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FARMING SHEEP AND GOATS

Cathy M Dwyer

Introduction

Sheep and goats are kept for milk, meat, skins, and fibre (wool and cashmere). The world population of these species is nearly 2 billion animals (1.1 billion sheep, 0.87 billion goats, FAOSTAT, 2014). Sheep are widely distributed across Asia, Africa, Europe, and the Americas, with most numerous populations in China, India, and Australia, but tend to be less common in tropical regions. Goat populations are found particularly in sub-Saharan Africa, Asia, Central America, and the Mediterranean. Typically, goats are better adapted to hot and humid environments than sheep, but fare less well in cold and wet climates, where sheep tend to predominate.

Sheep and goats are adaptable, hardy, and robust, able to utilise poor-quality forage through grazing and browsing. These traits continue to make them popular species for farming in some of the harshest environments on the planet, where they sustain subsistence farmers in Low- and Middle-Income Countries as multipurpose species, often managed in mixed-species herds. In Western countries, specialised breeds for meat, milk, or wool/fibre are more commonly used. They are farmed in extensive or very extensive (ranch) conditions in many countries but can also be kept in semi-intensive systems (housed for some parts of the day or for parts of the year) through to intensive (usually dairy) systems of continuous housing or kept on feedlots.

Extensive management systems are often perceived to be good for welfare. However, this does not mean that small ruminants have universally good welfare and there are no contentious welfare problems. With a few exceptions (such as milking), the most important welfare issues confronting small ruminants are associated with systems of management (essentially differences between animals spending all or most of their time outdoors, compared to all or most indoors) rather than production purpose. Extensive management is more common in sheep than goats, and more common in meat or wool production than in dairy but can be seen in all production systems. In these systems, animals may be held in fenced pastures or have access to large, open rangelands without fences. In the UK, unfenced systems make use of the natural habitat and home-ranging behaviour of sheep (termed hefting), in which generations of animals remain on the same area of land, where they are familiar with the location of food, water, or shelter. Although these unconfined systems can allow considerable behavioural freedom, animals are exposed to welfare issues, including environmental extremes (heat, drought, snowfall, wind, and rain), predation, variability in the availability and quality of food and water, and infre-

quent inspection, which can mean that disease or injury may be undetected, undiagnosed, or untreated.

In indoor management, animals can be more readily inspected, individual treatments are possible, and they can be provided with adequate nutrition more easily. Although sheep and goats are rarely subjected to the very close confinement of some other species, stocking density in indoor management is an issue, and aggression and competition can occur at high stocking density or when feeder space is insufficient. The quality of flooring, bedding, and the environment is also a concern, as small ruminants can be susceptible to respiratory disease, and foot and leg problems associated with poor environmental management. The nature of the human–animal relationship is also critical in indoor systems, where fearfulness and rough handling can cause poor welfare.

Several additional issues are common to all systems, including the use of painful management procedures, the need for handling and restraint, and neonatal morbidity and mortality. The following sections will consider more specific welfare aspects of small ruminant management.

Food and water

As ruminants, both sheep and goats are adapted to utilise low-quality roughage as food, and this contributes to their capacity to survive under some of the harshest environments. However, they can experience significant periods of undernutrition when the environment is unable to provide sufficient nutrients. This is more likely in extensive environments, as animals are more dependent on their ability to find food in the environment, than in more enclosed or indoor systems in which animals depend on humans to provide food. Malnutrition is also more commonly experienced by small ruminants in extensive conditions, where the balance of nutrients, including micronutrients, may be inappropriate.

