



# Animal Welfare in Extensive Production Systems Is Still an Area of Concern

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Traditionally, research on farm animal welfare has mainly been focused on welfare problems thought to be common in intensive systems, whereas the welfare of animals kept in extensive systems has attracted much less attention. This may be due to the generally held belief that extensive systems are advantageous in terms of animal welfare. Although it is undeniable that extensive systems have many benefits in terms of animal welfare, they are by no means free of welfare problems. This review highlights the animal welfare problems that are most likely to be found in extensive systems following the four animal welfare domains of “nutrition,” “environment,” “health,” and “behavior.” Extensive environments are highly variable and heterogeneous in terms of climate conditions, food quality, and access to high-quality water, and this can raise serious welfare concerns related to chronic hunger and thirst, and thermal stress. These problems will vary depending on the location and time of year. Some diseases are more likely in extensive systems than in intensive ones and this can be compounded by supervision of animals being more difficult in extensive systems. Several painful husbandry procedures as well as neonatal mortality and predation are other potential welfare issues for animals raised in extensive systems. Finally, infrequent handling and / or potentially aversive handling can impair human-animal relationship and have a negative effect on the welfare of extensive livestock. Detection and monitoring of welfare problems in extensive systems are essential for implementing practical solutions adapted to local challenges. Selecting animals that are adapted to local conditions reduces some of the welfare problems encountered in extensive systems. Practice-led innovations should be undertaken in extensive systems and should support knowledge-exchange strategies with producers.

**Keywords:** animal welfare, extensive livestock, knowledge exchange, nutrition, environment, health, behavior

## INTRODUCTION

Animal welfare is an essential element of modern animal production. First and foremost, animal welfare is grounded on ethical concerns that derive from the fact that animals are sentient beings, i.e., able to suffer and experience emotions (Le Neindre et al., 2017).

Societal concern over the welfare of farm animals has increased recently and a growing number of citizens in many countries now demand that farm animals are reared, transported, and slaughtered as humanely as possible. For example, according to a survey done in 2015 and involving more than 27,000 citizens from the 28 Member States of the European Union, 94% of EU citizens think that it is important to protect the welfare of farm animals. Interestingly, this

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percentage ranged from 86 to 99%, showing that even in the EU countries that are supposedly less concerned about the welfare of animals, a clear majority of citizens believe that it should be protected (European Commission, 2016).

Improving animal welfare may have additional benefits. As many welfare problems have a detrimental effect on production, improving the welfare of farm animals very often has positive effects on performance. Also, improving animal welfare is one of the strategies that may contribute to reduce the use of antimicrobials in farm animals (EMA EFSA, 2017) and hence may have long-term benefits for human health.

Traditionally, research on farm animal welfare has mainly been focused on welfare problems that are thought to be common in intensive systems. Conversely, welfare of animals kept in extensive systems has attracted much less attention. However, extensive systems of animal production are very important in many parts of the world. Extensive pastoralism occurs on 25% of global land surface and supports around 200 million subsistence pastoral households (Nori et al., 2005). In Africa, 40% of the land is dedicated to pastoralism (IRIN., 2007).

Despite two recent reviews on the welfare of extensively kept livestock, publications on this topic are limited (Villalba and Manteca, 2016; Villalba et al., 2016). The scarcity of research on animal welfare in extensive systems is partly due to the generally held belief that extensive systems are advantageous in terms of animal welfare. Admittedly, conditions experienced in extensive situations are more likely to provide for the behavioral needs of animals (Hemsworth et al., 1995). Indeed, extensive management systems are based on providing a natural environment where animals can express natural behaviors such as grazing or exploration. Also, livestock animals can exercise, which may be beneficial for their health (Regula et al., 2004). Pastures may provide a more comfortable lying area compared to indoor housing systems (e.g., dairy cattle, Krohn and Munksgaard, 1993) and may prevent the incidence of some diseases such as mastitis in dairy animals (Washburn et al., 2002).

However, the possibility to display natural behavior can be constrained by environmental features. For example, cows may prefer not to graze if temperatures are too high. Legrand et al. (2009) reported that lactating Holstein cows preferred pasture only at night and preferred indoor housing during the day, especially when the temperature and humidity increased, under the housing and environmental conditions tested. Charlton et al. (2011) also reported that lactating Holstein cows exhibited a partial preference to be indoors, which was influenced by rainfall and milk yield. Those studies on preference testing and motivations show that, in some conditions, animals may perceive outdoor conditions as aversive and if given the choice they would prefer the protection from the indoor area.

In principle, the welfare of herbivores kept in extensive grazing systems should benefit from the fact that they have evolved to make the best use of such environments. However, as commented by Villalba et al. (2016), animals are not always kept where they evolved, and the unpredictability of environmental factors, coupled with the management of livestock by humans, does not always match the adaptive features of livestock, which can lead to welfare problems for livestock kept in extensive

systems. In fact, livestock that live under extensive conditions are partially under the care of humans and, on the other hand, they fend for themselves for part or most of their lives. Therefore, selecting for animals adapted to prevailing local conditions contributes to avoid or reduce many of the welfare issues that will be discussed later (Provenza, 2008).

Despite these constraints, it remains true that extensive systems offer several advantages over intensive ones from an animal welfare standpoint, mainly in the behavioral domain. On the other hand, however, it is also true that extensive systems may pose several welfare problems that are far less common or severe in intensive systems.

The objective of this paper is to discuss animal welfare problems in extensive systems and suggest improvement strategies, as well as areas deserving further research. Several welfare issues included in this review are found in intensive systems also, but they still pose a significant threat to the welfare of animals in extensive systems, where they may require improvement strategies different from those commonly used in intensive systems.

As most of the extensive livestock are herbivores, particularly ruminants, this review will mainly focus on ruminants -mostly cattle, sheep and goats-, but pigs kept under extensive conditions will also be considered when appropriate. When there is little or no published information of a particular welfare issue in domestic livestock, references to studies on wild ungulates will be included. Welfare problems during transport and at slaughter will not be considered. To provide a conceptual framework for our discussion, first we will briefly summarize the concept of animal welfare.

## WHAT IS ANIMAL WELFARE?

The concept of animal welfare can be approached from different perspectives and these have been grouped into three categories: biological functioning, emotional state and “naturalness” (Fraser et al., 1997). Each of these approaches has its own merits but none of them captures on its own the different aspects of animal welfare. It has been suggested, therefore, that the assessment of animal welfare must include all three approaches. It is widely accepted that animal welfare encompasses not only the physical health of the animals (i.e., the absence of diseases and injuries) but also their behavior and emotions (Duncan and Fraser, 1997; Mendl, 2001).

The welfare of an animal can be measured objectively and independently of moral considerations, and may range from very poor to very good. According to one of the most widely accepted scientific definitions of animal welfare, the welfare of an individual is its state as regards its attempts to cope with its environment (Broom, 1986). An in-depth discussion of this definition is well-beyond the scope of this paper and it suffices to say that welfare depends on whether the animal is able to cope and on how much it has to do to cope with environmental challenges. As feelings are part of the coping mechanisms used by animals, feelings are an important part of welfare.

For many years, the Five Freedoms (Farm Animal Welfare Council, 1992) have provided a useful framework to identify the welfare problems of farm animals. These freedoms, which represent ideal states rather than actual standards for animal welfare are (1) freedom from thirst, hunger and malnutrition, (2) freedom from thermal and physical discomfort, (3) freedom from pain, injury and disease, (4) freedom to express most patterns of normal behavior, and (5) freedom from fear and distress.

