requirements may be well intended, they do not deliver or allow cow choice, and sometimes lead to animals being turned out in hot or inclement weather with limited quality or quantity of grazing.

Bulls

167. Legal public access rights and health and safety requirements can together make it difficult to keep bulls outdoors. In England and Wales it is illegal to keep dairy bulls of recognized breeds (Ayrshire, British Friesian, British Holstein, Dairy Shorthorn, Guernsey, Jersey and Kerry) in a field or enclosure crossed by a public right of way or restricted byway.[60] In such fields, beef bulls aged over 10 months must be accompanied by cows or heifers. In Scotland, under the Land Reform (Scotland) Act 2003 there is a general right to responsible public access, which makes it difficult to allow bulls to access outdoor space in accordance with HSE guidance.[61] Beef bulls can only be kept without females on areas that have infrequent public use, such as open fells and unenclosed moorland.

168. In the majority of beef herds, and in many dairy herds where artificial insemination is not used, the bull performs the essential role of impregnating cows. Some stockpersons, particularly those operating pasture-based systems, rely on vasectomized bulls for heat detection prior to artificial insemination. In many herds, however, bulls are only required for these purposes for a few weeks a year. This presents a challenge with respect to safe management and pasture access at other times.

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[55] Survey of previous studies in G Arnott, C Ferris and N O'Connell . A comparison of confinement and pasture systems for dairy cows: what does the science say? AgriSearch Report, 2015, at https://pure.qub.ac.uk/portal/files/127810644/Arnott_et_al._2015a.pdf.
[56] MAG von Keyserlingk, AA Cestari, B Franks, JA Fregonesi and DM Weary. Dairy cows value access to pasture as highly as fresh feed. Scientific Reports (2017) 7, 44953.
[57] RSPCA welfare standards for dairy cattle E2.3.
[58] PR Motupalli, LA Sinclair, GL Charlton, ECL Bleach and SM Rutter. Pasture access increases dairy cow milk yield but preference for pasture is not affected by herbage allowance. Journal of Animal Science 92 (2014), 5175–84.
[59] AC Smid, DM Weary, JHC Costa and MAG von Keyserlingk. Dairy cow preference for different types of outdoor access. Journal of Dairy Science 101 (2018), 1448–55.
[60] Wildlife and Countryside Act 1981, 59. The list of recognized breeds may be updated by the Secretary of State.
[61] Health and Safety Executive, Cattle and public access in Scotland: advice for farmers, landowners and other livestock keepers (2012), at https://www.hse.gov.uk/pubns/ais17s.pdf.

169. Many bulls spend a significant proportion of their lives in small single pens, in conditions that are likely to greatly compromise their ability to express normal behaviour. This confinement is primarily driven by health and safety concerns for stockpersons and the public. It is highly questionable whether bulls kept in these conditions can be considered to have a life worth living.

170. Housed breeding bulls may be able to express normal behaviour through social interactions, play and exercise if left to run with the herd. If in proximity to cows in oestrus but separated from them by fencing, bulls are likely to experience frustration. Although all bulls should be regarded with extreme caution (even when being playful, they can easily injure humans), how bulls are bred, handled, trained and identified can help reduce the risks of having them run with the rest of the herd.

Behaviour of cattle in outdoor systems

171. Compared to research on cattle behaviour in housed conditions, continual detailed observation of stock in an outdoor system is more challenging. Published research therefore tends to rely on monitoring behaviour at intervals during the day. More recent use of GPS tracking collars provides information about how cattle move around a site. This technology is not currently able to provide details of what animals are doing, although this can sometimes be surmised.

172. Animals that have spent much of their life in an outdoor system and have rarely been gathered may become highly stressed and agitated when gathered. This can result in refusal to be gathered, milling within the group and aggression between animals. Distress can usually be mitigated by a combination of good stockmanship, knowledge of herd dynamics (i.e. interactions and hierarchy within the group), well-designed handling systems and training stock to accept confinement for short time periods.

Behaviour of cattle in low-density grazing systems

173. Free ranging cattle tend to move around as groups of cows and calves. Space between animals is influenced by several factors including the abundance, condition and nutrient value of grazing, herd dynamics and whether the herd feels threatened. Animals may bunch together when investigating something or someone (e.g. a rambler). Large groups (over 100 cows) often subdivide into smaller matriarchal groups when grazing. Cows in smaller groups often display increased vigilance, depending on previous experience and innate temperament.

174. Cattle orientate their bodies to minimize the effects of adverse weather. In cold temperatures, they position themselves perpendicular to the sun's rays to maximize the warmth on their bodies. In cold wind and rain, they stand or graze with their hindquarters to the wind to protect their faces. Cattle are reluctant to lie on wet grass: if rain starts when they are already lying, they may not move, but if they are standing, they will often seek shelter rather than lie down. Depending on their degree of hunger, they may stop grazing in heavy rain, especially if shelter is available. If flies are a problem, cattle often prefer to rest in windy locations during the day (assuming it is not so hot that they seek shade).

175. How stock use a site depends on their previous experience and knowledge of it. If the stock know the habitat and the stockperson knows their cattle, it is often possible to predict where they will be located based on the season, weather and time of day. For example, in winter, if they are given supplementary feed, they may congregate near the feeding point or be waiting at the gate for the stockperson to arrive. In hot, wet or windy weather they are likely to seek shelter, while in drought conditions they often remain near a water source. If allowed into wooded areas, they may choose specific trees with appropriately shaped branches as scratching posts. Cattle usually choose to follow each other along the same track. In wet conditions this can result in significant poaching of the ground with resultant leg and belly dirt and mud accumulation ('lagging').