Small ruminants are well adapted to cope with periods of food shortage and naturally reduce their voluntary food intake in the winter (Iason et al., 2000). They show behavioural adaptations, including movements about the home range, to ensure optimal use of the available forage if they are given the opportunity to do so, and an increase in foraging and grazing behaviour to maximise feed intake. However, these adaptations may not be sufficient to prevent sheep and goats experiencing the impacts of undernutrition, such as prolonged hunger or discomfort. In addition, the period of low forage availability often coincides with pregnancy for extensively managed animals, which increases metabolic demand, particularly for highly fecund animals. The impact of available forage on the welfare of sheep and goats is usually assessed by measuring Body Condition Score (BCS). This is an assessment of the amount of fat and muscle covering the lumbar vertebrae at the level of the last rib, often supplemented with an assessment of fat and muscle cover at the sternum in goats, assessed on a 5-point scale, where 1 is emaciated and 5 is obese. These measures are best made by manual palpation, especially in sheep in full fleece as body condition cannot be accurately assessed by visual inspection alone. Ideal body condition is between 3.0 to 3.5, and management should aim to maintain animals at this level year-round, as thin animals may experience prolonged hunger (Verbeek et al., 2011) and are prone to complications, such as pregnancy toxaemia, whereas fat animals are susceptible to obstetric disorders and metabolic disease. In very extensive farms, with unimproved pastures, supplementary feeding in winter can help to maintain body condition, but in lowland and fenced fields the use of improved pastures, regular grass height measurement, multi-species swards and rotational grazing are all management techniques that can be used to help improve nutrient availability. Although most undernutrition is due to inadequate availability of food, small ruminants may also experi-

ence hunger, even with adequate provision of feed, due to the loss of dentition (termed “broken-mouthed”), which prevents them from foraging or grazing effectively.

In extensive environments, sheep and goats are often reliant on natural water courses for drinking, which can become contaminated, or show seasonal variation in flow rates. Although well adapted to low water levels and buffered to some extent by water reserves in the rumen, drought conditions can cause very significant welfare problems. In intensive conditions, sheep and goats are much more reliant on humans to provide adequate water supplies and food, as they cannot satisfy their hunger and thirst by food and water seeking. Social factors can inhibit feeding behaviour, as subordinate animals may be prevented from feeding at preferred times, and food competition, for example when animals are supplemented with highly palatable concentrate feeds, can lead to aggression, displacements, and undernutrition in subordinate members of the social group. In these conditions ensuring adequate feeder space for all animals, and appropriate management of the social group size and composition, can reduce competition to access feed. As both small ruminant species can be horned, ensuring that sufficient space is provided to minimise injuries from aggression is important.

Physical environment

For extensively managed animals the welfare impact of the physical environment is generally through exposure to climatic extremes (e.g. extremes of heat, cold, or wet), and whether adequate shade and shelter is available. Northern temperate sheep breeds have dense woolly fleeces, and are well adapted, physically, behaviourally, and physiologically, to a cold, damp climate. Ewes in full fleece can remain within their thermal neutral range even at temperatures below freezing, provided they are dry, and can avoid the impacts of windchill through making use of shelter in the environment (either natural such as rocky outcrops, or manmade). When given a choice, sheep prefer to be outside even at very low temperatures (Piirsalu et al., 2020), although young lambs, and recently shorn sheep, will be less able to cope with low temperatures. Hair sheep (e.g. Blackhead Persian, Santa Inés) and goats are less resistant to cold and damp, and require better protection from wind, rain, and snow (Bøe and Ehrlenbruch, 2013). The ability to find a dry resting area is important for the welfare of both species, as wet and muddy or contaminated coats will significantly reduce their ability to resist cold temperatures.

Heat stress, and exposure to high temperatures, can also be significant issues in outdoor management. Access to shade is an important factor in the ability of animals to resist high temperatures, and competition to remain in the shade can occur if insufficient shade is provided. High temperatures will increase water intake (Silanikove, 2000), and can reduce feed intake and reproductive behaviour in both males and females. Sheep are generally less tolerant of hot and humid environments compared to goats. With climate change, an increase in sudden and extreme weather, such as flooding, snow fall, wildfires, and heat waves, can leave extensively managed animals vulnerable to catastrophic events, leading to very poor welfare and high mortalities, such as drowning, smothering, or burn injuries. These can be difficult for stockpeople to manage, where often human lives may also be at risk, but risk management and emergency planning can help to limit the impact of these events.