More recently, the Five Freedoms have been criticized on the grounds that they can be misunderstood as aiming at eliminating all negative experiences (which is not realistic or even desirable) but also because they fail to capture our current understanding of the biological processes underlying animal welfare (Mellor, 2016). As an alternative to the Five Freedoms, the so-called Five Domains Model for assessing animal welfare was developed to address these problems. The Model incorporates four physical domains of “nutrition,” “environment,” “health,” and “behavior,” and a fifth “mental” domain. Each physical domain has an impact on the affective state of the animal (i.e., on the fifth domain), and the net outcome in the mental domain resulting from the combination of the four physical domains represents the animals’ overall welfare state.

## NUTRITION AND FOOD SELECTION

### Chronic Hunger

In extensive systems, animals forage for most of their feed and must sometimes cope with long periods where available food does not have sufficient nutrients to meet their requirements. When this is the case, animals will lose body condition and suffer chronic hunger. For example, in a study conducted on family farms from Southern Brazil, a mean prevalence of 14% of extensive dairy cows showed low body condition scores suggesting low pasture quality and availability on some farms (Costa et al., 2013).

Very low body condition may compromise the immune function of animals and very low body condition scores increase the risk of health problems during lactation in dairy cattle (Roche et al., 2008). Moreover, underfeeding is likely to have direct, negative effects on the affective state of the animals.

In addition to macronutrients, levels of minerals and vitamins may be inadequate. In extreme cases, deficiencies can result in death. For example, when raised on phosphorus-deficient pastures, cattle seek out bones to chew which can result in death from botulism in unvaccinated cattle, as decaying carcasses favor the concentration of botulinum toxin (McCosker and Winks, 1994).

Ruminants try to adapt to poor forage conditions by increasing their grazing time and by dispersing more widely (Manteca and Smith, 1994). On good pastures, grazing times for domestic ruminants usually range between 4 and 9 h per day (Haupt, 2018), whereas grazing times of up to 14 h have been recorded on poor forage conditions (Arnold and Dudzinski, 1978). Ruminants have a limited time budget for grazing, mainly because they have to devote a significant amount of time to ruminate. Under very adverse conditions, fatigue affects an animal before its nutritional requirements have been met (Birrell,

1991). The effects of food shortage may be aggravated by high stocking rates and environmental factors such as water scarcity and high ambient temperatures.

Stocking density is one of the most important factors affecting forage availability and quality (Edwards, 1980; Allison, 1985; De Villiers et al., 1994). In many extensive systems stocking density is often thought to be low, but changes can arise suddenly, sometimes as a result of policy. For example, in the main Spanish Dehesa area, some farmers have increased stocking density to maximize EU subsidies (Prieto and Martín, 1994; Escribano et al., 2002; Gaspar et al., 2009). Although increasing stocking density is often linked with improvements in profitability (Escribano et al., 2006), as well as in herbage production and utilization (Macdonald et al., 2008; McCarthy et al., 2012a), this is frequently achieved at the expense of the individual animal performance and welfare (Stakelum and Dillon, 2007; Macdonald et al., 2008; McCarthy et al., 2012b). For example, high stocking densities have been associated with reduced body weight (Sharrow et al., 1981) and fertility (McGowan, 1981).

Herbivores select plant and plant parts depending on stocking densities (Provenza and Villalba, 2006) and high animal densities can increase competition for food resources and reduce selectivity (Bailey and Brown, 2011). Furthermore, the prevalence of non-preferred plants species under high densities can increase the risk of consumption of poisonous plants (Pfister et al., 2002) (see below). As well, high animal densities may increase social stress leading to disturbed grazing patterns (Blanc and Theriez, 1998). Still, the link between stocking density and livestock welfare in extensive systems is not straightforward. In a recent study, Müller et al. (2014) did not report a significant effect of the intensity of grazing on the live weight gain of individual sheep grazing on a semi-arid grassland steppe in Inner Mongolia. On a different study with sheep in the same area, the live weight gain per sheep was much lower at high than at low grazing intensity (Schönbach et al., 2012). Different systems of grazing management cause animals to forage in different ways (Provenza et al., 2003) and continuous grazing at low stock densities encourages selectivity and reduces diet and habitat breadth, whereas short- duration grazing at high stock densities increases diet and habitat breadth.

Under heat stress conditions, ruminants tend to avoid grazing during the hottest part of the day and thus reduce daily grazing time (Arnold, 1985). The extent of this reduction varies greatly between breeds. For example, European breeds of cattle reduce their grazing time during hot and humid days much more than zebu cattle. The main factor accounting for these differences in behavior is that the sweat glands of *Bos indicus* are larger, more numerous and more active than those of most breeds of *Bos taurus* (Macfarlane, 1964). Walking long distance between watering points and grazing grounds may take a considerable amount of time and reduce time available for grazing. Continuous irritation by flies may also reduce grazing time (Lefcourt and Schmidtman, 1989). For example, in bad seasons, sheep may lose a great deal of grazing time due to irritation by *Oestrus ovis* flies (Blood et al., 1983).

Ruminants that graze in extensive systems are generalist herbivores, meaning that they evolved consuming diverse diets as

opposed to monotonous pastures. A decrease in the diversity of foods and/or habitats may compromise animal welfare (Manteca et al., 2008; Villalba et al., 2011; Catanese et al., 2013). On the one hand, the inability to satisfy requirements for energy, protein, and minerals can lead to nutritionally unbalanced intake, health problems, and stress. On the other hand, the animal may continue foraging in order to satisfy the requirements for nutrients in lower concentrations, inevitably leading to overconsumption of the nutrient in highest concentration (Raubenheimer, 1992). Furthermore, diverse diets increase the likelihood of ingesting beneficial chemicals that enhance the health and welfare of animals (Villalba et al., 2010a). Thereafter, excess of some nutrients, homogenous food environments and the inability to express diet preferences can induce aversive behavior (Provenza, 1996), frustration (Rutter, 2010) or negative post-ingestive feedback (Forbes, 2007; Villalba et al., 2010b).

Animals vary in their acceptance of particular plants and herbivores develop food preference because of the dynamic interplay between flavor and post-ingestive feedback, which is determined by an animal's physiological condition and a plant's chemical characteristics (Provenza, 1996; Provenza and Villalba, 2006). Neural communication between what a ruminant tastes and smells and the subsequent reactions in the viscera enable ruminants to sense the consequences of food ingestion (Provenza, 1995). Animals learn to recognize specific plants and discriminate food through taste, visual, and olfactory signals. Bitter taste, for example, has been studied for its role in plant selection (Glendenning, 1994).

Individuals of the same species may also differ in their acceptance of particular plants. This variability may be partially explained by early grazing experiences (Arnold and Maller, 1977). Early experiences in utero and shortly after birth influence gene expression and have long term effects on grazing behavior (Provenza et al., 2003; Kappeler and Meaney, 2010).

As opposed to traditional rotational grazing at low stock densities, managing stocking density in a flexible and dynamic way can enhance plant production and diversity (Provenza et al., 2003; Campbell et al., 2006) and should be encouraged. Such highly qualified management of stocking density can greatly benefit animal welfare and improve vegetation abundance and plant diversity (Grissom and Steffens, 2013; Villalba et al., 2016). Further research is needed on the relationship between stocking rate and livestock behavior and welfare under different environments and grazing regimes.