176. If there is insufficient space for the whole group to shelter, eat or drink, crowding may bring an increased disease transmission risk. Subordinate animals may be unwilling to stand near dominant animals and so experience lower welfare than other herd members.

177. Cattle graze a variety of plants including grasses, forbs and legumes. As long as there is sufficient grazing, cattle will choose not to graze next to a fresh cattle dung patch. If given access to trees and hedgerows, up to 12% of their diet may consist of browse. The choice and diversity of forage within the diet depends on learning from both copying others in the herd (especially the dam) and previous individual experience. For example, cattle that have grown up solely on a diet of rye grass, clover and supplementary grain-based feeds may not have learnt to eat other plant types. Such animals may struggle to maintain body condition if outwintered on marginal ground. The avoidance of some poisonous plants may be learned.

Behaviour of cattle in multi-paddock grazing systems

178. Most academic studies on MPG systems have focused on vegetation management, soil health and animal production. Few scientific publications have considered animal behaviour patterns in these systems.

179. MPG management aims to manipulate stocking density (i.e. number of animals within a paddock) and the time period during which plants are exposed to livestock. These systems often use electric fencing to contain stock that are moved between small paddocks at high frequencies. Experienced practitioners carefully monitor the ecology, available vegetation, animal impact (grazing, dunging, urinating and trampling), plant recovery times and weather. In response to these observations they frequently modify the various parameters: paddock size, animal density and duration within a paddock. These modifications may happen on almost every paddock move. In addition, practitioners also tend to keep only stock that are suited to this system. This highly adaptive and flexible approach is often hard to replicate within standardized scientific trials and this may partially explain the discrepancies observed between the limited experimental evidence currently available and the anecdotal experience of practitioners.

180. Some experimental trials have shown that frequent movements between fenced areas can cause agitation and stress as well as reduced ability to select palatable forage. This may depend on the frequency of movement, stocking density and prior experience of grazing within this type of system. Although in the UK there is

a lack of direct experience, it has been suggested that MPG variants using slightly larger paddocks (e.g. holistic planned grazing) may cause less agitation than high- or ultra-high-density grazing. As animals adapt to this form of grazing, they appear to become less stressed and the amount of aggression between animals decreases. It is reported that animals learn to gauge stockperson actions, predict when a move will happen and appear to 'relish' the frequent fresh grazing.

Calf and cow–calf behaviour

181. Calf behaviour and cow–calf interactions in beef suckler herds kept in extensive grazing systems are similar to those of wild and feral relatives. Before giving birth, the cow usually leaves the herd. Once the calf is born, the cow licks it intensively while both cow and calf start softly vocalizing to each other. Within the first hour, the calf usually stands, and teat-seeking behaviour follows. After suckling, the new-born will sleep. Initially the cow stands over or lies next to the calf, but then moves away to graze. During the first few days of life, the cow usually leaves the calf lying in a secluded area, returning for suckling 8–12 times daily. During this period, even when the cow is some distance from the calf, she is very aware of its location and if needed will return to protect it. After this initial period the cow and calf return to the herd.

182. During the second week of life the calf starts to move away from its dam and interact with peers. The herd often shows creche behaviour, with the calves lying in a group watched over by a single adult. This may be a cow with a calf of her own but may also be a cow that has lost her calf or an older adolescent. In some herds the bull seems to take this role. Calves are playful and inquisitive. They spend time with their peer group and older herd members, learning social and habitat dynamics. They begin to graze and ruminate around three weeks of age and start to graze regularly at between three and six months of age.

Dairy

183. The cattle welfare Codes state that calves must be left with their dam for at least 12 hours and preferably 24 hours after birth. Earlier removal may only be done for disease control purposes under the advice of a veterinary surgeon and the protocol must be recorded.[62]

184. Research and practitioner experience have shown that early separation (within 24 hours of birth) reduces the acute distress responses of cows and calves, while extended cow–calf contact may aggravate this acute distress. Relatively few studies have addressed whether this early separation has a longer-term effect on calf behaviour and growth, but some indicate that prolonging the period during which the calf remains with the dam may have positive effects on long term behavioural indicators.[63] However, it is not possible to draw firm conclusions because the results across these longer-term studies are inconsistent.

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[62] Codes of Recommendations for the Welfare of Livestock: Cattle for England (2003), 103-4; Wales (2010), 119-20; and Scotland (2012), 103-4.

[63] JF Johnsen, KA Zipp, T Kälber, AM de Passillé, U Knierim, K Barth and CM Mejdell. Is rearing calves with the dam a feasible option for dairy farms? – Current and future research. Applied Animal Behaviour Science 181 (2016), 1–11.

185. Although most separation research has focused on the calf, some has assessed the effect on the dam. For example, one study showed that cows increase their use of automated brushes for up to four weeks after calf removal.[64] It has also been reported that cattle from some dairy herds are slower to lick their calves after birth than beef cows. Some farmers are breeding for characteristics such as increased milk yield, which they report have the consequence of reducing maternal instinct, with manifestations including increased calf abandonment and treading.

186. Research indicates that calves raised in isolation have deficient social skills, are more fearful and have difficulty coping with novel situations.[65] They may also have poorer learning abilities than those reared in groups. All these factors may reduce an animal's ability to adjust to a variety of potential stress factors later in life. In the UK, isolating calves is illegal except in case of illness.[66] Calves must have sight and touch of another calf, but up until eight weeks this may be through contact between adjacent pens rather than in paired or group housing. Some assurance schemes require paired or group housing.

187. Given the opportunity, dairy calves begin interacting with other calves as early as two days after birth. Young dairy calves housed in groups prefer a known peer to an unfamiliar calf, indicating early specific social connections. They also vocalize less when put into a novel area with familiar calves. However, in a group of calves of different ages, younger calves may be bullied by older calves and denied milk and feed access.