For animals maintained indoors, stocking density, quality of flooring, provision of bedding, and air quality are all important factors for physical comfort. Heat stress can also be important indoors, as insufficient ventilation, even at relatively low ambient temperatures, can cause panting and distress, especially in pregnant ewes in full fleece. At stocking densities with less than 1 m² per animal, displacements, aggression, and activity increases (Averos et al., 2014), suggesting competition for preferred lying areas. Sheep do not always show overt aggression (although

butting and chasing occur at high stocking densities) but may still express dominant behaviour through directed eye gaze, pawing, chin-resting, and displacements. Subordinate animals may, therefore, be regularly moved and have reduced lying and resting times when insufficient space is provided. Small ruminants may be kept on solid or slatted floors, and bedded with straw, wood shavings, or other materials. Goats seem to prefer to lie on solid surfaces and to have access to elevated lying places (Andersen and Bøe, 2007), which may mimic a more mountainous, rocky environment. Access to this environment can also help to wear the hooves and prevent lameness from claw overgrowth in continually housed small ruminants. Sheep have been shown to prefer a bedded surface on which to lie, particularly when shorn (Faerevik et al., 2005), and newborn lambs need a bedded surface to help maintain body temperature. Indoor housed animals may develop calluses on knees and hocks if the bedding is inadequate (Stubsjoen et al., 2011).

Air quality is an important characteristic of small ruminant housing, as sheep and goats are susceptible to respiratory infection and heat stress if the ventilation is insufficient (Navarro et al., 2019). At low ventilation rates the air quality (concentrations of ammonia, carbon dioxide, and particulates) may be poor. This increases physiological stress markers and reduces behavioural activity, including feeding behaviour, immune responses and milk yield in lactating dairy sheep (Sevi et al., 2006).

Health and disease

Sheep and goats share many of the same endemic diseases that affect their welfare: chiefly lameness, internal and external parasitism, mastitis and reproductive disorders, especially dystocia (difficult births). They are also both susceptible to several infectious diseases, such as coccidiosis, Maedi-Visna, paratuberculosis, and Peste des petits ruminants. Some of these diseases can be controlled through vaccination, and concerted efforts have led to regional eradication in some cases. Disease management is challenging in extensive environments where infrequent inspections can reduce the likelihood of animals receiving prompt treatment. An exhaustive account of these different health issues is beyond the scope of this chapter. However, an overview of those issues considered to have the greatest impact on welfare (Rioja-Lang et al., 2020) are presented here.

Lameness

Lameness is a behavioural indicator of foot pain, ranging from mild gait abnormalities to animals ceasing to bear weight on an affected limb or becoming recumbent. The prevalence of lameness in both species can be as high as 9–10%, although this can be reduced by a half in sheep by implementation of best practice foot management (Winter et al., 2015). The main causes of lameness in sheep are infectious micro-organisms, with nearly 90% of lameness relating to footrot or scald caused by infection with *Dichelobacter nodosis*. This bacterium is widespread and can be transmitted between sheep in warm and moist conditions via pasture contamination. Infection causes pain and inflammation and, if untreated, can cause animals to lose condition, reduce lamb survival, growth rates and lactation. Although eradication has been attempted in some places, and vaccines against footrot exist, farmers' main approach is management of cases when they occur. Prompt treatment, with injectable and topical antibiotics, can reduce the incidence and pain associated with infection. Treating each case as it occurs helps reduce the welfare impact and can reduce the spread from one animal to another. However, if animals are seen infrequently, or individual treatment is challenging, animals may be lame for some time before treatment is given. Farmers' acceptance of a certain level of lameness in sheep as "normal"

may also contribute to delays in treatment (Dwyer, 2009). Previous approaches to the presence of footrot, particularly excessive paring or foot-trimming, have now been shown to be unhelpful, and may even contribute to the spread of footrot between animals (Wassink et al., 2003). In general, if sheep can walk on hard surfaces, there is adequate natural wear of the hoof. The overgrown hooves seen in footrot result from lameness and pain, preventing the animal from walking properly to wear the hoof, rather than as a cause of lameness.

Although footrot can also affect goats, horn overgrowth and separation are more common causes of lameness in housed dairy goats kept on soft bedding (Can et al., 2016). Up to 90% of dairy goats in Europe may have overgrown claws, and improved walking ability can be seen after trimming (Ajuda et al., 2019). Foot trimming does, however, require capture, handling, and inversion, which are aversive. Foot trimming equipment can also be a means of spreading infection between animals unless these are kept scrupulously clean. Providing for exercise and the opportunity to walk on a hard surface can improve welfare by allowing natural wear of the hoof horn and reducing the need for foot trimming (Gelaskis et al., 2017).