When offered a diversity of feeds, individuals may be better able to select nutrients according to their specific needs and consequently achieve an adequate state of nutrition and well-being (Manteca et al., 2008). Management strategies that allow animals to express their feeding preferences create opportunities to reduce costs and enhance performance of grazing livestock.

Providing food and mineral supplementation can improve forage digestibility and feed intake and prevent many welfare problems related to nutrition. However, supplementing animals may not be feasible in very extensive systems. An additional problem is that some animals may be reluctant to eat supplements if they are not accustomed to them. When providing

supplementary food, it is important to distribute it as widely as possible to avoid competition between animals.

Mixed-livestock stocking, defined as the simultaneous stocking and management of two or more animal species, has the potential to grow worldwide providing both economic viability and animal welfare benefits (Anderson et al., 2012). Using data envelopment analysis models on a sample of extensive farms from the Spanish Dehesa, Gaspar et al. (2009) reported that mixed-livestock farming (beef cattle, sheep, and Iberian pig) is a way to increase efficiency, reduce dependence on subsidies, and prevent adverse directional shifts toward unpalatable plant species. A major advantage of mixed-livestock is the better overall utilization of forage. Each animal species prefers different plant species and may use different parts of the landscape preferentially. Certain plant species that are toxic to one animal species may actually serve as forage for another species (Krueger and Sharp, 1978; Popay and Field, 1996). Food availability to the animals will vary depending of the species. For example, goats use resources that are not available as food to other species. Goats use the bipedal stance when feeding and may even climb trees, therefore reaching food unavailable to other ruminants. Goats also have a much higher rejection threshold for bitter tasting substances than sheep or cattle. This allows them to feed on shrubs rich in tannins (Bell, 1959). Mixed-species livestock is not a new livestock management concept and the ecological advantages of using such management systems have been extensively reviewed by Walker (1994). Nowadays, this type of production system may raise increasing interest both from being sustainable and profitable. Research on the impact of mixed-species systems on animal behavior, physiology and health is necessary to increase the implementation of such systems.

Early life experiences cause neurological, morphological, and physiological changes that shape the behavior of the animal in adulthood (McCormick et al., 2000; Dufty et al., 2002). From a management perspective, exposing animals early in their life to a diversity of foods and habitats can reduce the fear response to novelty and help the animals to adapt more easily to a diverse and variable environment. Numerous studies have shown that experience early in life can cause epigenetic changes that influence foraging behavior, habitat selection, and animal health (Provenza, 2008). Epigenetic effects suggest that future generations of livestock could be better adapted to the environment than their parents and should be given further importance in extensive livestock research as it can provide long-term benefits. Exposing pregnant mothers (Nolte and Provenza, 1992) or individuals early in life (Distel et al., 1994) are ways to improve intake of novel foods and decrease fearfulness. When sheep are placed in a new environment likely to elicit a stress response, they show a greater reluctance to eat novel foods compared with the same animals offered new food in a familiar environment (Burritt and Provenza, 1997). This may be particularly relevant when animals are moved from one area to another having a different plant community.

Precision livestock farming (PLF) technologies that can monitor foraging behavior could help to identify or even predict when and where forage is likely to be limited. As proposed by Rutter (2014) the integration of virtual fence technology with



other sensors, both on and off the animal, along with external data such as weather forecasts, should allow smart systems to be developed that dynamically monitor and control grazing in a way similar to traditional, human-based shepherding. Such a system could act as a “virtual shepherd” (Campbell et al., 2020). However, it is important to bear in mind that, although PLF technologies have a great potential to support farmers, they are not a substitute for farmers’ skills and experienced shepherds with a direct knowledge of animals’ needs and behavior can accomplish many things technology cannot (Meuret and Provenza, 2015). Further barriers and limitations for PLF are discussed later on in this review.

## Chronic Thirst

Water is often one of the most limited resources under extensive conditions. Depending on ambient temperature and feed intake, water intake can vary drastically. Under thermoneutral conditions, water requirements range from about 4–8 L per kg of DM intake for cattle and about 2–4 L per kg of DM intake for sheep and goats. Under heat stress conditions, water requirements can easily double. Forage type and conditions affect water intake. Thirst increases when the water content of the forage is low. Likewise, forages with high concentrations of salt increase water requirements. Therefore, livestock need to drink more water under heat stress and when forage conditions are poor.

Two main factors can impair the consumption of water: water availability and water quality. Water is not always available near a good pasture. Livestock may then face a dilemma having to choose between forage and water. When watering points are widely spaced, the area available for grazing is reduced and resources far away from water may not be used at all. Some animals can cope with infrequent water access (once every 2–3 days for tolerant cattle and a bit longer for sheep and goats (Gregory, 2007)). However, water shortage and intermittent water intake can cause detrimental physiological effects. In arid areas, animals can die from thirst in only a few days if they cannot find water.

Besides water availability, the quality of water has a direct impact on the welfare of animals. Access to water of poor quality can drastically alter the health of the animals. Drinking water may be contaminated by minerals, manure, microorganisms, and algae. These contaminants can impact the appearance, odor, and taste of drinking water as well as its physical and chemical properties. Some contaminants may directly impact animal health by causing disease and infection; others have a more indirect effect and may cause livestock to decrease their overall water intake. When water intake is suppressed, feed intake will also decrease, and, as a result, animals will gain less weight.

Contamination with manure can be a frequent problem when animals drink from ponds, as they may defecate into the water or carry manure on their hooves. In a Canadian study done over a 2-month period, yearling cattle gained 23% more weight and spent more time grazing when drinking clean water than when drinking directly from a pond (Willms et al., 2002). The authors argued that cattle have an aversion to drinking water contaminated with feces and suggested that dugouts contaminated with fecal material would reduce water palatability

and intake. Lardner et al. (2005) reported an improvement of 9–10% in weight gain by cattle consuming treated water. Water that is contaminated with manure can become a hotspot for bacteria and algae growth, which in turn can cause diseases such as mastitis, urinary tract infections, and diarrhea (Galey et al., 1987; Metz et al., 1997; Chorus and Bartram, 1999; Brew et al., 2009).

Water quality is also affected by total dissolved salts or TDS. Based on field experience, Beede (2006) reported that an increase in TDS in drinking water can negatively affect the productivity and health of lactating dairy cows both within the environmental thermoneutral zone and during heat stress. High salt content water negatively affected sheep performance (Barrio et al., 1991) and the lactation performance of dairy cows (Solomon et al., 1995). High salt content water can also produce acute effects such as excessive salivation and diarrhea and may be especially difficult to monitor and control under extensive systems.

Water quality should be checked regularly. Small changes in water management can enhance health and performance (Brew et al., 2009). Reducing the concentration of TDS, blue-green algae and other microorganisms, preventing fecal contamination, providing fresh rather than pond water and cleaning watering devices regularly can all result in measurable improvements in livestock welfare and performance (Brew et al., 2009). It may be useful to test the quality of the water on each property. Despite a lack of solid research information to set validated and practical guidelines for ruminants, many different water quality guidelines for farm livestock are suggested in the literature and can be useful (e.g., Beede, 2012).