188. A few UK farms now rear calves with either their own dam or a foster dam. Many of these are very small 'micro-dairies' processing raw milk, although one has over a hundred animals. Keeping calves with a dam enables them to develop a natural bond with an adult and may also support herd social structure. Transitioning into this practice may take as long as three years and has in some cases been found very challenging. Cows unwilling to share their milk into production are likely to be removed from the herd and either placed into a different system or slaughtered.

189. In fostering, 2–4 calves are kept together and suckle one cow. Fostering allows calves to be with adult cows and perform natural suckling behaviour. Difficulties may occur if a cow does not accept or bond with one or more of the calves. Although there is a lack of recent research into this issue, this may result in highly variable weight gain among suckled foster calves, especially if a cow's own calf remains with her.[67] Difficulties may be reduced by selecting an appropriate breed, fostering on calving and human control of suckling (e.g. order of calf arrival and calf positioning). There may be benefits for cow udder health. The additional milk demand resulting from fostering

[64] R Mandel and CJ Nicol. Re-direction of maternal behaviour in dairy cows. Applied Animal Behaviour Science 195 (2017), 24–31.

[65] JHC Costa, MAG von Keyserlingk and DM Weary. Effects of group housing of dairy calves on behavior, cognition, performance and health. Journal of Dairy Science 99 (2016), 2453–67.

[66] Schedule 6, paragraph 1 of The Welfare of Farmed Animals Regulations 2007 (both England and Wales) and 2010 (Scotland).

[67] M Petit, JP Garel, P Le Neindre, P Maronne. Allaitement de deux veaux par des vaches de race Salers. I. – Productions comparées de vaches allaitant 1 ou 2 veaux. Annales de zootechnie 27 (1978), 533–51; P Le Neindre, M Petit, JP Garel, P Maronne. Allaitement de deux veaux par des vaches de race Salers. II. – Étude de l'adoption. Annales de zootechnie 27 (1978), 553–69.

stimulates milk production. Reduced average milk consumption per calf may be offset by artificial milk feeding, increased grazing or ration provision as appropriate.

190. Keeping cows and calves together requires dairy farmers to adapt their practice and the cows to accept the change. Some farmers find they need to wait until calves reared this way enter the milking herd before the practice becomes successful. In the UK, the practice is still in its infancy. There has been little research into welfare benefits or costs, management or production as well as economic viability. Converting existing systems and facilities to accommodate the practice without risking malnutrition, disease or injury to calf or cow may be challenging and should only be undertaken following careful consideration and consultation and with veterinary oversight.

191. The diversity of practice in other European countries might aid reflection on any potential future developments in the UK.[68] This includes

- free contact (cow and calf have unrestricted access to each other)
- half-day contact (cow and calf are housed together during the day or night)
- restricted suckling (cow and calf have brief daily contact for nursing)
- fostering (one cow nurses 2–4 calves usually without milking)

In free contact and half-day contact systems the calf consumes a large milk volume and has high daily weight gains, whereas restricted suckling may require additional milk feeds to achieve comparable gains. Cows and calves may sometimes be separated before 13 weeks, which is likely to be distressing for both, although separation may be easier following half-day contact.

Multi-Paddock Grazing (MPG)

192. There is little published research on whether MPG systems effect calf and cow–calf behaviour. Practitioners often enlarge paddocks, such as by not moving the back fence until the cow-calf pairs have re-joined the herd. Alternatively, the calves choose to slip under the front fence to hide in the long pasture grass that is ahead of the current grazing paddock. Calves appear to learn the routine of regular paddock moves quickly.

Weaning

193. Weaning is usually stressful for both cow and calf. The underlying cause is probably multifactorial and may include loss of nutritional support (milk) for younger animals, loss of the short-term suppression of the cortisol response to mental stress that suckling provides, disruption of the social bond between dam and calf, and increased social stress as calves seek to establish their position in the herd hierarchy.

194. The Defra Code of Recommendations for the Welfare of Livestock: Cattle (2003) and the Scottish Government Code of Practice (2012) recommend weaning suckled beef calves at 6–9 months old, although 'earlier weaning is acceptable for suckler calves where the cow's health or body condition is poor'. The Welsh

[68] JF Johnsen, KA Zipp, T Kälber, AM de Passillé, U Knierim, K Barth and CM Mejdell. Is rearing calves with the dam a feasible option for dairy farms? Current and future research. Applied Animal Behaviour Science 181 (2016), 1–11.

Government Code of Practice (2010) recommends weaning at 5–9 months, with a similar proviso. A few UK farms keep beef suckler calves with their dam until they are 9–10 months old. At this stage, if the stockperson places a ‘calf sorting gate’ (which calves, but not adults, may walk under) between two adjacent fields, the calves will often move as a peer group into the second field and the stockperson may then fully close the gateway. This lowers the stress of the weaning process, which is otherwise done through a handling system.

195. In contrast, additional procedures performed at weaning may exacerbate calf stress. These may include vaccinations and/or anthelmintic treatments, disbudding, castration, transportation to another site or immediate sale. They may also further undermine the calf’s immune system, resulting in an increased incidence of disease (e.g. bovine respiratory disease). Delaying sale until several weeks after weaning may help reduce BRD incidence in calves.[69]

196. Traditionally, weaning was performed by abrupt separation with no further contact between dam and calf. Alternative strategies to reduce stress include fence-line weaning and/or anti-suckle nose flaps. In fence-line weaning, calves are weaned, but then cow and calf are kept in adjacent fields, allowing auditory, visual and tactile contact between the pair through the fence. If an anti-suckle device is used, a plastic nose flap is inserted into the calf’s nostrils and impedes suckling. However, the calf remains with the cow for several more days before separation, which can then be abrupt or fence-line.