Gastrointestinal parasites

Sheep and goats that are kept outdoors are susceptible to gastrointestinal parasites, through grazing contaminated pastures. These include blood-feeding stomach worms, such as *Haemonchus contortus* particularly in tropical regions, *Teladorsagia circumcincta* and *nematodirus* species, and liver fluke. Many of these parasites cause an anaemic response in the sheep or goat and can be identified through their impact on the colour of mucous membranes. Gastrointestinal parasites also cause discomfort, diarrhoea, dehydration, and loss of condition, and changes in behavioural expression (Grant et al., 2020). In young lambs or kids, when starting to ingest grass, infection can be a significant cause of pre-weaning mortality. The faecal soiling accompanying diarrhoea in infected animals can also cause an increased risk of flystrike or cutaneous myiasis.

High stocking densities contribute to the spread of infection, as well as poor pasture management which increases parasite load. Treatment of gastrointestinal parasites has frequently been by blanket drenching the whole flock or herd. However, a rise in the number of anthelmintic-resistant parasites has led to more targeted, alternative strategies to limit the development of resistance. In particular, the use of alternative forage types or mixed swards, such as chicory or plantain, can provide a more natural approach to reducing worm burdens. There is evidence that sheep and goats infected with parasites will self-medicate by increasing their intake of plants containing condensed tannins, which reduce worm burdens (Villalba et al., 2017).

Ectoparasites

Ectoparasites are organisms that infest the skin, wool, or coat of animals, and can cause lesions (and subsequent secondary infections), and intense discomfort, irritation, and itchiness. The major ectoparasites affecting the small ruminants include mites, lice, ticks, and blowfly larvae. Sheep scab, caused by infestation with mites, is highly contagious and has a major impact on sheep welfare. Scab is an acute or chronic form of allergic dermatitis, where the presence of the mites and its faeces cause the animal to produce a serous exudate at the skin surface on which the mites feed. This is accompanied by intense itchiness, and animals frequently rub against fence posts, pens, or other structures, bite their fleece and break off from feeding, lying, or other behaviours to scratch. Over time, if not treated, these discomfort behaviours occupy more of the animals' time, leading to wool loss and skin lesions, fits, and death (Corke and Broom, 1999). Sheep scab can be treated by plunge-dipping using an organophosphate dip or by injecting with

endectocides. Both these procedures carry some risks – organophosphate products are highly toxic to humans, and the recommended endectocides are also used to treat internal worms and can increase anthelmintic resistance. Use of quarantine for all new animals brought onto the farm, and ensuring that sheep flocks do not mix, can reduce the incidence of the disease, minimising the need for treatment and protecting animals from infestation.

Blowflies are one of the most widespread ectoparasites affecting small ruminants, with up to 80% of sheep farms in the UK reporting at least one case each year, causing a condition called cutaneous myiasis or “flystrike”. Different species of blowfly (Calliphoridae) are prevalent in different sheep- and goat-producing countries, with varying virulence, however the impact on the welfare of sheep or goats is similar. Female blowflies are attracted to dead animals, or live animals with wounds and soiled wool or hair, and lay their eggs in the warm, moist conditions typically found around the perineal region. Larvae hatch from the eggs and feed on the living tissues. This causes pain, discomfort and itchiness, as well as wool or hair loss at the site of the strike and a route for further infection. Animals with soiled coats around the anus (often called “dags”), through ingestion of rich grazing or gastrointestinal parasites, are more attractive animals for blowflies to attack. Preventative measures, such as clipping away soiled wool and using pour-on products, reduce the likelihood of infestation. Management procedures, such as tail-docking or mulesing (removal of folds of skin from the tail area, only in Australia), have been developed to reduce the risk of flystrike.

Mastitis

Mastitis is a bacterial infection of the udder in lactating animals, caused particularly by *Streptococcus* and *Staphylococcus* species, which results in inflammation, fever, and pain, sometimes severe, for the infected animal. This is more commonly observed in dairy animals, where it might be detected first by animals being restless or trying to avoid attachment of the milking machine, but it can also affect meat ewes or does. In a study in Australia of meat sheep, annually 1% of ewes had clinical mastitis (Munoz et al., 2018), and subclinical infections can also cause welfare concerns. Clinical mastitis involves physical changes in the udder (such as swelling and heat), sickness behaviour (lethargy), and animals may appear lame and reluctant to allow lambs or kids to suckle. In extensively managed animals the only evidence of mastitis might be slower growth rates in the offspring, or increased pre-weaning mortality, and changes in the udders of ewes (such as lumps or hard areas) seen after lactation, although the ewe may have suffered considerable pain earlier in the course of the disease.