## Toxic Plants

In extensive grazing systems, animals encounter a diversity of plants that contain plant secondary compounds (PSC). As reviewed by Pfister et al. (2016) and Provenza et al. (2003), PSC are highly diverse chemical structures with a wide variety of actions on animal health and behavior (Durmic and Blache, 2012). Interestingly, a specific PSC can have both detrimental and/or beneficial effects on animal welfare depending on the form and the dose ingested, the duration of ingestion, and the species exposed (Greathead, 2003). Among negative impacts, PSC can alter nutrient utilization, digestive function, respiratory and cardiovascular function, immune function, as well as deteriorating the nervous system and reproductive capacity (Vercoe et al., 2009; Villalba et al., 2016). Herbivores have acquired behavioral and metabolic adaptations that allow them to cope with PSC. The main behavioral adaptation is the capacity of herbivores to develop food aversions when ingesting PSC, because some of these compounds induce nausea (Provenza, 1996). However, not all PSC cause food aversions (Pfister et al., 2010) and delayed toxic effects can limit the ability of herbivores to form food aversions (Villalba et al., 2016). The ingestion of toxic plants by extensively kept animals can thereafter be a source of pain and suffering (Roger, 2008; Pfister et al., 2016). Raising cattle breeds which are not adapted to tropical environments with subsequent exposure to unfamiliar plants can compromise their welfare and production (Eisler et al., 2014). Furthermore, if food is scarce, animals may eat less palatable plants, some of which can contain

toxins. Animals may die because of toxic plants that they would avoid eating under normal circumstances (Krueger and Sharp, 1978; Provenza and Balph, 1990; Provenza et al., 1992).

Conversely, as reviewed by Villalba et al. (2016), plant secondary compounds can also have a beneficial effect on health when they are ingested in the right quantity, for the right amount of time, or in the right combination. For example, PSC have recognized actions on the control of gut pathogen load through different mechanisms (e.g., Athanasiadou et al., 2001; Martínez-Ortiz-de-Montellano et al., 2010). Recent results suggest that parasitized sheep and goats increase preferences for antiparasitic PSC when experiencing parasitic burdens relative to non-parasitized animals (Osoro et al., 2007; Martínez-Ortiz-de-Montellano et al., 2010; Villalba et al., 2010b; Juhnke et al., 2012). Other studies suggest livestock self-medicate by grazing specific medicinal plants when ill (Grad et al., 2009). Thereafter herbivores may learn about the benefits of specific PSC for mitigating discomfort and pain associated with certain health pathologies.

The medicinal effects of PSC have a great potential to improve both the health and welfare of ruminants kept in extensive systems. As commented by Villalba et al. (2016) the biochemical diversity of plants offers animals the opportunity to enhance their health and well-being. Eating diverse diets thus provides herbivores all the advantages of bioactive compounds such as anti-parasitic agents and immunomodulators daily with health maintenance effects. Herbivores exposed to varied diets may also learn about the benefits of specific plant secondary compounds as natural analgesics. Management practices that promote plant diversity and enhance animals' diet selection offer ways to reduce the impact of some health pathologies.

## ENVIRONMENT STRESSORS

### Thermal Stress

Depending on its intensity and duration, heat stress may negatively affect livestock health by causing metabolic alterations, oxidative stress, immune suppression, and death (reviewed by Lacetera, 2019). The effects of heat stress on animals are expected to be similar independently of the production system. However, extensive environment are highly variable and heterogeneous in terms of climate, pasture quality, and topography. Climate is changing toward warmer and drier conditions accompanied with poorer vegetation growth in pastures and higher ambient temperatures and solar radiation (Silanikove and Koluman, 2015). Extensive livestock production systems will come under increased pressure with predicted climate change scenarios (Rust, 2019).

Heat stress is one of the greatest challenges faced by producers and their livestock in many regions of the world. Heat stress reduces feed intake by 15–40% and increases maintenance requirements by 30% (NRC., 2007; Hooda and Singh, 2010; Hamzaoui et al., 2013; Rhoads et al., 2013). The decrease in milk production under heat-stress situations is directly linked to reduced feed intake, while the energy needs of the animal increase. In addition, heat stress reduces protein and fat contents in the milk, inhibits rumination, and causes immunosuppression,

thereby increasing the incidence of some diseases. Heat stress drastically reduces reproductive performances by reducing the synthesis and release of LH and GnRH, which are essential hormones for ovulation and expression of oestrus behavior. Under heat stress conditions, cattle increase the time they stand still, decrease the time they spend resting, and moving around (Cook et al., 2007; Allen et al., 2015). This allows cattle to maximize body surface area in contact with air but increases the risk of lameness. Thermal stress increases thirst. Hyperthermia and dehydration have been associated with an increase in neuromuscular fatigue and incoordination of movement in animals. This means that in hot climates the risk of injury can increase.

The feeling of warmth depends not only on the ambient temperature, but on the effective temperature which results from several factors, including ambient temperature, relative humidity, wind, and solar radiation. The temperature and humidity index (THI) is often used to estimate the effective temperature based, as the name suggests, on ambient temperature, and relative humidity. An adjusted THI for solar radiation and wind speed has been proposed by Mader et al. (2006).

Tolerance to thermal stress varies strongly depending on the species and breed. Dromedary camels are known for their high heat tolerance. Besides their high capacity for sweating, camels are also able to dissipate a significant amount of heat by convection, as the vasodilation of peripheral vessels leads to an increase in cutaneous blood flow and heat dissipation (Abdoun et al., 2012). Breeds of cattle differ in their capacity to thermoregulate and adapt to hot environment. For example, Nellore cattle are more tolerant of tropical heat conditions than Holstein breed (McManus et al., 2009). Moreover, factors such as milk production levels, the quantity and quality of food, health status and hydration levels of the animals can exacerbate the effects of high temperatures (Silanikove, 2000). Under extensive management systems, poor forage quality during summer and reduced water availability can increase the negative impact of heat stress. For example, in cattle in the Southern US, fertility is reduced from around 50% in winter to less than 15% in the summer (Thatcher and Collier, 1986). Most of the published data available on the impact of heat stress have been obtained under experimental conditions and few studies on the impact of heat stress on extensive livestock in field conditions are available.

Cold can also be a welfare problem for extensive livestock. Energy requirements for maintenance are 20% greater in cold winters, and if animals are wet and not protected from the wind, these requirements can double (NRC., 2007). If forage is available and highly digestible, animals can increase energy intake and cope with cold stress. However, when ambient temperature is near freezing both forage availability and digestibility decrease (Adams, 1987). During long and cold winters, ewes with very low body conditions can die from exhaustion. A fleece that is soaked by rain and mud provides little protection against cold. Hypothermia of the newborn due to cold stress is a main cause of neonatal mortality (Dwyer, 2008). Newborn lambs, once dry, are much more sensitive to cold than their mothers. For an adult ewe with full fleece, the approximate lower critical temperature is  $-20^{\circ}\text{C}$  whereas dry lambs can suffer cold stress

under 15°C (McCutcheon et al., 1983). It is therefore essential to provide areas protected from wind and rain, especially during the birth period.

Keeping appropriate species and breeds, especially those adapted to local areas climate conditions is fundamental for sustainability of the production system. Physiological characteristics of goats provide them an advantage over other ruminant species in harsh environmental conditions and dwarf goats are particularly resistant in arid regions. A long-term strategy aims to select for heat- and cold-tolerant breeds. Marker-assisted selection will become more relevant for the genetic improvement of extensive production animals.