197. There are conflicting conclusions about which methods are most likely to minimize stress at weaning. This may be because different studies have used different weaning ages or different criteria to indicate stress, including pacing, vocalization, altered eating and drinking patterns, poor weight gain, increased heart rate and altered stress biomarkers (e.g. cortisol). In addition, because many studies have only monitored small groups the behaviour of individuals may have skewed results. Alternatively, there may have been inadequate nutritional support or subjective ‘observer’ bias. However, even with the same methodology, outcomes have been different across different locations or variable over time. This suggests that factors outside of the weaning process affect cow and calf stress levels. These might include unrecognized stressful incidents during calf rearing, e.g. stockperson attitude, nutritional availability, nutritional state or weather patterns.

198. Little research has been done on the behavioural effect of weaning on the cow itself. However, practitioners notice that, after weaning, some individuals are more distressed and/or have lower performance than others.

14. Ethical considerations

199. The systems on which this Opinion focuses represent extremes. Nevertheless, many farmers who operate year-round grazing, and many who run continuous

[69] DL Step, CR Krehbiel, HA DePra, JJ Cranston, RW Fulton, JG Kirkpatrick, DR Gill, ME Payton, MA Montelongo and AW Confer. Effects of commingling beef calves from different sources and weaning protocols during a forty-two-day receiving period on performance and bovine respiratory disease. Journal of Animal Science 86 (2008), 3146–58.

housing, believe that each system fully meets animal needs by minimizing negative welfare states and delivering positive freedoms. At their best, both types of system have the potential to deliver high welfare to appropriate cattle types and breeds.

200. Within dairy systems, there is a trend towards increased electronic data gathering. For example, milking robots analyse the chemical composition of an individual cow's milk, which indicates health issues that visual observation may miss or take longer to identify. Nevertheless, some simple welfare issues, such as dominant animals impeding access to milking robots, are likely to be more rapidly identified by a stockperson who is physically present.

201. Linked with electronic data gathering is automated management. For instance, within a dairy system, individuals could be permitted access to robotic milking up to five times a day, and within a dairy or beef system, pasture rotation could be remotely managed, with animals being granted self-access through appropriate gates and tracks. However, ongoing stockperson availability is essential to ensure that non-standard situations and emergencies, such as animals becoming trapped or slipping, may be dealt with immediately. Moreover, identifying and treating lameness is a complex matter that requires an experienced stockperson. Even in a highly automated environment, welfare remains a human responsibility.

202. Stockperson observation and timely intervention are also important in year-round grazed beef herds, which may not be checked at intervals sufficient to avoid suffering. For management reasons, both beef and dairy outdoor systems may require a tight calving season, with cows that are slow to calve being removed from the herd. They may be culled or assimilated into other herds, which could create biosecurity and/or behavioural (e.g. bullying) problems.

203. The welfare implications of some aspects of developing automated management technologies pose ethical questions. The use of electric shocks in milking robots (to make an animal exit the facility) and via collars (to delimit its range by creating a virtual 'fence') are areas of significant concern.

204. Bovines tend to be viewed at the herd level or the individual level. Given the widespread practice of separating calves from their young very soon after birth, the intermediate family group level may require more attention. Keeping calves with the cow until weaning enables cows to express mothering behaviour, potentially provides calves with a high degree of nourishment and care, which result in increased growth rates, and allows calf socialization, including into milking. Although the practice has been significantly adopted in some other European countries, in the UK it is exceptional, and in any case requires extremely careful management. In dairy systems most cows with their calf at foot are willing to share their milk into production, but those that do not are culled or placed into another herd. This may create biosecurity problems, as suckling is sometimes a disease vector due to faecal contamination of teats, or of colostrum and milk, or behavioural problems. In situations where disease control is needed a degree of physical separation may be justifiable for a fixed period, although cows and calves may still be able to be reared near one another. In this situation efforts should be made to combat disease at source, such as by developing a closed herd.

205. As in human populations, normal behaviour is likely to vary somewhat between individuals. It may ultimately be the case that, given the choice, some animals will opt for year-round outdoor grazing while others will prefer continuous housing. Preference testing is complicated by the fact that behaviour is learned over time, with present preference shaped by experience.

15. Economics

206. The cattle sector is a large part of UK livestock. In June 2019 there were approximately 10 million cattle and calves, including 1.9 million dairy cows and 1.5 million beef cows. The overall value of the sector was £7.2bn (almost half total livestock output), with milk production the largest contributor (£4.4bn).[70]

207. Farm income performance is influenced by production, input costs and commodity prices, which in turn are affected by weather, exchange rates, fuel price and global supply. Hence UK income is highly variable and volatile from year to year. It differs from farm to farm depending on how well a farmer manages their business and on external economic factors.

208. Beef farms have been highly dependent on the direct payments received under the Common Agricultural Policy, which have provided over 90% of average farm income for grazing livestock (LFA and lowland grazing). In contrast, dairy farms have relied less on direct support (38% of average farm business).[71]

209. The financial performance of beef and dairy farms, measured as average farm business income or gross margin including direct payments (subsidies), varies significantly regardless of the housing system. In 2018/19, average farm income was £79,700 for a dairy farm, £12,500 for a lowland beef grazing farm and £15,500 for a Less Favoured Area beef grazing farm.[72] The gross margin for the top quartile of all suckler herds in England in 2017/18 was 3.5 times higher (at £441 per cow to bull) than for the bottom quartile (£125 per cow to bull). The gross margin for the top quartile of all finishing beef was £452 per head output compared with only £167 per head for the bottom quartile.[73]

210. These differences are mainly due to the high variability of both fixed costs (e.g. labour) and variable costs (e.g. feeding and forage) per animal across farms. For example, total variable costs, the main component of which is feed and forage, were twice as high for the bottom quartile of all suckler herds in England in 2017/18 as for the top quartile. Similarly, paid labour, which is the largest component of fixed costs, was almost three times as high for farms in the bottom quartile of beef finishing farms, as for those in the top quartile.