Mastitis can be reduced by good management and hygiene. This is particularly important for indoor lambing/kidding pens, to prevent infectious agents passing between animals through contaminated bedding. In dairy animals, infection can also be caused by poor hygiene of milkers and milking machines, with manual milking associated with more mastitis than machine milking (Marogna et al., 2010). Physical injury to the udder or teats can also provide a route for infection. Mastitis is more frequent in ewes/does with high milk yield, and in females raising multiple offspring, where competition for milk may cause stress and physical injury to the udder. Mastitis is readily treatable with antibiotics, and anti-inflammatory drugs to reduce pain.

Dystocia

Dystocia is a prolonged or complicated birth process, that often requires human intervention to deliver the offspring. This can cause pain, haemorrhage, and exhaustion in the mother, and increases the risk of uterine infection and damage through interventions. In the offspring, dys-

tocia causes hypoxia, and birth injuries, including cerebral haemorrhage and central nervous system damage. Birth difficulty is a significant contributor to mortality in both mother and offspring, implicated in the majority of pre-weaning mortalities in lambs and kids (Refsauge et al., 2016; Robertson et al., 2020). Dystocia increases stillbirth in viable offspring, and mortality of liveborn offspring through an increased risk of mothers showing reduced maternal care (Dwyer and Lawrence, 1998), and impacts on neonatal vigour, teat-seeking, and thermoregulation (Dwyer, 2003). Human interventions can help reposition lambs before cervical delivery, although very complicated presentations may require caesarean section. However, the timing of interventions is crucial, as unnecessary obstetric help can cause damage or injury, and may reduce mother-offspring bonding behaviour. Extensively managed animals are less likely to be observed in difficulty at a time when interventions will be able to prevent the deleterious consequences of dystocia. In these situations, often a goal of farm management is to develop a flock or herd where dystocia is less common and animals are more self-reliant.

Dystocia is related to multiple causes, and risk factors for a difficult delivery can be both animal and environmentally based. Dystocia is caused by offspring malpresentation, feto-pelvic disproportion, uterine inertia, delayed or incomplete cervical opening, disease, or congenital malformation in the offspring. Genetic factors (including breed and within breed selection), litter size, maternal nutrition, environmental stress, and exposure to, for example, phytoestrogens can all contribute to the risk of a difficult birth. It is possible to breed for an easier birth process, and this can reduce the risk of dystocia (Matheson et al., 2012) and consequently improve welfare. As prey species, ewes and does are vulnerable when giving birth, and have developed physiological mechanisms to delay giving birth if they feel threatened. If there is constant disturbance, or there is a poor human-animal relationship, parturient females may experience delayed or prolonged births as the effectiveness and frequency of uterine contractions are reduced with stress.

Pregnancy toxemia

Pregnancy toxemia occurs in late gestation in ewes and does and is primarily caused by inadequate nutrition in late gestation. This causes mobilisation of fat stores to provide sufficient glucose for the developing foetuses, but at high levels this can overwhelm the capacity of the liver to produce glucose, resulting in the production of ketones. As this is more common in dams carrying larger litters it is often known as twin-lamb disease, or pregnancy ketosis. The presence of ketones in the blood causes lethargy and a reduced appetite, which can exacerbate the condition, neurological symptoms through the poisoning effects of the ketones, and finally recumbency, coma, and death. Pregnancy toxemia is considered one of the main causes of ewe mortality in some studies (Politis et al., 2021).

Ewes that are very thin (with a BCS of less than 2) or fat ewes (BCS greater than 4) towards the end of pregnancy are most at risk, although sudden loss of feed, stress, or other contributory health conditions, such as lameness or dental disease, also increase the incidence. Ewes in the early stages of pregnancy toxemia can be treated with oral propylene glycol and encouraged to eat through provision of highly palatable food, such as molasses, and management changes to allow increased feeder space or protection from adverse weather. In the later stages of the disease, treatment is difficult and often euthanasia is required.