Shade structures can reduce total heat load by 30–70% (Blackshaw and Blackshaw, 1994; Muller et al., 1994a; West et al., 2003). Shade shelters can have a beneficial effect on productivity and reproductive performance (Gaughan et al., 2010). During hot weather, dairy cows have a strong motivation to seek shade to avoid heat and sunlight (Schütz et al., 2008, 2009). Shaded cows under South African Mediterranean summer conditions had higher milk production, lower plasma cortisol concentration, lower rectal temperatures and respiration rates than non-shaded cows (Muller et al., 1994b). Cows with access to shade spent more time feeding during the day and less time standing (Muller et al., 1994c). Under summer Mediterranean conditions, the respiration rate of shade sheep (80 breaths per min) was 56% lower than in non-shade sheep (125 breaths per min) (Silanikove, 1987). In semi-arid and arid environments provision of shade structures is a good investment. Access to woodlands and provision of trees and shrubs also can be important sources of shade.

Feed supplements can help livestock cope with thermal stress, as they allow the animal to maintain water balance and nutrient intake and provide for specific nutritional needs during heat stress (Renaudeau et al., 2012; Salama et al., 2016). As mentioned earlier, optimization of water intake by providing easy access to good quality water is especially relevant under heat stress conditions.

Despite strong practical barriers, extensive systems can also benefit from engineering solutions to mitigate the impact of heat stress. For example, providing even very brief access to shade and sprinklers can result in lower body temperatures for up to 4 h (Kendall et al., 2007). The risk of hypothermia in newborn animals such as lambs can be reduced using wind breaks. Additionally, as low body weight at birth increases the risk of hypothermia, ensuring adequate feed intake during pregnancy is important (see above).

## Predation

Predation accounts for a small percentage of total losses in livestock raised in extensive management systems and may range between 0.2–0.8% for cattle and 4–6% for sheep in the US (summarized in Laundré, 2016). These figures include not only losses caused by wild predators but also by domestic dogs, which in many parts of the world are the main predators of livestock. Similarly, wolf depredation affected annually  $0.69 \pm 0.14\%$  of free-ranging livestock in the region of Asturias, NW Spain (Fernández-Gil et al., 2016). From a global perspective,

livestock losses due to predators are relatively low and non-predator losses such as mortality due to diseases or malnutrition are much higher. However, predation losses are not evenly distributed and some farmers experience much higher losses than others (Nowak et al., 2005; Gazzola et al., 2008). Furthermore, in some regions conflicts between farmers and predators have recently increased, leading to a reduced acceptance of wild carnivores (Lescureux et al., 2018). For example, the number of dead livestock caused by predation has steadily increased in France over the last 12 years, with 1,000 more animals killed each year, despite the implementation of protection measures against predators (Meuret et al., 2017). Predators may therefore represent a threat to pastoral farming systems in areas where wild carnivores are abundant.

The indirect effects of repeated predator intrusions on the welfare of livestock animals are often unrecognized as the cause-effect relationship is often difficult to establish (van Bommel and Johnson, 2017). Nevertheless, some studies suggest significant indirect effects. For example, Steele et al. (2013) reported significant effects of the presence of wolves on weaning weights and conception rates of cattle in Wyoming. Similarly, Ramler et al. (2014) found that calves in herds that have suffered wolf attacks have lower average body weights. Some evidence suggests that cattle exposed to predators forage less efficiently and thus experience lower average daily weight gain (Ashcroft et al., 2010). Cattle herds exposed to predators can also have lower conception rates, either due to stress (Howery and Deliberto, 2004) or because cattle used as replacements do not breed as efficiently as those lost to predators (Ashcroft et al., 2010). Laporte et al. (2010) reported that cattle moved closer to other cattle and increased path sinuosity in the presence of wolves in Southwest Alberta, Canada. Also cows with calves increased their vigilance levels when predation risk was higher (Kluever et al., 2008, 2009). As documented in wild species, behavioral changes such as increased vigilance and grouping appear to be common response to predator presence in livestock. Predators may therefore have an impact on their prey, not only by killing but also by scaring them. According to several studies, livestock escape predator intrusions as often as 80% of the time (Mech et al., 2001). This means that “survivors” may have experienced fear. Fear is an adaptive response, essential to the survival of predated species, that normally gives rise to defensive behavior or escape. However, the exposure to repeated fearful situations can lead to negative emotional states such as anxiety (Boissy, 1995). Repeated exposure to acute stress can lead to chronic stress with long-lasting consequences such as reduced immune function, suppress reproduction, and reduced production (Dwyer and Bornett, 2004).

Farmers report a long-lasting reluctance from their herd in using certain places where a wolf attack occurred (Meuret and Provenza, 2015; Garde and Meuret, 2017). Such practical local knowledge should be given a greater value. A complex welfare issue such as predation would greatly benefit from bottom-up approaches and joint learning amongst scientists and the farming community.

Predators can have a long-term effect on the use of space by livestock and this in turn could negatively affect their welfare and



performance (Meuret et al., 2017). This effect is often referred to as “the landscape of fear” and is based on the assumption that under predator pressure, animals change their use of the landscape to seek safer pastures (Hernández and Laundré, 2005; Laundré et al., 2010; Sheriff et al., 2010), which can be overgrazed and thus lead to lower foraging efficiency (Christianson and Creel, 2010). Most studies on the “landscape of fear” have been done in wild animals and an increasing number of authors are questioning the existence of the landscapes of fear in wild herbivores. In particular, the extent to which prey movement patterns actively minimize predation risk across space and time is still controversial (Creel et al., 2008). Indeed, there is a debate regarding the relative importance of proactive vs. reactive spatiotemporal responses by prey to predators and the risk of predation (Creel, 2018). In the recent years, advances in tracking technology can provide a huge amount of information to better understand behavioral patterns of prey and predators. In a recent study, Cusack et al. (2020) assessed the spatiotemporal response of GPS-collared female elk to the risk of predation by wolves during winter in northern Yellowstone. The study highlights a notable absence of spatiotemporal response by adult female elk to the risk of predation posed by wolves. Further, there was no evidence of any reactive responses of individual elk to the presence of wolves in proximity. These results suggest that predator-prey interactions may not always result in strong spatiotemporal patterns of avoidance.

Wherever possible, strategies that allow the coexistence of extensive livestock with predators should be encouraged and include using electric fences, night confinement, close supervision of livestock during high risk periods such as lambing, removing dead animals to avoid attracting predators and supervision of weak, sick, and young animals. Depending on the context of a given local area and herd management, some of these measures are difficult to implement in a feasible way without affecting negatively the welfare of the farmers and their livestock (Meuret et al., 2017). The huge capacity of adaptation of wild carnivores such as the wolf to human practices is an additional constraint to the efficiency of such measures. Overall, however, livestock guarding dogs (LGDs) remain the most effective non-lethal method to reduce losses to predators. The ability of LGDs to protect livestock from predators has been documented in a range of contexts (reviewed in Rigg, 2001; Gehring et al., 2010; Yilmaz et al., 2015). A recent LGD program implemented in Portugal showed that the majority of farmers considered that the advantages of having LGDs outweighed the costs and they were interested in maintaining them in their flocks (Ribeiro et al., 2017a). The lack of traditional knowledge in regions where LGDs have never been used or where their use was discontinued following the eradication of large carnivores can be an obstacle to their implementation. However, LGDs have been successfully introduced where there was no previous tradition of using them, such as in Australia, Namibia, the US and more recently in the Nordic countries and Germany (e.g., Coppinger et al., 1983; Hansen, 2005; Levin, 2005; Marker et al., 2005; Otstavel et al., 2009; Reinhardt et al., 2012; van Bommel and Johnson, 2012). A survey by van Bommel and Johnson (2012) in Australia reports that 95% of participants

thought their dogs were a cost-effective way of protecting livestock. Besides the direct impact in reducing damages from predation, producers also report that their livestock become calmer, and are therefore easier to handle and more productive, in the presence of LGDs. The main factor influencing how well LGDs work in Australia was the number of livestock they are required to protect. It is important to remember that dogs work in a group, and thus it is important to have a well-balanced working group of dogs (e.g., Iliopoulos et al., 2009).