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[70] Agriculture in the United Kingdom, 2019. Defra.

[71] Defra. Moving away from Direct Payments Agriculture Bill: Analysis of the impacts of removing Direct Payments, September 2018.

[72] Defra, Farm Business Income by type of farm in England, 2018/19. FBI is defined as the financial return to all unpaid labour (farmers and spouses, non-principal partners and directors and their spouses and family workers) on their capital invested in the farm business, including land and buildings.

[73] AHDB Beef and Lamb Farmbench, Cost of production 2017/2018, at https://ahdb.org.uk/farmbench.

211. Evidence regarding the exact costs and benefits of the production (housing and grazing) systems addressed in this Opinion are not readily available. Although indoor, large and high-output farms are separate categories, indoor farms tend to have a greater number of animals and produce more.[74] However, there is the perception that any well-managed system, indoor or outdoor, can be profitable.

212. An empirical study of the economic performance of different grazing systems (full, restricted and zero) in the Netherlands showed that farms with large production volumes (more than 600,000 kg milk/year) that used full grazing recorded on average a higher net income per annual work unit than large farms that applied restricted or zero-grazing.[75] This effect was not observed across small farms. However, there was no significant difference between the gross margin (expressed as €/cow or €/100 kg milk) within large or small farms. The difference in economic performance may therefore not be due to the grazing system, as both grazing and non-grazing can result in high or low income.

213. There is some evidence that producing beef using 100% pasture and forage crops is profitable. Pasture for Life beef finishers achieved both a positive gross margin and a positive net margin.[76] However, the study sample size is too small to draw general conclusions, so caution is required in reaching conclusions.

214. An outdoor pasture-based system also depends on the weather and soil type and conditions, with farmers having less control on production volume. As discussed earlier in this Opinion, challenging weather conditions (e.g. excessive heat or cold, high rainfall) and poor soil contribute to an increase in farm costs, affect animal yield and profit per cow and per hectare.[77] Outwintering herds usually require less infrastructure (e.g. fewer barns, no slurry storage requirement) than seasonally or continuously housed herds. In addition, there are minimal bedding costs and supplementary winter feed costs tend to be lower. New entrants to farming may therefore perceive this as a financially viable start-up option.

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[74] MD March, MJ Haskell, MGG Chagunda, FM Langford and DJ Roberts. Current trends in British dairy management regimens. Journal of Dairy Science 97 (2014), 7985–94.

[75] JW Reijs, CHG Daatselaar, JFM Helming, J Jager and ACG Beldman. Grazing dairy cows in north-west Europe: economic farm performance and future developments with emphasis on the Dutch situation, LEI Report 2013-001, Project code 2275000595, LEI Wageningen UR, The Hague, 2013. In this report the following definitions were used: Full grazing: day and night grazing of milking cows for >70% of time in summer months (May–October); Extended grazing: milking cows graze >28% of time in summer months but do not fulfil the criteria of full grazing; Restricted grazing: milking cows graze 5–28% of time in summer months. No grazing: milking cows graze <5% of the time in summer months.

[76] Pasture for Life Association. It can be done: the farm business case for feeding ruminants just on pasture (2016).

[77] JW Reijs et al. Grazing dairy cows; A-C Dalcq, Y Beckers, P Mayeres and E Reding. The feeding system impacts relationships between calving intervals and economic results of dairy farms. Animal 12 (2019), 1662–71.

16. Conclusions

215. When well-managed, both pasture-fed and continuously housed systems bring welfare benefits. Grazing may offer many opportunities to express normal behaviours and access to abundant diverse pasture, which promotes ruminal and overall health. Continuous housing may enable close monitoring of food and water intake and high biosecurity. However, even when well-managed, each system also has potential weaknesses. For example, grazing brings increased biosecurity risks from faecal contamination of pasture. Continuous housing may inhibit normal behaviour and within restricted indoor environments there is an increased risk of bullying by dominant animals.

216. Well-designed continuous housing may provide natural light, abundant natural ventilation, views of fields and landscape, sounds and smells from nature and walking surfaces as good or better than those available outdoors in particular localities. In all systems, housed animals need opportunities to express normal behaviour and experience a range of normal stimuli. In areas with high rainfall and ground at high risk of poaching, continuous housing is likely to provide a better option than year-round grazing, which, although offering more opportunities to express normal behaviour, is unlikely to be able to deliver the more basic freedoms in all UK climates and topographies. In these situations, a traditional system may combine the strengths of housing and grazing according to season.

217. Different cattle types are appropriate to different systems. If a system is effectively implemented and managed, welfare advantages may be maximized and disadvantages minimized.

218. Very few animals spend their whole life in one system. Continuous housing and zero-grazing certainly represent a small minority of total production. Nevertheless, it is difficult to obtain current data indicating the scale of continuously housed beef systems and the extent and geographical distribution of outdoor beef finishing corrals.

219. Cattle typically find a sudden switch in their social grouping or habitat very stressful but are often able to adapt their behaviour to new situations if given adjustment opportunities. These might include staged changes in management or habitat or keeping two or more animals that know each other together.

220. Outdoor production does not necessarily entail extensivity or high welfare. Outdoor dairy systems and beef finishing corrals make intensive demands on animals, providing a high level of inputs with the aim of maximizing productivity. Public concern with corrals may increase.

221. Although cattle are herd animals, welfare requires a focus on the individual. Individuals have their own personalities and may not easily conform to all herd management practices.