Painful management procedures

Small ruminants are subjected to several management procedures that can cause pain, some of which are undertaken for improved health or welfare management of the animal, and some to

make management easier for the stockpeople. The most common of these are castration of male lambs and kids, tail docking and mulesing in sheep, and disbudding in kids.

Castration

Castration is usually carried out, within a few days of birth, to reduce unplanned matings, to avoid changes in sensory characteristics of meat in post-pubertal males, and to reduce the risk of injury in managing entire male animals. Several different techniques are routinely used, including use of tight rubber rings (elastration), banding, instruments designed to crush the spermatic cords (known as Burdizzo), and surgical approaches. In many countries the method or timing of the use of some of these methods without appropriate anaesthesia or analgesia may be restricted. For example, in the UK, castration with tight rubber rings without anaesthesia or analgesia is only permitted for lambs or kids under seven days of age and is banned in some European countries. Castration by any method has been shown to be associated with pain behaviours (e.g. rolling, kicking, stamping, abnormal postures: Molony et al., 2002), elevations of plasma cortisol and heart rate (Kells et al., 2020), and altered behavioural expression (Maslowska et al., 2020). These behaviours can persist for several hours after the procedure and can be reduced using local anaesthetics injected into the testes and scrotal neck, but not completely abolished (Kells et al., 2020). Subcutaneous, but not intramuscular, injections of non-steroidal anti-inflammatory drugs (NSAIDs) reduce pain behaviours in the 12 hours after castration (Paull et al., 2012), although not acute pain responses (Kells et al., 2020). More recently, formulations to deliver NSAIDs through a buccal route in small ruminants have been developed and can help to reduce pain expression to a greater degree than is achieved through local anaesthetic alone (Small et al., 2018).

The pain associated with castration in young males can interrupt the bonding between mother and offspring, and the presence of lesions and possible infections can increase the risk of mortality in males. In addition, male lambs and kids may have a growth check associated with pain, and castration can cause slower growth and result in a less commercially valuable carcass. For these reasons, farmers who keep fast-growing breeds of meat sheep or goats, where slaughter weights can be achieved before puberty, are less likely to castrate lambs or kids than previously. However, for hill farmers, with slower growing sheep breeds, their ability to lamb early in the year is restricted by the weather and the need to provide ewes with good grazing during lactation. In addition, a lack of fenced pastures on hill farms may make it impossible to keep entire male lambs away from females. The market for post-pubertal male lambs is a contributory factor in the continuing need for farmers to castrate males, but there is an urgent requirement for a painless method to achieve this.

Tail docking

For sheep, tail docking is routinely carried out to reduce the risk of faecal soiling of the breech area, which can be a risk factor for flystrike (see above). However, the evidence that tail-docking can reduce the incidence is limited (Sutherland and Tucker, 2011), with some studies showing no impact of tail length on the extent of dags or flystrike incidence (Fisher et al., 2004; Soriano et al., 2020). The use of other practices, such as regular shearing of the perineal area, insecticides, and topical applications of deterrents may be as effective and more ethical (Gascoigne et al., 2021).

Tail docking is generally carried out by the same methods as described for castration, or by using hot docking irons. Similar restrictions apply in many countries, and the procedure is associ-

ated with behavioural and physiological evidence of pain in the lamb, albeit at a lower level than seen for castration (Molony et al., 2002). The use of subcutaneous local anaesthetic drugs, such as bupivacaine, administered immediately before docking is effective at reducing these responses. However, there is some evidence for long term hyperalgesia and neuroma formation in the tail stump (Larrondo et al., 2019) and that tail docking may have longer lasting impacts on pain sensitivity and behaviour (Clark et al., 2014). Most countries recommend that tails should be docked to retain enough of the tail to cover the vulva and anus. Very short tail docking, where almost no tail is present at all, is associated with an increased risk of bacterial arthritis and rectal prolapse (Thomas et al., 2003; Lloyd et al., 2016), and may increase the risks of flystrike (Fisher et al., 2004).