However, despite the efficacy and widespread use of LGDs, many producers still struggle to raise these dogs in an effective manner. A mismatch is often found between traditional literature and current problems and expectations (Liebenberg, 2017) and there is a lack of knowledge on how to breed and train LGD effectively (Liebenberg, 2017). In particular, socialization of LGDs is becoming increasingly important to prevent aggressions toward people and should be balanced with the need for dogs to bond with livestock. A LGD can fulfill the role of protector while being sociable to persons. Lack of selection for working dogs, inappropriate cross breeding and poor training techniques are additional bottlenecks for the successful use of LGDs. Finally, the general public often does not know how to behave in the presence of LGD, which may cause conflicts in touristic areas. Promoting networking and knowledge-exchange between farmers, as well as providing them with proper technical support on raising and training LGDs to avoid undesirable behavior may help to solve or prevent conflicts (Ribeiro et al., 2017b).

## Livestock Handling

Animals are usually handled less often in extensive systems compared with intensive ones, thus welfare problems related to human-animal relationship may ensue. Farm animals may associate humans with rewarding and punishing events that occur at the time of their interactions and may thus develop conditioned fear responses to humans (Hemsworth and Coleman, 2011). In extensive management systems, human-animal interactions are mostly sporadic and seasonal. Additionally, handlings of extensively managed livestock is usually aversive as it includes procedures such as vaccination, restraint, and shearing. For example, most beef cattle in northern Australia are handled, at most, twice annually when they are herded for weaning (Bortolussi et al., 2005). The first close encounter between calves and stockpersons is at the time of weaning when calves undergo numerous aversive procedures (Petherick, 2005). Calves associate humans to aversive situations and show fearful reaction in future handlings. When herding livestock, the use of fast, sudden, unexpected movements, and yelling provokes fear. Cattle are sensitive to auditory interactions with humans showing a similar aversion to hitting as to shouting by humans (Pajor et al., 2000). Extensively managed animals are therefore more likely to associate humans with negative experiences rather than rewarding ones such as routine food deliveries. The lack of regular human contact in extensive systems can contribute to livestock suffering fear and distress during herding and handling. Fearful animals are difficult to handle and may react



excessively and injure stockpeople and themselves (Petherick, 2005).

As in other production systems, good stockmanship is the key to minimizing animal welfare problems in extensive livestock (e.g., cattle, Petherick, 2005). There are strategies to improve human-animal relationships in extensively managed systems and reduce fear reaction from the animals. Some animals with calm temperament seem to find management procedures less stressful (Curley et al., 2006; Petherick et al., 2009; Cooke et al., 2012). Low-stress stockmanship techniques are an effective tool to reduce livestock stress during herding and handling (<https://stockmanship.com/>; Hibbard and Barnes, 2016). Those techniques aim to drive animals properly minimizing the use of negative interactions such as unnecessary force or noise and preventing fear reaction. Training programs for stockpeople can offer good opportunities to improve human-animal interactions. In many areas, livestock are gathered on horseback or using motorcycles, and cattle can be trained from an early age to move calmly and follow a person on horseback or motorcycle (Fordyce, 1987; Petherick, 2005). *Bos indicus* breeds and crossbreeds tend to be “followers” and this behavior can help for moving them quietly (Grandin, 1998). Rewarding experiences, such as provision of a preferred feed or positive handling, around the time of the procedure may reduce the aversiveness of the procedure and the chances that animals associate the negative component of the procedure with humans (Hemsworth, 2007). For example, rewarding sheep with food improves subsequent handling (Hutson, 1985; Grandin, 1998). Finally, well-designed handling facilities can greatly improve animal welfare by reducing fear and injuries [e.g., Grandin (1993, 1997)].

## PAIN, DISEASES, AND OTHER HEALTH RELATED PROBLEMS

### Pain

Pain is a major welfare problem and the main causes in farm animals (both in extensive and in intensive systems) are diseases and injuries (including health problems caused by toxic plants and injuries caused by predators) as well as some husbandry practices. In addition, neonatal mortality is a health-related issue that can cause substantial suffering in animals (see below).

A thorough discussion of pain physiology and assessment is beyond the scope of this paper. However, it is worth emphasizing that newborn ruminants and pigs experience pain. Moreover, some evidence suggests that pain shortly after birth can increase pain sensitivity and this effect is likely to persist for months or years. Animals do not habituate to chronic pain, instead they become more sensitive so that pain increases with time. Ideally, regular observation of the animals' behavior to identify signs of pain as early as possible is of paramount importance to ensure their survival and the sustainability of the production system. However, the detection of behavioral expression of pain may be more difficult in animals under extensive conditions. Species that are traditionally managed extensively such as ruminants show subtle signs of pain as they have evolved as prey species (Romeyer and Bouissou, 1992; Dwyer, 2004). For example,

pain management in sheep is often inadequate and one of the reasons given by veterinarians for not administering analgesics to sheep in pain is the alleged difficulty to identify and assess pain in this species. Main signs of pain include reduced feed intake and rumination; licking, rubbing, or scratching painful areas; reluctance to move; teeth grinding and lip curling; altered social interactions; changes in posture to avoid moving or causing contact to a painful body area. More recently, a Sheep Pain Facial Expression Scale (SPFES) has been developed to identify sheep suffering pain caused by mastitis or footrot (McLennan et al., 2016).

The difficulty in pain identification can be compounded in many extensive systems where animals have little contact with humans, with infrequent handling. Gathering livestock to identify and treat sick animals may be difficult, and prevention of disease is of paramount importance. For example, foot bathing should be done to prevent footrot in sheep when environmental conditions are getting warm and moist. Rapid diagnostic of diseases represents a huge challenge in extensive systems.

### Painful Husbandry Practices

Independently of the production systems, management practices such as castration, tail-docking, dehorning, disbudding, branding, nose ringing, and mulesing (i.e., cutting wool-bearing and wrinkled skin from the perineal region and adjoining hindquarters of sheep) are stressful and painful procedures for animals. Several of these procedures induce acute pain that lasts several hours and is followed by chronic pain which can last more than 48 h (Stafford, 2017; Adcock and Tucker, 2018). As explained before, pain assessment relies mainly on general changes in behavior, as they are sensitive and non-invasive indicators of pain. For example, behavioral changes such as lip curling, trembling, vocalization, and abnormal postures have been described in lambs undergoing tail-docking or castration (Molony et al., 2002; Fitzpatrick et al., 2006). Guesgen et al. (2016) described changes in the ear posture of lambs associated with the negative experience of pain after tail docking using a rubber ring.

Besides being painful to the animals, such procedures are unpleasant to livestock producers. In some cases, evidence of benefits from a given practice is lacking and the practice should be abandoned. For example, tail docking of dairy cows is routinely done in some countries to reduce the risk of mastitis, but there is no evidence it has any effect. In other cases, less painful alternatives are available and should be adopted. For example, although both practices are painful, disbudding of young calves, or kids is far less painful than dehorning at a later age. When a procedure is clearly justified and no alternative is known, then pain mitigation methods should be used as much as possible using the least painful method plus administration of anesthesia and post-operative analgesia. However, lack of knowledge of pain-management practices has been identified as a primary barrier preventing the routine adoption of pain mitigation strategies (Nordquist et al., 2017).