222. Good stockmanship is vital to the success of any system. Technology may support this by informing human decision-making and prompting early interventions but cannot replace it.

223. Use of new technologies is greatest in large continuously housed systems, where the welfare of numerous animals depends on its correct use by an individual or small team. This entails a high level of responsibility. In contrast, extensive outdoor systems may use little technology. Nevertheless, for grazed cattle, pasture quality and disease risks require careful professional management. Precision grazing technology analyses pasture depth and composition and provides the ability to control these better.

224. Milking robots are becoming more common and may include an electric 'tickler' to encourage an animal to exit. Delegating to machines the decision to apply an electric shock to an animal is a serious development that requires ethical reflection. Regulations state that any bovine touched by an electric goad should be able to move forward, but the exit from milking robots is sometimes blocked by a dominant animal. This suggests that, unless there is direct human supervision of the parlour, the use of milking robots capable of administering an electric shock to encourage an animal to exit contravenes regulations.

225. Within grazing systems, the use of electric shocks to control animals is also increasing, with 'invisible fencing' to contain animals now developing from fixed buried lines to GPS technology. The protection that this technology may offer from hazards (e.g. transport infrastructure, steep drops) brings welfare benefits providing it functions reliably. Very shortly, similar GPS technology is likely to be in use in the UK to manage rotational grazing. The managed feeding this allows also brings welfare benefits, and the risks posed to animals if the technology malfunctions are lower than in containment situations. Nevertheless, the lack of visible markers of the grazing limits may negatively affect the mental wellbeing of animals. In any case, allowing an algorithm to determine when an animal should receive an electric shock for containment or feeding management purposes also requires ethical reflection.

226. Animals in year-round grazing systems require protection from sun, extreme temperatures, wind and rain. As a result of climate change, their need for this is likely to become greater. In some weather conditions, animals need to be moved. Purpose-built shelters will increasingly be required in some settings.

227. Disbudding and dehorning are less likely to be needed in year-round grazing systems due to the absence of physical hazards.

228. Calves require shelter, a comfortable ambient temperature and the company of other calves. They should only be confined within an individual stall in exceptional circumstances, such as when showing clinical signs of an infectious condition (e.g. neonatal diarrhoea), if no similarly aged calf (e.g. up to two weeks older or younger) is available for pairing, or if aggressive navel suckling, which is likely to compromise welfare, is observed.

229. The legal definition of a calf as a bovine animal aged up to six months old[78] does not reflect how cattle are now kept.

[78] EU Council Directive 2008/119/EC article 2.1.

230. Farmers need to give proper attention to bull housing, welfare and access to conspecifics. Public right of way and roaming access to fields and open land where cattle are reared limits their availability to dairy bulls in particular.

231. Climate change may be accentuating regional climate differences. Parts of the UK may be especially vulnerable to more warm and wet weather in future, reducing the suitability of land for grazing due to increased mud, poaching and infectious disease risk. Alterations that aim to reduce GHG emissions, including breeding strategies and production intensification, may have unintended consequences for cattle health and welfare.

232. GHG reduction initiatives may encourage earlier finishing of beef animals and slaughter at less than twelve months. Legislation currently requires that meat from animals slaughtered aged twelve months or less be marketed as veal rather than as beef.[79]

233. New or refurbished facilities require significant investment. Older buildings may be unable to meet current welfare standards or to accommodate current herd numbers or body sizes. To guard against unintended negative consequences, transitions require careful planning and monitoring. In extensive systems, high-quality cow tracks are essential for welfare and reducing rates of lameness and require significant financial outlay. Resourcing improvements can be difficult.

[79] EU Regulation 1308/2013, Establishing a Common Organisation of the Markets in Agricultural Products, annex 7, part 1.

17. Recommendations

234. The Codes of Recommendations for the Welfare of Livestock: Cattle for England (2003), Wales (2010) and Scotland (2012) should be updated as soon as possible and every five years thereafter. Subsequently, whenever there is a significant new change in regulation or knowledge, updates should be made.

235. Governments should work with the British Standards Institution to update BS5502, Part 40 (1990) on Building and Structures for Agriculture: Code of Practice for Design and Construction of Cattle Buildings, including minimum space allowances and requirements for lunging space. This Standard should be subject to regular review.

236. To improve welfare in cattle systems that include housing, Governments should legislate to phase out fully slatted cattle accommodation and issue clear guidance on how hard surfaces should be modified to prevent animal injury.

237. Governments should legislate to phase out tie stalls and all other tethering of cattle for extended periods, whether indoors or outdoors, with tethering only permitted for specified purposes such as handling, artificial insemination, TB testing and other veterinary procedures. In the shorter term, farm assurance schemes should consider excluding farms that tie or tether cattle either continuously, or for most of a 24-hour period, from their membership.

238. The definitions of technologies that apply an electric shock to animals (including goads, ticklers/trainers, motorised gates, motorised fences and collars) should be legally clarified.

239. The use of electronic ticklers/trainers in milking robots and parlours should be reviewed by Governments.

240. Existing welfare outcome measures for beef cattle should be adopted by all farm assurance schemes, and by retailers and food businesses. They should promote whole-life assurance from calving to slaughter, with the levy bodies facilitated by Governments developing accessible identification and tracking services.

241. All stockpersons, including conservation graziers, need to understand and be trained in welfare, which now includes engagement with relevant emerging indoor and outdoor technologies.

242. Environmental stewardship schemes that use cattle need to address their welfare at planning, funding selection and review, by drawing on expert advice.

243. The welfare aspects of environmental stewardship schemes that use cattle, including stockperson availability, competence in handling ill or injured animals, and risks posed by terrain and habitat, require capable ongoing management.