Mulesing

Mulesing is another practice designed to reduce the incidence of flystrike, and is generally only carried out on Merino sheep, where the very wrinkled skin around the breech area provides an ideal environment for blowflies to lay their eggs. This process requires the removal of skin on either side of the anus, which then heals to a smooth, scar tissue which is less likely to become soiled. The procedure is banned in many countries but is still commonly practised in Australia. Mulesing is carried out by accredited contractors and occurs at the same time as several other procedures, including tail docking, ear marking, and vaccination. Lambs that have experienced this procedure show physiological and behavioural signs of pain that can last for several weeks and altered behavioural responses to humans for up to a month following mulesing (Fell and Shutt, 1989). Although there is no statutory requirement in Australia to provide analgesia or anaesthetic, there is evidence that pain-related behaviour can be partly reduced by use of NSAID and topical anaesthetics (Small et al., 2018). Attempts to develop Merino sheep which have been bred to be less wrinkled in the breech area may provide a permanent solution to the need for mulesing (Scobie et al., 2007).

Disbudding

Disbudding is usually carried out in goat kids soon after birth but is rarely practised with sheep. Disbudding is done to avoid handler or between-animal injury, especially when animals are kept in confined spaces. Disbudding can be carried out using caustic paste, scoops, or thermal cautery (Hempstead et al., 2018b). In general, pastes and scoops are not recommended methods due to the pain associated with these approaches and, with paste, the potential for causing burns to other parts of the animal. In many countries disbudding can only be carried out by a veterinarian, and requires the use of at least local anaesthesia, and often post-operative analgesia. In goat kids, the skull is thin around the site of the horn bud, and disbudding is often carried out under general anaesthesia to reduce the risk of inadvertently causing brain damage. Even with the use of local anaesthesia and analgesia, or general anaesthetic and NSAID, there is evidence of pain in kids post-operatively (e.g. head shaking, reduced growth rate: Hempstead et al., 2018a; Ajuda et al., 2020) for a number of days after the procedure. There are increasing numbers of polled breeds of animals, and cross-breeding or genetic manipulations may make it less likely that these procedures will be required in the future.

Behavioural interactions

Small ruminants are commonly managed in social groups, usually a breeding female flock/herd, with or without their offspring, and a separate male group, except at mating. In general

animals are free to express most normal social behaviours and interactions, and, unless kept at high stocking density or with limited resources, conspecific aggression is rare. In animals kept for meat or fibre the offspring remain with their mothers for a relatively long period of time, up to 50% or more of natural lactation. Dairy animals can vary from very intensive systems, which require separation of the offspring from their mothers within a day of birth, to less intensive where the lamb or kid may suck from the mother for up to six weeks before a milking period. Mating in both species is often natural, through exposure of oestrus females to the ram or buck for a period of weeks, which can allow courtship and mating behaviours to be expressed. Stereotypic or abnormal behaviours are rarely seen in animals at pasture, but can occur in housed animals, especially if housed individually. The most frequently reported of these is wool-biting or chewing, where the wool of another animal, sometimes a more subordinate animal, is pulled out. This seems to be related to diet as increased provision of fibre reduces the expression of this behaviour. Other forms of oral stereotypy (licking, biting, or chewing pen fixtures, eating non-food items) and locomotor stereotypy, such as route tracing and repetitive rearing or jumping, also occur, almost always under conditions where animals are confined alone in small pens.

The main causes of welfare concern relating to behavioural interactions come from fear or distress often caused by separation from the social group, interactions with humans or interactions with other animals such as predators.

Fear and distress

As prey species, sheep and goats have specific and highly motivated behavioural adaptations to deal with potential threats from predators. These are maintained, regardless of whether a predator threat is present. This involves highly organised social behaviour, fear, and anxiety when socially isolated or in novel scenarios, and flight from a threat (Dwyer, 2004). All species will also use aggression, particularly head threats and butting, although entire males are more aggressive than females. Sheep are generally more fearful than goats, although less likely to use aggression as a response and more fearful of novel environments or events. Goats can be more curious and less fearful with novelty or potentially threatening situations.

Fear behaviour is expressed by increased vigilance (time spent with the head raised scanning the environment), flight, or panic reactions when flight is prevented. This can increase the chances of injury if panicking animals attempt to climb or jump out of an enclosure to avoid a perceived threat. A potent fear-inducing condition in these species is social isolation. Being part of the social group is an antipredator response, and not being in the social group is extremely stressful. This is usually seen as frequent loud “distress” vocalisations and attempts to re-join social companions, although vocalisations can be suppressed in conditions where there is a perceived predator present (such as a dog or human).