Tail docking is frequently done in sheep kept in extensive conditions and will be discussed below to illustrate general principles applicable to other painful husbandry practices. It is

thought that tail docking reduces the risk of fly strike in sheep by preventing build-up of fecal material (called “dags”) on the tail, breech, and hindquarters. While some studies show that daggy sheep are more likely to be struck, the relationship between tail docking and dags is unclear. Indeed, conflicting results have been obtained when comparing the incidence of fly strike in docked and undocked sheep (Sutherland and Tucker, 2011). Overall, the justification for tail docking in sheep varies on a flock by flock basis depending on the geographical region, the breed of the animal and other management practices. Routine tail docking is unlikely to benefit sheep that do not have wool (hair breeds and some dairy sheep) or that are kept in regions with low incidence of blowfly strike. In some cases, tail docking is done because of tradition and this is not acceptable on animal welfare grounds.

The application of rubber rings within the 1st week of life seems to be the most frequently performed procedure. The rubber ring reduces blood flow to the distal portion of the tail, which eventually becomes necrotic and sloughs off. In some cases, a clamp is applied for 10 s next to the rubber ring as a method to crush and thereby destroy the underlying nerves. Lambs tail-docked with rubber rings show elevated cortisol levels and spend more time in abnormal postures and active behaviors associated with ischemic pain compared with control lambs (Kent et al., 1993). When the tail is docked, it is recommended to leave a minimum of three palpable coccygeal vertebrae in the tail stump (covering at least the anal region and vulva of the animals). Application of a clamp associated with ring tail docking reduces pain. Local anesthetics reduce acute pain. Following tail docking, lambs receiving nonsteroidal anti-inflammatory drug show less pain-related behavior compared with lambs receiving no pain relief, and the magnitude of the effect can be substantial (Small et al., 2014). Important considerations for the use of analgesic drugs in sheep include the ease of application and the duration of their effect. Age has very little effect (if any) on the pain caused by castration and tail docking.

Despite the proven efficacy of various nonsteroidal anti-inflammatory drugs (NSAID) and local anesthetic as discussed in the extensive reviews of Coetzee (2011) and Stafford et al. (2005, 2006), there is limited use of these products by farmers and practitioners during husbandry procedures. Local anesthetic injections are rarely used during routine husbandry procedures because of practical and economic constraints. Main practical limitations to the use of anesthetics arise from the delayed onset of action and the need for veterinary administration. The anesthetic effectiveness of lidocaine under experimental conditions has been reviewed (Rault and Lay, 2011) and found not to be immediate and of limited duration. In case of the use of intratesticular injection of lidocaine with adrenaline, it takes the lidocaine 3 min to reach the testicular cordons (Haga and Ranheim, 2005). This can require double handling of animals and a time delay between administration and procedure, both of which are huge barriers for its application on commercial conditions, especially in extensive production systems.

Genetic strategies such as breeding less wrinkled Merino sheep or polled animals which obviate the need to perform painful procedures such as mulesing or dehorning are important long-term welfare solutions. Intensive genetic research and breeding

programs are underway, but this is a long-term objective (e.g., James, 2006; Scobie et al., 2007).

Ensuring that pain management becomes mainstream on-farm will be a critical challenge for all livestock industries, both intensive and extensive. However, as mentioned before, the use of anesthesia remains a big constraint. Recently, topical anesthesia has been reported to be effective in ameliorating wound pain and improving healing during mulesing, castration, and tail docking in sheep and castration in calves. Lomax et al. (2010) present evidence that alleviation of pain up to 4 h is achieved for lambs undergoing surgical castration plus surgical or hot iron tail docking using a spray-on topical anesthetic. Significant pain alleviation and improved recovery were also reported in lambs for up to 24 h after mulesing through the use of topical anesthesia (Lomax et al., 2013). Topical anesthesia reduced the pain up to 24 h in calves undergoing surgical castration (Lomax and Windsor, 2013). According to the authors, administering the product topically during and immediately postprocedure allows for rapid onset of anesthesia (within 1 min on the basis of sensory testing results). Long lasting pain should then be controlled through the use of long-action analgesia. Further field studies on the development of feasible and effective protocols to minimize acute as well as chronic pain associated with husbandry procedures should be undertaken in extensive managed livestock.

Immunocastration and leaving males intact are two alternatives to castration. Positive results have been experienced with regards to immunocastration (GnRH vaccine) in extensively managed *Bos indicus* in Brasil (Amatayakul-Chantler et al., 2013) and commercial Dohne Merino rams maintained extensively on kikuyu pasture in South Africa (Needham et al., 2016). To be effective the GnRH vaccine should be applied twice, strictly respecting the time between the two injections. Correct application of the vaccine is essential for its effectiveness.

## Diseases and Injuries

Some diseases are more likely in extensive systems than in intensive ones. For example, internal parasites such as nematodes and external parasites such as mites and ticks are significant causes of diseases in extensive livestock. Importantly, some breeds such as *Bos indicus* genotypes are more resistant to parasites such as ticks and helminths (Frisch and Vercoe, 1984). Hoof injuries due to footrot are additional factors that contribute to poor health and pain of livestock (Raadsma and Egerton, 2013).

Several factors can represent a risk for disease under extensive management systems (Goddard, 2016). For example, herds with different sanitary states can share common grazing areas and water points which raises biosecurity issues. Disease control measures such as quarantine, vaccination and disinfection are more difficult to implement in extensive management systems. Cooperation between herders may be difficult as well, although it is essential to plan disease control measures. Treatment of sick animals can be considerably difficult since restraint facilities that allow close examination of the animal and treatment are rarely available in the extensive lands.

Livestock-wildlife transmissions of diseases can happen both in intensive and extensive systems. However, in extensive systems

the main methods to control disease transmission may be difficult or impossible to apply. Some extensive production systems allow a greater interface between domestic and wild animals. With livestock and wildlife sharing the same ecosystems, several diseases can be transmitted among them. Those diseases can be caused by viruses, bacteria, and parasites. Pathogen transmission at the livestock–wildlife interface is frequently bi-directional (Bengis et al., 2002). For example, livestock have introduced several pathogens, such as bovine brucellosis and tuberculosis bacterium, to naïve wildlife populations in North America (Miller et al., 2013). In Africa, disease status associated to extensive livestock systems was reported as a threat to the existence of traditional pastoral society and wildlife resources (Kock et al., 2002). Health problems associated to contaminated water is an additional disease hazards as commented earlier.

In extensive systems, the difficulty to quickly recognize an injured or sick animal impairs efficient health care. Changes in animal behavior indicative of injury or disease, such as reduced locomotion and reduced feed intake could be automatically detected, and the farmer alerted so that rapid treatment could be provided (Rutter, 2016). PLF technologies could help farmers detect health issues. Although PLF systems were initially developed for use in more intensive systems (Berckmans, 2014), there is no reason why they should not be used in extensive systems. PLF technologies can provide continuous 24/7 monitoring of the animals and facilitate the detection of injured or sick animal. PLF can help farmers to make extensive systems more efficient without necessarily making them more intensive (Rutter, 2016).