244. The Agricultural Census should gather data about the farming systems and types of housing that animals are kept in.

245. Within multi-paddock grazing systems that are being developed and justified on production grounds, welfare implications should be given full consideration.

246. The legal requirement imposed by schedule 1, paragraph 4 and schedule 7, paragraph 1 of The Welfare of Farmed Animals Regulations 2007 (both England and Wales) and 2010 (Scotland) that within indoor cubicle accommodation there must be enough cubicles for all cattle and lactating cows in the building to be able to lie down at all times (i.e. at least one cubicle per animal) should be clarified, disseminated and enforced.

247. Farm assurance schemes should require that within indoor cubicle accommodation a minimum of 5% more cubicles than animals be provided.

248. The legal requirement imposed by section 4(2) and schedule 1, paragraph 29 of The Welfare of Farmed Animals Regulations 2007 (both England and Wales) and 2010 (Scotland) that only breeds with appropriate physical and behavioural characteristics may be farmed within a particular system should be clarified, disseminated and enforced.

249. Farm assurance schemes and the cattle welfare Codes should require that calf hutches be sited (or re-sited throughout the year) in a position that allows calves to be kept largely within their thermoneutral zone, e.g. within shade during summer and in a sheltered, draught-free area in winter.

250. Schedule 6, paragraph 1(1) of The Welfare of Farmed Animals Regulations 2007 (both England and Wales) and 2010 (Scotland) should be amended to reduce the maximum age at which a calf may be routinely confined within an individual stall from eight weeks to one week.

251. Bull pens designed for a single animal should be phased out. Farm assurance schemes and the cattle welfare Codes should require that individual bulls are not kept or managed in small ‘bull pens’ separate from other cattle but with other animals in suitable, safe indoor and outdoor accommodation through the year.

252. Farm assurance schemes and the cattle welfare Codes should promote the principle that animals are free to choose where to lie at any time.

253. Five years following FAWC’s 2015 Opinion on the welfare implications of nutritional management strategies for artificially-reared calves from birth to weaning, feed manufacturers, advertisers and farmers still need to understand better that calf welfare requires several feeds spaced through each 24-hour period.

254. The legal requirement imposed by schedule 6, paragraph 12(1) of The Welfare of Farmed Animals Regulations 2007 (both England and Wales) and 2010 (Scotland) that calves must be fed at least twice a day should be tightened by including a maximum time (e.g. 16 hours) between feeds.

255. Where needed to reduce injury risks and improve comfort, buildings should be altered such as by grooving concrete and other hard surfaces.

256. To safeguard animal welfare, the algorithms and decisions of electronic monitoring systems should be developed in consultation with welfare professionals (e.g. veterinary surgeons).

257. Wider dissemination and knowledge are needed of The Control Of Worms Sustainably documents ‘Control of lungworm in cattle’ and ‘Control of roundworms in cattle’ (both January 2020) and ‘Integrated parasite control on cattle farms’ (May 2020) among farmers, vets and herd health specialists.

258. Farm assurance schemes should develop an appropriate focus on buildings by encouraging and supporting farmers in planning and identifying grants or loans to fund, where needed, the adaptation or decommissioning of buildings that cannot deliver high animal welfare and the construction of new buildings able to support high welfare.

259. Governments should issue new guidance to local authorities requiring them to take animal welfare needs into account when reaching planning decisions, balancing these with environmental considerations regarding the height, size and orientation of farm buildings in which animals are housed.

260. The behavioural and welfare implications of transferring a bovine animal or group of animals between systems, farms or groups should be carefully considered before any such transfer occurs, and transfers should in general be minimized. Farm assurance schemes should continue to encourage careful consideration of this by farmers.

261. Where increased public access to the countryside is encouraged through legislation or in other ways, possible unintended negative consequences for animal welfare (e.g. restrictions on bulls) need to be considered and mitigated, including in the Countryside Codes and other official guidance.

262. The definition of a farmed animal in section 3(2) of The Welfare of Farmed Animals Regulations 2007 (both England and Wales) and 2010 (Scotland) should be revised so that animals used for ecological and/or land management are explicitly included.

263. The Environment Bills should clarify the duty of care that humans have for animals used in rewilding schemes.

264. Imported beef and dairy products should be from animals that have been farmed in conditions that meet UK welfare standards.

Research gaps

265. Electronic collars used for containment purposes (invisible fencing) in grazing systems require a British Standard and oversight, following more research on their welfare implications.

266. For both dairy and beef cattle, research is needed to inform the further development of welfare outcome measures that allow statistically robust appraisal.

267. More research is needed on the need to disbud or dehorn year-round grazed cattle, including on the implications for expressing normal behaviour, and on polled genetics for continuously housed herds.

268. In most buildings that house cattle there is potential for a far more creative approach to enrichment and much more diverse behavioural opportunities. Research is needed to build an evidence base for the effectiveness of individual forms of enrichment so that the levy bodies, assurance schemes and Government payments may promote them.

269. What counts as a loafing area should be clearly defined in legislation, and assurance schemes should draw on research when establishing requirements. For both indoor and MPG systems, the concept of 'living space' should be given consideration, and further research into its association with welfare outcomes should be examined.

270. Via knowledge transfer, farm assurance schemes should pursue research and development opportunities to promote calf welfare, including nutritional, thermal, mental and weaning needs.

271. More research is needed into the effects on cow and calf welfare in the UK context of keeping calves at foot, to inform farmer decisions and veterinary oversight.

272. Research is needed into the welfare implications of multi-paddock grazing systems, especially where cattle are grazed at high density.

273. All Governments should continue to model and support research into the possible future impacts of regional climate change on grazed systems, parasitism, other infectious diseases and animal resistance to treatments.