Human–animal relationships

Unless well-handled and familiarised with stockpeople from a young age, small ruminants, especially sheep, regard humans as potential predators. The presence of a stockworker can elicit the same behavioural responses (flight if approached too closely or too quickly) as a predator. For extensively managed animals in some countries this response is utilised for animal movement, often reinforced by using sheepdogs. Small ruminants will tolerate the presence of humans (and dogs) at a distance but maintain a “flight zone” around themselves whereby encroachments into this space will elicit movement away from the threat (Grandin, 2020). The size of the flight zone will vary with species, experience, breed and context, but for both species “low-stress handling”

involves working at the outer edge of the flight zone, such that the animal moves away slowly and calmly. Rapid movement into the flight zone will elicit panic and flight, which is counter-productive and can result in injury.

In shepherded management systems, groups of small ruminants can be moved by following the herder, rather than driving the animals from behind. Sheep and goats have a pronounced “following” response, where they tend to follow the animal in front, and this can be used to move animals in a manner that elicits less stress than driving from behind. Dairy animals also encounter humans at close quarters far more frequently than sheep and goats kept for meat or fibre. The quality of the relationship between human and animal is vital for good welfare, and a poor relationship can cause fear, which also affects milk production. Animals milked in a parlour rapidly learn the order of entry and find their position in the parlour, particularly if reinforced by food rewards. Calm and consistent behaviour by stockpeople helps to reinforce this learning, reduces fear and uncooperative behaviour (such as baulking or turning back) and makes the experience more pleasant for both human and animals.

Predation

Small ruminants are often farmed in environments where large predators (wolves, coyotes, bears, etc.) still live. Attacks on small ruminants may also occur from uncontrolled domestic dogs. Sheep and goats have limited defences against predators other than attempting to escape to higher ground (if available) or to run. Small ruminants with horns defend themselves or their young from avian predators to some extent, but in general they have few opportunities to avoid the impact of predation. Predation is therefore still a significant threat to welfare in countries with high predator density, particularly on young lambs.

Predation is obviously a severe welfare issue where sheep or goats are caught and killed or injured by predators. However, the presence of predator also acts as a fear stimulus, increasing vigilance and anxiety, and animals will avoid areas of pasture where predator attacks have occurred for prolonged periods. Prolonged chasing, as can occur particularly with domestic dogs, can lead to exhaustion, injury, and abortion in pregnant animals. Methods of dealing with predators involve fencing, bringing animals in at night, lethal predator control, shepherding, and the use of guardian animals. Although shepherding or bringing animals into housing can be very effective means of dealing with predation, in some systems, it is not practical or possible. Use of guardian animals (usually dogs but also donkeys or llamas) can be effective alternatives (van Bommel and Johnson, 2017). This involves rearing dogs with the flock from a young age, where the dog effectively becomes part of the social group, and the dog will then protect the animals directly through interactions with predators or deter predation and attacks through its presence.

Conclusions

In many systems, small ruminants are kept in extensive outdoor environments, which avoids excessive confinement and replicates to some extent the natural environment in which these species evolved. In these systems animals have considerable behavioural freedom and opportunities to express positive welfare, through social interactions and environmental complexity. The consequences of management in these environments, however, can be a reduction in human–animal contact and an inability to provide individualised health and welfare treatments. This often means that the most severe welfare impacts are through untreated, or sometimes undiagnosed, disease and injury, impacts of predation and through severe environmental changes. This

can lead to higher incidence of morbidity and mortality in these systems, compared to indoor management.

In dairy systems animals may be kept more confined, or completely indoors, with daily movements to the milking parlour, although grazing opportunities are still offered in many cases. The quality of the human–animal relationship, space available to each animal and the housing environment are all potential risk factors for poor welfare, as well as early separation of the offspring from the mother. In shepherded, and more pastoral dairy systems, the milking period may be more related to the natural production cycle of the ewe or doe, including a suckling period, and animals may have a positive relationship with the shepherd who leads them to fresh grazing.

Overall, there are considerable opportunities for improving welfare for the management of sheep and goats, since several significant challenges to welfare exist. Many of these can be overcome by good management, veterinary care, and sensitive shepherding. Labour shortages, which may require small ruminants to be more resilient or self-sufficient, and climate change, which can increase the severity of unpredictable environmental events, are increasing risk factors for the welfare of small ruminants.

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