Still, it is important to be aware of the risks and limitations of PLF technologies. First, PLF do not replace good stockmanship but should be only used as a tool to help farmers monitor livestock. Farmers cannot rely entirely on PLF technology and must be prepared to respond adequately when the system fails. Second, PLF data are sometimes difficult to interpret and the use of applications may need appropriate training (Rutter, 2016). Another potential barrier to the uptake of PLF technologies is the availability of reliable internet access, especially in the remote, rural location typical of many extensive farms. To access cloud services, farmers need reliable internet access, and more needs to be done to ensure rural communities can have the benefits of fast and reliable internet access. Finally, PLF represents a substantial financial cost. A survey of Scottish sheep farmers (Morgan-Davies and Lambe, 2015) found that the cost of the equipment was the main barrier to the adoption of Electronic Identification. Cost of PLF may represent a big impairment for its application in many extensive systems in the world.

## Neonatal Mortality

Neonatal mortality is a concern in both intensive and extensive systems. Pre-weaning mortality rates of extensively kept livestock have been estimated (summarized in Dwyer and Baxter, 2016) to be around 9% in beef cattle, 15% in pigs, 15% in sheep, 20% in goats, and 30% in camels. Nearly 50% of pre-weaning

mortality in cattle and sheep and 20% in pigs occurs within the first 3 days of life (Patterson et al., 1987; Nowak et al., 2000; Edwards and Baxter, 2015). Besides being a strong economical concern for the sustainability of extensive production systems, neonatal mortality raises animal welfare issues. A dying neonate can experience breathlessness, hypothermia, hunger, sickness, and pain (Mellor and Stafford, 2004). The mother may experience frustration, anxiety, inability to show maternal behavior and pain from a full udder (Dwyer and Baxter, 2016).

Causes of mortality of neonates born in extensive systems are diverse. Birth related injury plays an important role in the deaths of 80% of neonatal lambs (Haughey, 1993) and it is a major causal factor in beef calf mortality (Barrier et al., 2013). Nearly half of all calf mortality in first parity heifers and a quarter of all calf mortality in cows are associated with dystocia (Eriksson et al., 2004). The relative size of the neonate compared to the mother's size is a risk factor for injuries of the neonate during birth. Livestock born from dystocia are usually less vigorous and take longer to ingest the colostrum. Long and difficult parturitions are usually attended by people in intensive or semi-extensive systems. In extensive management systems, assistance during complicated parturitions may be delayed or impossible which increases the risk of death of the newborn. In extensive systems, neonates are vulnerable to thermal stress. Nearly half of all perinatal lamb losses are attributed to hypothermia under cold, wet, and windy weather conditions at lambing (Dwyer, 2008). Newborn kids and piglets are particularly susceptible to cold stress. In arid and semi-arid environments, high ambient temperatures and dehydration of the mother can impair milk ingestion and increase the risk of neonate mortality as well. In pigs kept in extensive systems with loose farrowing, crushing of the piglet by the mother is a major source of neonatal mortality (Edwards et al., 1994). Predation of newborn animals is another source of neonatal death, especially lambs, and kids.

Early suckling is essential for immunity transfer. In many domestic species, neonates do not acquire maternal immunity through the placenta. Instead, they depend entirely on passive immunity transfer through colostrum intake. Thus, neonates are born vulnerable to infectious diseases until colostrum intake and any delay in colostrum intake will increase the risk of disease in the neonates. Low birth weight and low vigorous newborn, combined with poor quality colostrum which can be attributed to poor maternal nutrition, impair immunity transfer and hence the health of the neonate. In camels, 50% of mortality occurs the first week of life. Inadequate passive immunity transfer via colostrum intake partly explains high neonatal mortality in camels (Kamber et al., 2001).

In extensive management systems the behavioral abilities of mother and young are especially relevant to reduce neonatal mortality. Appropriate maternal behavior and the newborn behavioral response are key features for the newborn survival (Dwyer and Baxter, 2016). Given that human intervention during parturition is difficult or sometimes impossible in extensive management systems, the provision of an appropriate shelter is expected to enhance neonatal survival.

## CONCLUSIONS

This article has highlighted the animal welfare challenges most likely to be found in extensive systems. Unlike intensive systems, which tend to be rather homogeneous across countries, the conditions encountered by animals in extensive systems are variable depending on climatic conditions, topography and pasture quality, among other factors. Therefore, some welfare problems of extensive systems may be a major concern in some parts of the world but not in others.

Nevertheless, extensive systems are by no means free of welfare problems, although these are likely to be (at least to some extent) different in nature from welfare problems found in intensive systems. Animal welfare is complex, multidimensional concept that includes the biological functioning of the animals (i.e., their health and nutrition), their affective state and whether they are able to display their natural behavior. We suggest that the widely held assumption that extensive systems are better than intensive ones from an animal welfare standpoint partly results from the fact that the general public may prioritize “naturalness” as the most important aspect of welfare. Although natural behavior is indeed an important aspect of animal welfare, it is widely accepted that a proper assessment of animal welfare requires that the other two aspects are also considered.

Welfare challenges in extensive systems can be addressed using a variety of strategies. Selection of animals well-suited to the climatic and nutritional environment appears to be of paramount importance. This selection means not only that locally adapted breeds should be used whenever possible, but also that selection of genetic lines or varieties that offer advantages in terms of reduced neonatal mortality or resistance to specific diseases, among others, must be implemented.

Other improvement strategies are related to management and husbandry, and close supervision of animals is very important. Admittedly, such a close supervision may be very difficult in very extensive production systems, but both changes in husbandry practices and / or using technological developments that allow remote supervision of the animals or pasture conditions are a priority area.

Some welfare problems of extensive systems require very specific management practices. One example is the presence of livestock guarding dogs (LGD) as a non-lethal method of predator control. Studies in many countries have shown that LGD are useful—particularly when used together with other measures, such as close supervision of animals and night fencing—to reduce losses to predators. In those areas of the

world when predation is now a problem but the use of LGD was discontinued many years ago, it is important to implement programs of knowledge-exchange among producers.

Finally, welfare assessment tools are needed to identify problem areas and monitor improvement strategies. One major difficulty here is that, to a large extent, welfare assessment protocols have been designed mainly for intensive systems. Although some of them can be partly adapted to extensive systems, adjustments are needed. Hence, welfare assessment protocols for extensive systems of livestock production are urgently needed.

Extensive systems of livestock production play a key role in the livelihoods of many people around the world and in many areas are the only way to produce food for humans. Moreover, such systems are important as they contribute to the conservation of genetic diversity of livestock species, rural development and, very often, biodiversity conservation. However, in order to guarantee their long-term social and economic sustainability, an effort must be made to realize that even though they offer clear advantages over intensive systems in some areas of welfare, they are not free of challenges. Furthermore, research aimed at developing welfare assessment tools which can be used in extensive systems is needed.

Many animal welfare issues in extensively kept animals are complex and face multifactorial challenges that may be better addressed by alternative approaches to the traditional top-down dissemination of knowledge from science to practice. There is growing policy interest in more “bottom-up,” practice-led, collaborative approaches to innovation which involve livestock producers (Brunori et al., 2013). These practice-led approaches respond to the demand for innovation to solve local problems using practical knowledge and creativity at the farm level (Vogl et al., 2016; Molnár et al., 2020). A greater value should be given to participatory approaches to practice-led innovation in addressing complex, multi-factorial issues (van Dijk et al., 2019). More opportunities are needed to enhance the integration of such participatory approaches to practice-led innovation in future strategy and policy initiatives for animal health and welfare improvement of animals. The welfare of animals kept in extensive production systems should greatly benefit from such approaches.

## AUTHOR CONTRIBUTIONS

DT and XM wrote the manuscript. All authors contributed to the article and approved the submitted version.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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