274. The potential implications of GHG reduction measures for cattle health and welfare (e.g. dietary changes and breeding strategies to accelerate growth) need to be considered and appropriate research conducted.

These recommendations should be read in conjunction with those contained in the FAWC Opinion on the welfare of cattle kept for beef (2019).

18. Glossary

Body condition score: a method of estimating the amount of body fat carried by an animal by assessing certain visual and physical criteria at set comparison points.

Buffer feeding: giving a grazed animal supplementary non-grazed food.

Calf: a bovine animal up to six months of age.

Conspecific: an animal of the same species.

Continuous housing: a farming system in which cattle are kept within an enclosed environment, either an indoor barn or an outdoor corral.

Corral: a fenced or otherwise enclosed outdoor area for accommodating cattle.

Creep: an area only accessible to calves, used to provide supplementary feed and/or refuge, including bedding if not available elsewhere.

Finishing: the final stage in the beef rearing process to reach the desired body condition for slaughter that is most likely to achieve the required market or contracted carcass evaluation. In intensive systems it is characterized by a short period of intense nutritional management to promote the rapid growth of muscle and fat.

Forb: a non-grass herbaceous flowering plant.

Fully slatted system: a housing system with all underfoot and lying areas as slats, which is typically reliant on high stocking density to facilitate manure removal. In the UK this is not legally permitted for calves or calving cows.

Hay: pasture that is cut and dried in the sun then collected, baled and stored for future use.

Heifer: a female bovine that has not yet borne a calf.

Intensive: in economics, an indoor or outdoor farming system in which a high level of input delivers a high level of output.

Less Favoured Area (LFA): an EU Common Agricultural Policy classification based on natural limitation measures that has been used to determine eligibility for some payments.

Mob grazing: see Multi-paddock grazing

Multi-paddock grazing (MPG): a grazing system in which electric or similar fencing divides into small paddocks to control pasture access. Variants include adaptive multi-paddock grazing (AMPG), holistic planned grazing (HPG), management-intensive grazing (MIG), precision grazing, strip grazing, high density grazing (HDG) and ultra-high-density grazing (UHDG).

Outwintered: a farming system in which animals remain outside during winter.

Partially slatted system: a housing system in which a non-slatted lying area is offered, but which incorporates some slats for manure removal in feeding and/or loafing areas.

Partial mixed ration (PMR): a feeding system in which a mixture of feedstuffs fed in measured proportions is complemented by bouts of feeding on individual feedstuffs.

Pasture: the mixture of grass, wildflower and herb plants growing in a field that ruminant animals may feed on.

Pasture-based: a farming system in which most of the diet comes from freshly grazed pasture, with a small amount of other feed sources filling any nutritional gaps.

Pasture-fed: under some certification schemes, a farming system in which the diet comes entirely from freshly grazed pasture and from hay and silage derived from it.

Plate meter: a mechanical or electronic device to measure sward height and density.

Poaching: damage to grass and the underlying soil caused by livestock standing and walking on it for prolonged periods in wet conditions.

Rearer: a beef enterprise that typically takes calves from weaning to the start of finishing. Rearing may be combined with suckler and/or finishing systems.

Seasonal housing: a farming system in which animals are housed during the winter and turned out to pasture during the grass growing season.

Set stocking: grazing a single area for a long period.

Silage: undried pasture that is preserved by compaction and airtight storage.

Store animal: an animal, at any stage of life after weaning, that has not reached its accepted slaughter specification.

Suckler: a cow that is kept to feed its own or other young. Calves suckle the cow for around 9–10 months before weaning. Beef suckler cows typically calve in either early spring or early autumn.

Total mixed ration (TMR): a feeding system in which cattle are fed entirely on a mixture of feedstuffs dispensed in measured proportions.

Voluntary milking system (VMS): a system that uses one or more milking robots that cows may access on demand without the need for human intervention.

Year-round housing: see Continuous housing.

Zero-grazing: a farming system in which animals do not graze but are fed on some combination of freshly cut grass, conserved forage, a total mixed ration or a partial mixed ration.

Appendix 1: Grazing-based labelling schemes

The table below shows required grazing at pasture durations and dietary requirements. Other scheme requirements are not listed.

Scheme	Requirements*	Certification Body
Organic Beef/Dairy	Over 200 days on average at pasture when conditions allow. Minimum 60% grass-based, GM-free diet.	Soil Association
Pasture Promise – Free Range Dairy	Graze for at least 180 days and nights (6 months) a year.	A recognized farm assurance scheme (e.g. Red Tractor)
Pasture for Life	Must have access to grazing when conditions allow. Animals may be housed over winter. Zero-grazing systems are prohibited. Pasture and forage must be the only feed source (excepting colostrum and milk consumed by calves prior to weaning). Animals must not be fed grain nor any other form of feed concentrate.	Pasture-Fed Livestock Association (PFLA)
free range	No official definition	
grass-fed	No official definition	
grass-finished	No official definition	

Appendix 2: AWC Membership

Peter Jinman—Chairman
Martin Barker
Dr Andy Butterworth
Richard Cooper
Dr Jane Downes
Dr Troy Gibson
Dr David Grumett
Dr Maria Carmen Hubbard
Richard Jennison
Richard Kempsey
Dr Dorothy McKeegan
Dr Romain Pizzi
Dr Pen Rashbass
Debbie Stanton
Mark White
Prof Sarah Wolfensohn
Dr James Yeates

Co-opted members
Dr Alexander Corbishley (University of Edinburgh)
Dr Jenny Gibbons (AHDB Dairy)
Lorna Stevenson (APHA veterinary advisor)

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Dr Matthew Barnbrook
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Appendix 3: Those who gave evidence and assistance

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